COOL STARS 19

PROGRAM & ABSTRACTS

The 19th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun

06 – 10 June 2016 | Uppsala, Sweden

www.coolstars19.com

RYMDSTYRELSEN
Swedish National Space Board

UPPSALA
UNIVERSITET

Contents

Welcome to Cool Stars 19

On behalf of the Cool Stars 19 LOC, the SOC, and Uppsala universitet, we welcome you to Uppsala, home to the oldest university in Scandinavia and the home of Carl Linnaeus, Anders Celsius and Anders Jonas Ångström. It is our goal to provide you with a relaxed and comfortable experience. Sweden is a safe friendly place and the Cool Stars 19 organizers are committed to making this meeting productive and enjoyable for everyone, regardless of gender, sexual orientation, disability, physical appearance, body size, ethnicity, nationality, or religion. If you need anything, please don't hesitate to contact a member of the LOC or send us an email at cs19@physics.uu.se.

We hope you enjoy our beautiful historic city and have a fruitful and productive scientific meeting.

As we say in Sweden, välkommen!

Disclaimer: Information in this document is accurate as of publication on 01 June 2016. However, we cannot guarantee that the information will remain accurate throughout the duration of the workshop. To the best of our ability, we will make announcements to inform you of changes to the program. You may download an up to date program and abstract book from our webpage:
http://www.coolstars19.com/files/cs19_program.pdf

Local Contact Information

Conference organizers: cs19@physics.uu.se

Venue Security: +46 (0)18-727 90 70 (tel)

LOC Representative: Gregory Feiden (+46 (0)76-212 32 26; gregory.feiden@physics.uu.se)

Local taxi companies

5 Star Taxi: +46 (0)18-60 60 12 (tel), +46 (0)73-445 45 05 (sms), http://5startaxi.se/

Uppsala Taxi: 100 000 (tel), +46 (0)18-480 82 00 (tel), http://www.uppsalataxi.se/

Local Emergency Contact Information

Local law enforcement: 112 (tel)

National Women's Helpline: +46 (0)20-50 50 50 (http://kvinnofridslinjen.se/)

Local emergency (e.g., ambulance): 112 (tel)

Non-emergency medical (e.g., urgent care, day clinic, dental): 1177 (tel) or +46 (0)77-111 77 00.

Science Organizing Committee

Gibor Basri (UC Berkeley)

Sarbani Basu (Yale University)

Axel Brandenburg (NORDITA)

Adam Burgasser (UC San Diego)

Dainis Dravins (Lund University)

Andrea Dupree (Harvard CfA)

Gregory Feiden (Chair; Uppsala University)

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Daniel Huber (University of Sydney)

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John Stauffer (IPAC – Caltech)

Jeff Valenti (Space Telescope Science Institute)

Gerard van Belle (Lowell Observatory)

Patricia Whitelock (SAAO / University of Cape Town)

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Gregory Feiden (Chair)	Alexis Lavail
James Silvester	Lisa Rosén
Thomas Nordlander	Thomas Marquart
Nikolai Piskunov	Kjell Eriksson
Samuel Regandell	Paul Barklem
Eric Stempels	Andreas Korn
Bengt Gustafsson	Ulrike Heiter

VENUE

Uppsala Konsert och Kongress

Room Locations

All Cool Stars 19 science sessions will be held in one of the following locations at the Uppsala Konsert och Kongress (UKK):

Rum	Room	Function	UKK Level
Stora salen	Great Hall	Plenary & Splinter Sessions	6
Sal B	Hall B	Splinter Sessions	3
Sal C	Hall C	Splinter Sessions	3
Sal D	Hall D	Splinter & Poster Sessions	0
K1 - K4, K6		Bookable Meeting Rooms	3
K5		Speaker Ready Room	3
K8		On-Site Child Care	7

Registration Desk

The registration desk is located in the south-east corner of UKK, behind the escalators near the entrance to Hall D.

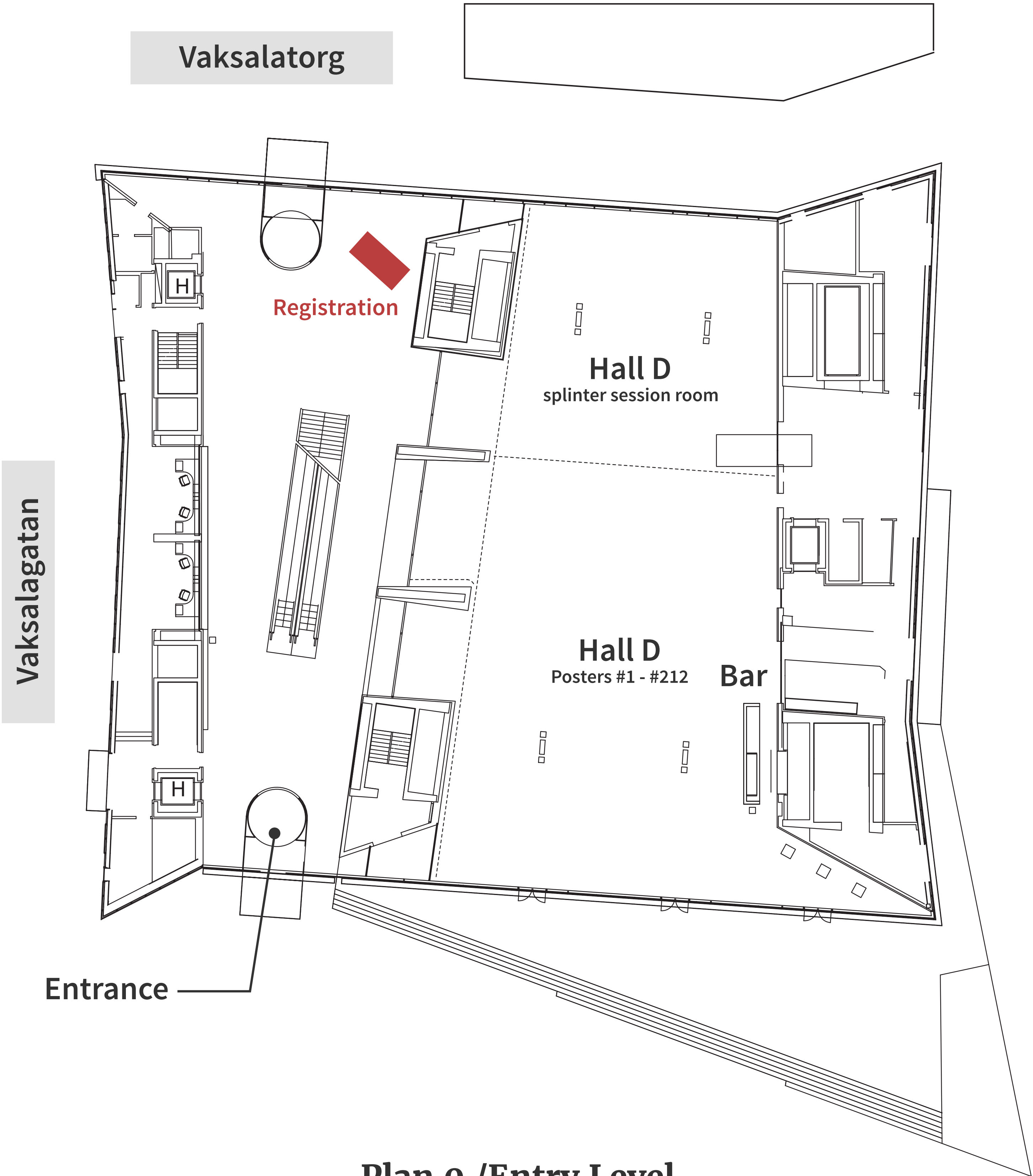
Date	Registration Desk	On-Site Registration
Sunday June 5th	18:30 – 20:30**	Closed
Monday June 6th	08:00 – 17:30	08:30 – 12:00
Tuesday June 7th	08:30 – 17:30	08:30 – 12:00
Wednesday June 8th	08:30 – 12:30	08:30 – 12:00
Thursday June 9th	08:30 – 17:30	Closed
Friday June 10th	08:30 – 12:30	Closed

** Registration desk will be located at the welcome reception in Uppsala's Botanical Garden.

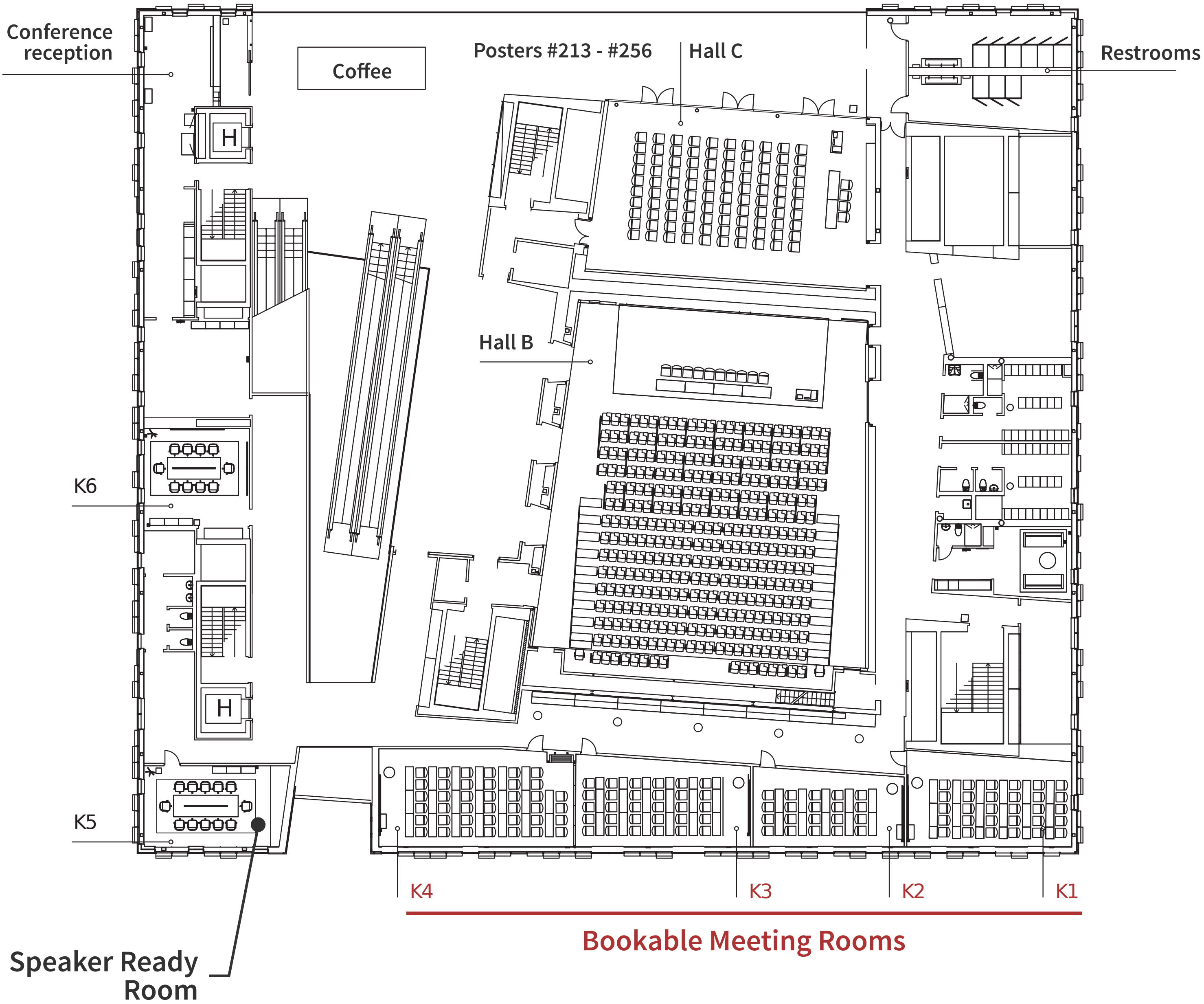
Reserve a Meeting Room

There are five meeting rooms in UKK (rooms K1 – K4, K6) that may be used for meetings or telecons. The rooms are located on level 3 and seat between 12 and 24 people. If you want to hold a small meeting, you can either speak to the LOC representative at the registration desk or reserve a meeting room online.

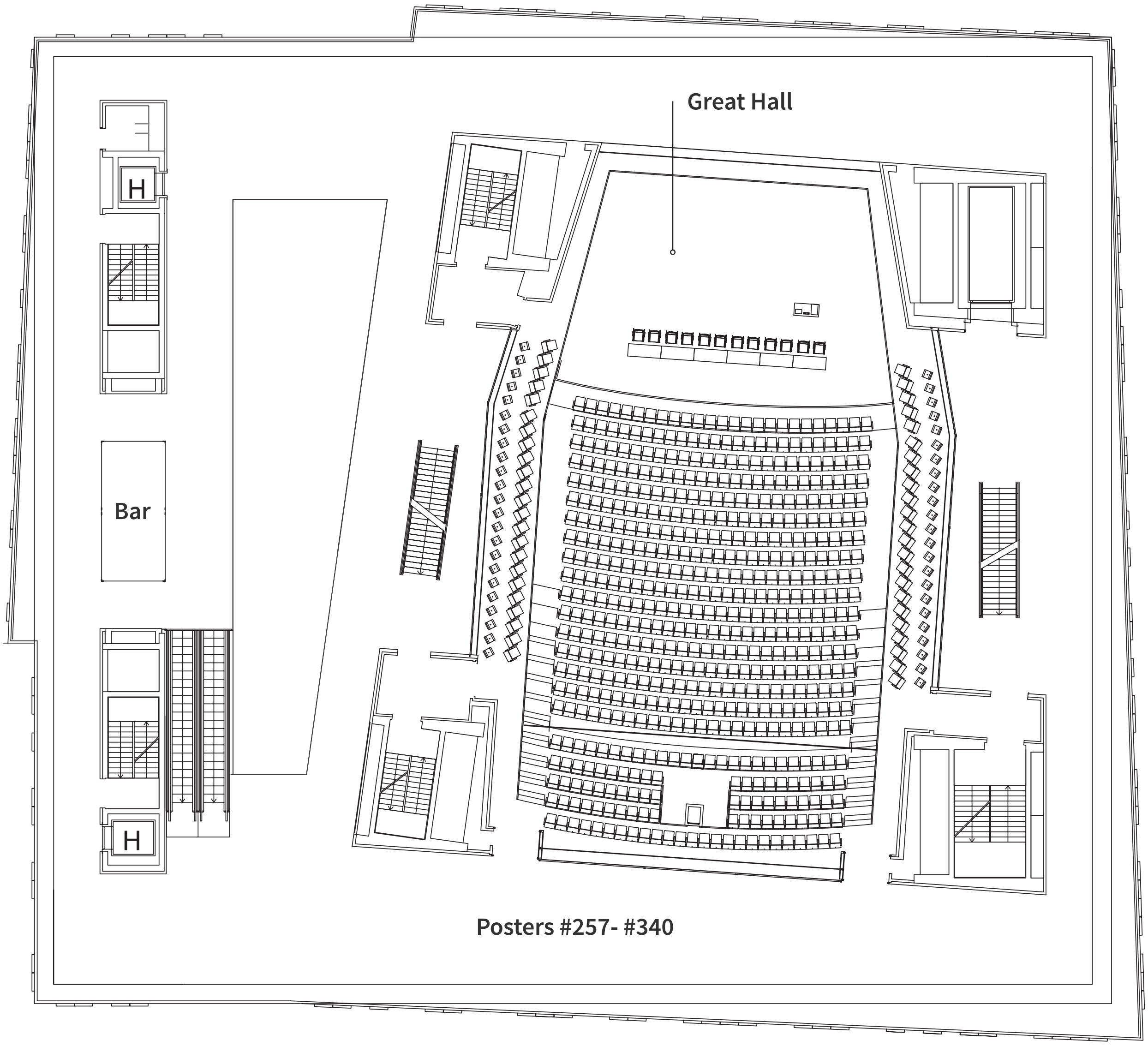
Online Instructions: To reserve a room using the spreadsheet, please leave a comment in the cell that corresponds to your desired room and start time. In the comment, please specify the length of your meeting, the approximate number of people, a short description (meeting name), your name, and your email address. Your reservation will be confirmed via email by a member of the LOC.



Plan 0 /Entry Level



Plan 3 / Level 3



Plan 6 / Level 6

SCHEDULE

Overview

Monday

Time	**Hall**	***Event***
08:45 – 09:00	Great Hall	*Welcome Address*
09:00 – 10:35	Great Hall	*Plenary: (sub)Stellar Interiors & Fundamental Properties*
10:35 – 11:00		**Break**
11:00 – 12:35	Great Hall	*Plenary: (sub)Stellar Interiors & Fundamental Properties*
12:35 – 14:00		**Lunch**
14:00 – 17:30	Great Hall	*Splinter: Surface Magnetism of Cool Stars*
14:30 – 17:30	Hall B	*Splinter: Star Clusters from Space, from the Ground, and Over Time*
14:30 – 17:30	Hall C	*Splinter: The Brown Dwarf to Exoplanet Connection*
14:00 – 17:30	Hall D	*Splinter: Mass-Losing AGB Stars and Supergiants*
17:30 – 20:30		*Evening Poster Session*

Tuesday

Time	**Hall**	***Event***
08:50 – 09:00	Great Hall	*Morning Announcements*
09:00 – 10:35	Great Hall	*Plenary: Physics of (sub)Stellar Atmospheres & Cool Star Abundances*
10:35 – 11:00		**Break**
11:00 – 12:35	Great Hall	*Plenary: Physics of (sub)Stellar Atmospheres & Cool Star Abundances*
12:35 – 14:00		**Lunch**
14:30 – 17:30	Great Hall	*Splinter: Variability of Solar/Stellar Magnetic Activity*
14:30 – 17:30	Hall B	*Splinter: Star Clusters from Space, from the Ground, and Over Time*
14:30 – 17:30	Hall C	*Splinter: Flares in Time-Domain Surveys*
14:00 – 17:30	Hall D	*Splinter: Mass-Losing AGB Stars and Supergiants*
18:00 – 19:00	Hall D	*Cool Stars & The James Webb Space Telescope: A Townhall Meeting*

Wednesday

Time	**Hall**	***Event***
08:50 – 09:00	Great Hall	*Morning Announcements*
09:00 – 10:35	Great Hall	*Plenary: Stellar Winds, Mass Loss, and Rotation from the Pre-MS through the AGB*
10:35 – 11:00		**Break**
11:00 – 12:35	Great Hall	*Plenary: Stellar Winds, Mass Loss, and Rotation from the Pre-MS through the AGB*
12:35 –		**Lunch**
		Free Afternoon / Excursions
19:00 – 20:00	Great Hall	*Public Lecture: Seeing the Distant, the Dusty, and the Dark*

Thursday

Time	**Hall**	***Event***
08:50 – 09:00	Great Hall	*Morning Announcements*
09:00 – 10:35	Great Hall	*Plenary: Solar/Stellar Magnetic Activity and the Impact on Planetary Environments*
10:35 – 11:00		**Break**
11:00 – 12:35	Great Hall	*Plenary: Solar/Stellar Magnetic Activity and the Impact on Planetary Environments*
12:35 – 14:00		**Lunch**
14:30 – 17:30	Great Hall	*Splinter: Variability of Solar/Stellar Magnetic Activity*
14:00 – 17:30	Hall B	*Splinter: Sun-like Stars Unlike the Sun*
14:30 – 17:30	Hall C	*Splinter: Cool Dwarf Multiplicity Throughout the Ages*
14:30 – 17:30	Hall D	*Splinter: The Solar/Stellar Connection in the ALMA Era*
18:30 – 23:59	Uppsala Castle	*Cool Stars 19 Banquet Dinner*

Friday

Time	**Hall**	***Event***
08:50 – 09:00	Great Hall	*Morning Announcements*
09:00 – 10:35	Great Hall	*Plenary: Cool Stars in the Galactic Context*
10:35 – 11:00		**Break**
11:00 – 12:35	Great Hall	*Plenary: Cool Stars in the Galactic Context*
12:35 – 12:45	Great Hall	*Concluding Remarks*

SCHEDULE

Detailed

Monday

Plenary Session: (sub)Stellar Interiors & Fundamental Properties

Room: Great Hall — Chair: Eric Stempels (Uppsala University)

Time	Speaker	*Title*
08:45 – 09:00		*Welcome Address*
09:00 – 09:35	G. Chabrier	*(New) provocative ideas in the physics of cool objects*
09:35 – 09:55	B. Montet	*Fundamental Parameters of M Dwarfs in Young Moving Groups*
09:55 – 10:15	I. Baraffe	*New Approaches to the Evolution of Young Low Mass Stars and Brown Dwarfs: Consistent Models of Accretion History and Multi-Dimensional Structure of Accreting Young Stars*
10:15 – 10:35	K. France	*The MUSCLES Treasury Survey: X-Ray to IR Spectral Survey of M and K Dwarf Exoplanet Host Stars*
10:35 – 11:00		**Break**
11:00 – 11:20	R. Egeland	*Dynamo Sensitivity in Solar Analogs with 50 Years of Ca II H & K Activity*
11:20 – 11:40	N. Meunier	*Stellar Granulation and Convective Blueshift: Dependence on Spectral Type and Magnetic Activity*
11:40 – 12:15	J. Faherty	*Constraints on the Fundamental Properties of Substellar and Planetary Mass Objects*
12:15 – 12:35	T. Dupuy	*Testing Substellar Models with High-Precision Parallaxes*
12:35 – 14:00		**Lunch Break**

Splinter Session: Surface Magnetism of Cool Stars

Room: Great Hall — Conveners: O. Kochukhov, P. Petit, K. Strassmeier

Time	Speaker	*Title*
14:00 – 14:05		*Welcome Address*
14:05 – 14:30	K. Strassmeier	*Methods of direct studies of stellar surface magnetic fields*
14:30 – 14:45	L. Rosén	*Challenges of cool star ZDI: self-consistency and four Stokes parameters*
14:45 – 15:00	S. Jeffers	*Magnetic cycles of solar-type stars*
15:00 – 15:15	H. Korhonen	*Imaging stellar surfaces with near-infrared interferometry: comparison to Doppler imaging results*
15:15 – 15:40	C. Folsom	*Magnetic fields of young cool stars*
15:40 – 15:55		**Break**
15:55 – 16:10	B. Nicholson	*Magnetic fields of weak-line T Tauri stars*
16:10 – 16:35	J. Morin	*Magnetic fields of low-mass stars*

Time	Speaker	Title
16:35 – 16:50	D. Shulyak	*Beyond the saturation: detecting the strongest magnetic fields in M dwarf stars*
16:50 – 17:05	R. Fares	*Tomographic imaging: the Sun as a test case*
17:05 – 17:30	A. López Ariste	*Solar and stellar spectropolarimetry: A comparison*

Splinter Session: Star Clusters from Space, from the Ground, and Over Time

Room: Hall B — Conveners: M. Agüeros, F. Bastien, K. Covey, R. Jeffries, E. Moraux, S. Randich, G. Sacco, N. Wright

Time	Speaker	Title
14:30 – 14:50	J. de Bruijne	*The Potential of Gaia*
14:50 – 15:00	M. Roelens	*Short Timescale Variables in Stellar Clusters: From Gaia to Ground-Based Telescopes*
15:00 – 15:10	A. M. Cody	*Cool Young Stars in the Time Domain: The View with K2*
15:10 – 15:20	L. Spina	*The Gaia-ESO Survey: Exploring the Galactic Metallicity Gradient Using Star Forming Regions and Young Open Clusters*
15:20 – 15:30		*Poster pop-ups*
15:30 – 16:00		**Break/Poster session**
16:00 – 16:20	S. Matt	*Stellar Angular Momentum Over Time*
16:20 – 16:30	S. Douglas	*Testing the Rotation-Activity Relation with the Hyades and Praesepe*
16:30 – 16:40	L. Rebull	*Rotation Periods in the Pleiades with K2*
16:40 – 16:50	J. Curtis	*Ruprecht 147 and the Quest to Date Middle-Aged Stars*
16:50 – 17:00	L. Malo	*The Pre-Gaia Search for Young Objects in the Solar Neighborhood*
17:00 – 17:10	L. Prisinzano	*The Gaia-ESO Survey: Addressing Extinction and Reddening Towards NGC 6530*
17:10 – 17:30		*Day 1 wrap up*

Splinter Session: The Brown Dwarf to Exoplanet Connection

Room: Hall C — Conveners: J. Faherty, J. Gagné, E. Rice, C. Morley, K. Cruz

Time	Speaker	Title
14:30 – 14:35		*Introduction*
14:35 – 14:50	J. Gagné	*On Finding Isolated Planetary Mass Objects and Brown Dwarfs*
14:50 –	J. Stone	*A nearby brown-dwarf triple system with a planetary mass companion*
	C. Morley	*Inferring Formation History from Atmospheric Characterization of the First T Dwarf Exoplanet, GJ 504b*

Time	**Speaker**	***Title***
	A. Rajan	*Characterization the lowest mass directly imaged planet 51 Eri b*
	M. Cushing	*WISEA J114724.10-204021.3: A Free-Floating Planetary Mass Member of the TW Hya Association*
	W. Best	*Discovery of Young L Dwarfs in Taurus and Scorpius-Centaurus*
15:20 – 15:35		*Discussion of all objects in this session*
15:35 – 15:50	E. Manjavacas	*Characterizing young brown dwarfs atmospheres with polarization data*
15:50 – 16:05	B. Biller	*Cloud-Driven Variability on Young Brown Dwarfs and Giant Exoplanets*
16:05 – 16:20		**Break and Lightning Talks**
16:20 – 16:35	P. Tremblin	*Cloudless atmospheres for L/T dwarfs and extrasolar giant planets*
16:35 – 16:50	B. Burningham	*Atmospheric retrievals in the cloudy regime of free-floating planetary mass objects and directly imaged exoplanets*
16:50 – 17:05	J. Patience	*Clues on the Origins of Planetary Mass Companions*
17:05 – 17:20	C. Beichman	*Observing Planets with JWST/NIRCAM*
17:20 – 17:30		*Discussion*

Splinter Session: Mass-Losing AGB Stars and Supergiants

Room: Hall D — Conveners: S. Höfner, M. Boyer, M. Wittkowski, P. Whitelock, A. Zijlstra

Time	**Speaker**	***Title***
14:00 – 14:30	C. Paladini	*The coolest (sur)faces we have seen so far in the infrared*
14:30 – 14:50	S. Liljegren	*Pulsation properties of AGB star 3-D model grids*
14:50 – 15:10	M. Wittkowski	*VLTI/PIONIER imaging observations of the AGB star R Sculptoris*
15:10 – 15:30	S. Bladh	*Wind models of M-type AGB stars in the LMC*
15:30 – 16:00		**Break**
16:00 – 16:30	E. Humphries	*AGB and RSG Stars: From the Radio to the Sub-mm*
16:30 – 16:50	E. O'Gorman	*Long Baseline Radio Continuum Observations of Betelgeuse: Understanding Mass Loss in Red Supergiants*
16:50 – 17:10	B. Tessore	*Surface magnetic field detection in M-type supergiant stars: the non-uniqueness of Betelgeuse*
17:10 – 17:30	J. Hron	*The dynamic atmospheres of carbon rich giants - constraining models via interferometry*

Cool Stars 19 Evening Poster Session, 18:00 – 20:30

Location: UKK Hall D, Level 3, Level 6 — Conveners: Cool Stars 19 SOC

Tuesday

Plenary Session: Physics of (sub)Stellar Atmospheres & Cool Star Abundances

Room: Great Hall — Chair: Jaime de la Cruz Rodriguez (Stockholm University)

Time	**Speaker**	***Title***
08:50 – 09:00		*Morning Announcements*
09:00 – 09:35	C. Morley	*The Current Status and Frontiers of Modeling Substellar Atmospheres*
09:35 – 09:55	M. R. Line	*Characterizing Physical Processes in Late T-Dwarfs with Atmospheric Retrieval*
09:55 – 10:15	S. Metchev	*Implications From Photometric and Spectroscopic Variability Monitoring of Substellar Atmospheres*
10:15 – 10:35	H. Giles	*"What's Eating Those Starspots?" Determining a Relationship Between Starspot Size and Their Decay Timescale With Respect to Stellar Spectral Type*
10:35 – 11:00		**Break**
11:00 – 11:35	P. Jofré	*Gaia Benchmark Stars: Providing a Reference Scale for Spectroscopic Surveys of the Milky Way*
11:35 – 11:55	M. Pinsonneault	*[C/N] Ratios in Red Giants as a Function of Mass and Metallicity: Comparison with Theory*
11:55 – 12:15	V. Adibekyan	*Trends with Condensation Temperature and Terrestrial Planet Formation: The Case of Zeta Reticuli*
12:15 – 12:35	S. Blanco-Cuaresma	*How Much Can We Trust High-Resolution Spectroscopic Stellar Atmospheric Parameters and Abundances?*
12:35 – 14:30		**Lunch Break**

Splinter Session: Variability of Solar/Stellar Magnetic Activity

Room: Great Hall — Conveners: D. Fabbian, R. Simoniello, R. Collet, S. Criscuoli, H. Korhonen, N. Krivova, K. Oláh, A. Shapiro, A. Vidotto, N. Vitas

Time	**Speaker**	***Title***
14:30 – 14:50	M. Giampapa	*Photometric Variability in the Sun and Sun-like Stars*
14:50 – 15:02	R. A. García	*Probing Stellar Magnetism with Space Photometry of Solar Analogs*
15:02 – 15:14	C. Marvin	*Measurements of Absolute Calcium II H & K in FGKM Stars*
15:14 – 15:26	R. Haywood	*Radial-Velocity Variability of the Sun as a Star with HARPS and HARPS-N*
15:26 – 15:38	J. R. Barnes	*Photospheric Acne at the Bottom of the Main Sequence: Doppler Images of M4.5 - M9V Stars*
15:38 – 16:15		**Break**

Time	Speaker	*Title*
16:15 – 16:35	S. Marsden	*Magnetic Fields on Solar-Type Stars: The Solar-Stellar Connection*
16:35 – 16:55	S. Aigrain	*The Effects of Stellar Activity on Detecting and Characterizing Planets*
16:55 – 17:07	J. Llama	*The Impact of Stellar Activity on High Energy Exoplanet Transits*
17:07 – 17:19	J. D. Alvarado-Gómez	*Simulating the Environment Around Planet-Hosting Stars*
17:19 – 17:31	M. Jardine	*Predicting the Wind Speeds of Solar-Like Stars*

Splinter Session: Star Clusters from Space, from the Ground, and Over Time

Room: Hall B — Conveners: M. Agüeros, F. Bastien, K. Covey, R. Jeffries, E. Moraux, S. Randich, G. Sacco, N. Wright

Time	Speaker	*Title*
14:30 – 14:50	C. Bell	*Clusters as Benchmarks for Measuring Fundamental Stellar Properties*
14:50 – 15:00	A. Kraus	*The Mass-Radius Relation of Young Stars*
15:00 – 15:10	G. Somers	*Open Cluster Lithium as a Strong Test of Core-Envelope Re-Coupling Timescales*
15:10 – 15:20	J. Choi	*Toward the Absolute Age of M92*
15:20 – 15:30		*Poster pop-ups*
15:30 – 16:00		**Break / Poster session**
16:00 – 16:20	R. Parker	*The Diagnostic Potential of Spatial and Kinematic Tracers*
16:20 – 16:30	N. Da Rio	*The IN-SYNC Orion Survey*
16:30 – 16:40	R. Jeffries	*Structure and Dynamics of Young Star Clusters With the Gaia-ESO Survey*
16:40 – 16:50	M. Pecaut	*Substructure in the Scorpius-Centaurus OB Association*
16:50 – 17:00	R. Angus	*Exploring Gyrochronology with LSST*
17:00 – 17:10	S. Meibom	*The TESS Open Cluster Survey*
17:10 – 17:30		*Wrap up and next steps*

Splinter Session: Flares in Time-Domain Surveys

Room: Hall C — Conveners: A. Kowalski, A. Berlicki, G. Cauzzi, J. Davenport, L. Fletcher, S. Hawley, P. Heinzel

Time	Speaker	*Title*
14:30 – 14:45	J. Davenport	*The Kepler Catalog of Stellar Flares*
14:45 – 14:51	Y. Notsu	*Superflares on solar-type stars found from Kepler data*

Time	Speaker	*Title*
14:51 – 14:57	P. Loyd	*FUV Emission Line Flares on M and K Dwarfs in the MUSCLES Survey*
14:57 – 15:12	J. C. Martinez Oliveros	*SDO/HMI White-light flares and their associated manifestations*
15:12 – 15:18	C. Pugh	*Quasi-Periodic Pulsations in Stellar Flares*
15:18 – 15:30	P. Heinzel	*On the behavior of light curves of solar and stellar flares*
15:30 – 15:50		**Break**
15:50 – 16:05	S. J. Schmidt	*Finding the Largest Flares on Ultracool Dwarfs with ASAS-SN*
16:05 – 16:11	S. Karmakar	*X-ray Superflares on CC Eri*
16:11 – 16:16	J. Pye	*The frequency of dM-star X-ray flares from a large-scale XMM-Newton sample*
16:16 – 16:31	A. Berlicki	*F-CHROMA project: Observations and modelling of solar flare chromospheres*
16:31 – 16:36	E. Flaccomio	*A multi-wavelength view of magnetic flaring from PMS stars*
16:40 – 16:46	S. Hawley	*Recovering Flares in LSST*
16:46 – 17:00		**Break**
17:00 – 17:30		*Round Table Discussion*

Splinter Session: Mass-Losing AGB Stars and Supergiants

Room: Hall D — Conveners: S. Höfner, M. Boyer, M. Wittkowski, P. Whitelock, A. Zijlstra

Time	Speaker	*Title*
14:00 – 14:30	E. Lagadec	*The Circumstellar Environment of AGB stars and Supergiants*
14:30 – 14:50	L. Decin	*High spatial resolution studies of the winds of evolved stars*
14:50 – 15:10	A. Nanni	*Constraining dust properties in Circumstellar Envelopes of C-stars in the Small Magellanic Cloud: optical constants and grain size of carbon dust*
15:10 – 15:30	O. Jones	*The dustiest AGB Stars and RSG in the Magellanic Clouds*
15:30 – 16:00		**Break**
16:00 – 16:30	S. Mohamed	*Modelling the interactions of cool giants with (sub)stellar companions: Implications for mass-transfer rates and outflow geometries*
16:30 – 16:50	A. Trejo-Cruz	*Dust-production rates of AGB stars in the Solar Neighborhood*
16:50 – 17:10	T. Güth	*A First Look at the Circumstellar Dust Composition of O-type Mira Variables observed with Spitzer*
17:10 – 17:30	M. Montarges	*The optical interferometry view of convection in nearby red supergiants*

Tuesday

Cool Stars & The James Webb Space Telescope: A Townhall Meeting, 18:00 – 19:00

Room: Hall D — Conveners: David Soderblom & the JWST team

Wednesday

Plenary Session: Stellar Winds, Mass Loss, and Rotation from the Pre-MS through the AGB

Room: Great Hall — Chair: Wouter Vlemmings (Chalmers Institute of Technology / Onsala Space Observatory)

Time	**Speaker**	***Title***
08:50 – 09:00		*Morning Announcements*
09:00 – 09:35	J. Fuller	*Asteroseismic Windows into the Hearts of Red Giants*
09:35 – 09:55	J. L. van Saders	*Testing Gyrochronology with Kepler: Anomalous Braking in Old Field Stars*
09:55 – 10:15	V. Réville	*Age Dependence of Wind Properties for Solar-type Stars: A 3D Study*
10:15 – 10:35	C. Garraffo	*The Missing Morphology Term in Stellar Rotational Evolution*
10:35 – 11:00		**Break**
11:00 – 11:20	S. Gregory	*Magnetic, Coronal, and Rotational Evolution of Pre-MS Stars*
11:20 – 11:40	E. R. Newton	*Rotation Periods for Fully-Convective M Dwarfs in the Solar Neighborhood*
11:40 – 12:15	S. Höfner	*(Re)solving Mysteries of Convection and Mass Loss of AGB Stars: What New Models and Observations Tell Us About Long-Standing Problems*
12:15 – 12:35	M. Maercker	*ALMA Observations of the Not-So Detached Shell Around the Carbon AGB Star R Sculptoris*
12:35		**Lunch and Free Afternoon / Excursions**

Public Lecture

Room: Great Hall — Conveners: N. Piskunov, G. Feiden

Time	**Speaker**	***Title***
19:00 – 20:00	David Soderblom	*Seeing the Distant, the Dusty, and the Dark: How the James Webb Space Telescope will help reveal the origins of our Universe, our Galaxy and our World*

Thursday

Plenary Session: Solar/Stellar Magnetic Activity and the Impact on Planetary Environments

Room: Great Hall — Chair: Mats André (Swedish Institute of Space Physics)

Time	Speaker	*Title*
08:50 – 09:00		*Morning Announcements*
09:00 – 09:35	A. Kowalski	*Advances in Understanding Solar and Stellar Flares*
09:35 – 09:55	R. Simoniello	*Latest Developments in the Solar Dynamo: A Key to Stellar Magnetic Activity and Variability*
09:55 – 10:15	J. A. Caballero	*Carmencita: The CARMENES Input Catalogue of Bright, Nearby M Dwarfs*
10:15 – 10:35	O. Kochukhov	*Understanding the Multifaceted Nature of M Dwarf Magnetism*
10:35 – 11:00		**Break**
11:00 – 11:35	A. Vidotto	*Stellar Magnetism, Winds, and their Effects on Planetary Environments*
11:35 – 11:55	X. Dumusque	*HARPS-N Observes the Sun as a Star*
11:55 – 12:15	B. Stelzer	*A Path Towards Understanding the Rotation-Activity-Age Relation of M Dwarfs With K2 Mission, X-Ray and UV Data*
12:15 – 12:35	A. Mortier	*Tracking Magnetic Variability From High-Resolution Unpolarised Spectra*
12:35 – 14:00		**Lunch Break**

Splinter Session: Variability of Solar/Stellar Magnetic Activity

Room: Great Hall — Conveners: D. Fabbian, R. Simoniello, R. Collet, S. Criscuoli, H. Korhonen, N. Krivova, K. Oláh, A. Shapiro, A. Vidotto, N. Vitas

Time	Speaker	*Title*
14:30 – 14:50	S. K. Solanki	*Variability of the Sun and Sun-Like Stars on Different Time Scales*
14:50 – 15:10	G. Basri	*Age-Rotation-Activity Relations: Observations and Theory*
15:10 – 15:22	R. Booth	*An Improved Stellar Age-Activity Relationship for Ages Beyond a Gigayear*
15:22 – 15:34	J. Lehtinen	*Rotation and Spot Activity of Young Solar-Type Stars*
15:34 – 15:46	V. See	*What Can We Learn About Stellar Activity Cycles from ZDI?*
15:46 – 16:15		**Break**
16:15 – 16:35	L. Jouve	*Numerical Simulations of Solar/Stellar Dynamos*
16:35 – 16:47	T. Metcalfe	*The Stellar Context for Solar Magnetism*

Time	Speaker	*Title*
16:47 – 17:59	K. Augustson	*Magnetic Furnaces: Examining Fully Convective Dynamos and the Influence of Rotation*
16:59 – 17:11	S. Engle	*Activity-Rotation-Age Relationships for M dwarfs and the Ages of Extrasolar Planets*
17:11 – 17:30		*Final discussion session for afternoons 1 & 2: Peculiarities and Common Features of Magnetism and Activity in the Sun and in Solar-Like Stars*

Splinter Session: Sun-like Stars Unlike the Sun

Room: Hall B — Conveners: V. Adibekyan, E. Delgado Mena, S. Feltzing, J. González Hernández, N. Hinkel, A. Korn

Time	Speaker	*Title*
14:00 – 14:05	V. Adibekyan	*Session Welcome*
14:05 – 14:23	P. E. Nissen	*High-precision parameters and chemical abundances of solar-like stars*
14:23 – 14:41	J. Melendez	*Planet signatures in the chemical composition of Sun-like stars*
14:41 – 14:59	E. Delgado Mena	*Possible explanations for the abundance trends with condensation temperature*
14:59 – 15:11	L. Spina	*The nucleosynthetic history of elements in the Galactic disk: [X/Fe] - age relations from high-precision spectroscopy*
15:11 – 15:25	M. Deal	*The 16 Cygni system: A laboratory for studying the influence of a planetary system on its host star*
15:25 – 15:45		**Break**
15:45 – 16:03	B. Gustafsson	*Possible reasons for solar oddity*
16:03 – 16:21	M. Bergemann	*Do we need NLTE in the abundance analysis of solar-type stars?*
16:21 – 16:39	M. Asplund	*3D-based solar/stellar abundance analyses*
16:39 – 16:51	S. Honda	*Lithium abundance of the solar-type superflare stars*
16:51 – 17:05	P. Beck	*Observational inputs on the solar/stellar connection: Probing solar analogues with asteroseismology and high-resolution spectroscopy*
17:05 – 17:30	A. Korn	*Round Table Discussion*

Splinter Session: Cool Dwarf Multiplicity Throughout the Ages

Room: Hall C — Conveners: D. Bardalez Gagliuffi, C. Gelino, N. Deacon

Time	**Speaker**	***Title***
14:30 – 14:35		*Session Welcome*
14:35 – 15:00	C. Clark	*The implications of cool star multiplicity statistics for star formation theories*
15:00 – 15:14	B. Tofflemire	*Accretion Dynamics in Pre-Main Sequence Binary Stars: Observationally Testing the Accretion Stream Theory*
15:14 – 15:28	E. Gillen	*Constraining the early stages of binary star evolution*
15:28 – 15:42	T. David	*Fundamental Calibrators for Stellar Evolution Models: New Eclipsing Binaries in Young Clusters Identified by K2*
15:42 – 16:16		**Poster Pops & Break**
16:16 – 16:30	R. Parker	*The role of dynamics in multiplicity*
16:30 – 16:44	D. Bardalez Gagliuffi	*Towards the True Binary Fraction of Very Low Mass Stars and Brown Dwarfs*
16:44 – 17:58	K. Ward-Duong	*Properties of Stellar and Substellar Companions from the M-dwarfs in Multiples (MinMs) Survey*
16:58 – 17:12	S. B. Dieterich	*Fundamental Stellar Parameters with HST/STIS Spectroscopy of M Dwarf Binaries*
17:12 – 17:26	T. Dupuy	*Doubling Down: Individual Dynamical Masses for Ultracool Binaries*
17:26 – 17:30		*Closing Remarks*

Splinter Session: The Solar/Stellar Connection in the ALMA Era

Room: Hall D — Conveners: S. Wedemeyer, H. Hudson, T. Bastian

Time	**Speaker**	***Title***
14:30 – 15:00	V. Vlemmings	*ALMA - Introducing the status and capabilities of ALMA*
15:00 – 15:30	S. Ramstedt	*Stellar observations with ALMA*
15:30 – 15:45	E. O'Gorman	*Mapping the 'Radio Surface' of an Evolved Star with ALMA*
15:45 – 16:15		**Break**
16:15 – 16:45	M. Shimojo	*Solar Observations in Cycle 4 of ALMA*
16:45 – 17:00	T. Ayres	*The Cold Heart of the Solar Chromosphere*
17:00 – 17:30	J. Linsky	*Prospects for ALMA studies of the solar-stellar connection*

Cool Stars 19 Banquet Dinner

Rikssalen, Uppsala Castle — Conveners: Cool Stars 19 LOC

Friday

Plenary Session: Cool Stars in the Galactic Context

Room: Great Hall — Chair: Dainis Dravins (Lund University)

Time	Speaker	*Title*
08:50 – 09:00		*Morning Announcements*
09:00 – 09:35	A. Karakas	*The Role of Cool Evolved Stars in Galactic Chemical Evolution*
09:35 – 09:55	N. Matsunaga	*Miras Found in KWFC Intensive Survey of the Galactic Plane*
09:55 – 10:15	K. T. Wong	*Resolving the Extended Atmosphere and the Inner Wind of Mira (Omicron Ceti) With Long ALMA Baselines*
10:15 – 10:25	Student	*TBD: Poster Award Winner*
10:25 – 10:35	Postdoc	*TBD: Poster Award Winner*
10:35 – 11:00		**Break**
11:00 – 11:35	S. Feltzing	*The Milky Way as a galaxy – impact of large spectroscopic surveys in the era of Gaia*
11:35 – 11:55	L. M. Howes	*The Oldest Stars in the Milky Way*
11:55 – 12:15	J. Patience	*Gemini Planet Imager Exoplanet Survey: Overview and Highlights*
12:15 – 12:35	A. Dieball	*Deep Near-IR Observations of the Globular Cluster M4: The First Brown Dwarf Candidates in a Globular Cluster*
12:35 – 12:45		**Concluding Address**

ABSTRACTS

MONDAY

plenary session

(New) Provocative Ideas in the Physics of Cool Objects

Gilles Chabrier (Centre de Recherche Astrophysique de Lyon)

Abstract
In this (provocative!) review I will discuss a few recent ideas, invoking particular physical mechanisms, which lead to significant revisions of our conventional understanding of low-mass star, brown dwarf and gaseous planet mechanical and thermal properties. If time allows, I will also briefly address issues about these object formation mechanisms. Finally I will mention how on-going and future observational projects will help us constrain the theoretical scenarios

Fundamental Parameters of M Dwarfs in Young Moving Groups

Benjamin Montet (Caltech)

Brendan Bowler (UT Austin), Evgenya Shkolnik (Arizona State), Michael Liu (Hawaii), Adam Kraus (UT Austin), Lynne Hillenbrand (Caltech)

Abstract

Despite their widespread use, evolutionary models of low-mass pre-main sequence (PMS) stars are poorly constrained by observations. Fewer than 20 PMS M dwarfs in binary systems have measured dynamical masses to a precision of 25% or better through astrometric monitoring. The vast majority of these systems are extremely young (<10 Myr). We have identified a new sample of more than 50 stars in binary systems with ages 10-100 Myr where dynamical masses can be measured through high-resolution AO imaging of young moving group members. Through astrometric orbit monitoring with the Differential Speckle Survey Instrument at the Discovery Channel Telescope and Gemini Observatory as well as Keck/NIRC2, combined with radial velocity observations from TRES and CHIRON, we have measured dynamical masses for more than a dozen systems. We then combine relative and absolute broadband photometry with medium-resolution spectroscopy to compare the measured masses and atmospheric parameters to those predicted by stellar evolutionary models. I will present initial results of this survey, which provides the first opportunity to test evolutionary models for many stars with masses between 0.1 and 0.5 solar masses and ages between 10 and 100 Myr.

New Approaches to the Evolution of Young Low Mass Stars and Brown Dwarfs

Consistent Models of Accretion History and Multi-Dimensional Structure of Accreting Young Stars.

Isabelle Baraffe (University of Exeter)

Abstract

I will present new results for pre-Main sequence and early brown dwarf evolutionary models accounting for the effect of early accretion history. First, I will present self-consistent numerical simulations fully coupling numerical hydrodynamics models of collapsing prestellar cores and evolutionary models of the central protostar or proto-brown dwarf. I will in particular analyse the main impact of consistent accretion history on Li depletion. I will also present the first attempt to describe the multi-dimensional structure of accreting young stars based on fully compressible time implicit multi-dimensional hydrodynamics simulations. I will discuss the relevance of assumptions and treatments of accretion used in 1D stellar evolution codes.

The MUSCLES Treasury Survey

X-Ray to IR Spectral Survey of M and K Dwarf Exoplanet Host Stars

Kevin France (University of Colorado)

R. O. Parke Loyd (Colorado), Allison Youngblood (Colorado), Jeffrey Linsky (Colorado), and the MUSCLES Team.

Abstract

High-energy photons (X-ray to NUV; 5 – 3200 Ang) from exoplanet host stars regulate the atmospheric temperature profiles and photochemistry on orbiting planets, influencing the production of potential "biomarker" gases. However, few observational and theoretical constraints exist on the high-energy irradiance from typical (i.e., weakly active) M and K dwarf exoplanet host stars. Towards the development of an empirical database of stellar spectra to support exoplanet atmosphere modeling, we present results from a panchromatic survey (Hubble/Chandra/XMM/optical) of M and K dwarf exoplanet hosts. The MUSCLES Treasury Survey (Measurements of the Ultraviolet Spectral Characteristics of Low-mass Exoplanetary Systems) combines UV and X-ray observations with reconstructed Lyman-alpha and EUV (100-900 Ang) radiation to create 5 Angstrom to 5 micron stellar irradiance spectra. These data are now publically available as a High-Level Science Product on MAST. We find that all low-mass exoplanet host stars exhibit significant chromospheric/transition region/coronal emission – no "UV/X-ray inactive" M or K dwarfs are observed. The F(FUV)/F(NUV) flux ratio, a driver for possible abiotic production of the suggested biomarkers O2 and O3, increases by $\sim$3 orders of magnitude as the star's habitable zone moves inward from 1 to 0.1 AU, while the incident FUV (912 – 1700 Ang) and XUV (5 – 900 Ang) radiation field strengths are approximately constant across this range. Far-UV flare activity is common in 'optically inactive' M dwarfs, and we present tentative evidence for the interaction of massive planets with the upper atmospheres of their cool host stars.

Dynamo Sensitivity in Solar Analogs With 50 Years of Ca II H & K Activity

Ricky Egeland (High Altitude Observatory/National Center for Atmospheric Research, Boulder, USA; Montana State University, Bozeman, USA)

Willie Soon (Harvard-Smithsonian Center for Astrophysics, Cambridge, USA), Sallie Baliunas (Harvard-Smithsonian Center for Astrophysics, Cambridge, USA), Jeffrey C. Hall (Lowell Observatory, Flagstaff, USA), Gregory W. Henry (Center of Excellence in Information Systems, Tennessee State University, Nashville, USA)

Abstract

The Sun has a steady 11-year cycle in magnetic activity most well-known by the rising and falling in the occurrence of dark sunspots on the solar disk in visible bandpasses. The 11-year cycle is also manifest in the variations of emission in the Ca II H & K line cores, due to non-thermal (i.e. magnetic) heating in the lower chromosphere. The large variation in Ca II H & K emission allows for study of the patterns of long-term variability in other stars thanks to synoptic monitoring with the Mount Wilson Observatory HK photometers (1966-2003) and Lowell Observatory Solar-Stellar Spectrograph (1994-present). Overlapping measurements for a set of 27 nearby solar-analog (spectral types G0-G5) stars were used to calibrate the two instruments and construct time series of magnetic activity up to 50 years in length. Precise properties of fundamental importance to the dynamo are available from Hipparcos, the Geneva-Copenhagen Survey, and CHARA interferometry. Using these long time series and measurements of fundamental properties, we do a comparative study of stellar "twins" to explore the sensitivity of the stellar dynamo to small changes to structure, rotation, and composition. We also compare this sample to the Sun and find hints that the regular periodic variability of the solar cycle may be rare among its nearest neighbors in parameter space.

Stellar Granulation and Convective Blueshift

Dependence on Spectral Type and Magnetic Activity

Nadège Meunier (Univ. Grenoble Alpes, IPAG, F-38000 Grenoble, France)

A.-M. Lagrange (IPAG), L. Mbemba Kabuiku (IPAG), M. Alex (IPAG), L. Mignon (IPAG), S. Borgniet (IPAG)

Abstract

In solar type stars, the attenuation of convective blueshift due to magnetic activity dominates the radial velocity variations over small mass planets. Models of stars different from the Sun will request a good knowledge of these properties to be extrapolated. It is therefore crucial to precisely determine not only the amplitude of the convective blueshift for different types of stars, but also the dependence of this convective blueshift on magnetic activity, as they are key factors in models producing the radial velocity variations. We study a large sample of G and K stars and focus on their temporally averaged properties, i.e. the activity level and a criterion allowing to characterize the amplitude of the convective blueshift using the variation of the velocity versus the intensity at the bottom of spectral lines. We find this criteria to depend on spectral type, on wavelength (this dependence is correlated with the temperature and the activity level as well) and on the activity level. We find that the convective blueshift decreases when the effective temperature decreses, in good agreement with models. The relative dependence of the convective blueshift on activity (with respect to the average convective blueshift for a given stellar type) seems to be constant over the considered range of spectral types. We finally compare the observed RV variation amplitudes with those derived from our convective blueshift estimations using a simple law and find a general agreement on the amplitude and trend, and show that inclination plays a major role.

Constraints on the Fundamental Properties of Substellar and Planetary Mass Objects

Jacqueline Faherty (Carnegie Institution of Washington)

Abstract

Measuring fundamental properties of substellar and planetary mass objects is at the heart of much of "Cool Star" research. Measurements of effective temperature, gravity, mass, radius, and metallicity hold the key to our understanding of substellar objects, including their formation, atmospheres and evolution. Parallax measurements along with broad band photometry and spectral coverage from the optical through the mid infrared have led to breakthroughs in our understanding of atmospheric physics of brown dwarfs and directly imaged exoplanets. The small subpopulations of age-calibrated sources such as low gravity moving group members as well as subdwarfs (the extremes) provide critical benchmarks, allowing us to decouple the effects of age, metallicity, and gravity on the population as a whole. The substellar population spans hot, young M dwarfs to extremely cold and low-mass Y dwarfs allowing us to study an extreme range of temperatures. In this review talk, I will present our current understanding of the fundamental properties of substellar and planetary mass objects. I will show trends in luminosity, absolute magnitude, and temperature that are correlated with age, mass, and atmosphere properties. While many of the measurements made rely partially on models to fill in missing information, I will also comment on consistency and discrepancies between observations and current model predictions.

Testing Substellar Models With High-Precision Parallaxes

Trent Dupuy (UT Austin) [for Michael Liu]

Michael Liu (University of Hawaii), Katelyn Allers (Bucknell)

Abstract

Our understanding of brown dwarfs and directly imaged exoplanets relies on theoretical models of their evolution and emergent spectra. Hence testing such models is paramount. Such tests are substantially more powerful when the distances are directly known for the objects, but the necessary parallaxes have been lacking for key portions of parameter space due to the distance and faintness of relevant targets. We present here parallaxes for 65 young (∼10-100 Myr) brown dwarfs and planetary-mass objects from the Hawaii Infrared Parallax Program, about a factor of 5 increase over previous studies and with substantially higher precision. Combined with results for older field objects, we construct an empirical map of the influence of temperature and gravity on ultracool objects from ∼100 Mjup to ∼5 Mjup. Comparison with state-of-the-art theoretical reveals that the models are generally too blue and/or faint compared to the data. We demonstrate that the effect of reduced gravity (i.e. lower mass) can be distinctly charted on infrared color-magnitude diagrams and show that the gravity dependence of the L/T transition differs from the current predictions. Finally, we find that the low-gravity sequence and the locus of directly imaged substellar companions largely coincide but not entirely, raising the question of whether the two populations span a common range of physical properties.

MONDAY

Surface Magnetism of Cool Stars

Methods of Direct Studies of Stellar Surface Magnetic Fields

Klaus Strassmeier (AIP)

T. A. Carroll

Abstract

How to measure stellar magnetic field? Its strength and orientation in full 3D or just a disk-averaged flux density? We will summarize the most commonly applied techniques (and assumptions) and glimpse into some other novel methods not yet fully appreciated in our community. We also relate to the latest and future instruments available for above basic question.

Challenges of Cool Star ZDI

Self-Consistency and Four Stokes Parameters

Lisa Rosén (Uppsala University)

Oleg Kochukhov (Uppsala University)

Abstract

Magnetic fields strongly influence stellar and planetary evolution. It is therefore important to reconstruct the magnetic fields as accurately as possible. Conventional cool star ZDI studies are made using only circular polarization, (Stokes V), since that is usually the only type of polarization possible to detect in cool stars. However, numerical ZDI studies have shown that using only Stokes V is not optimal. If a cool spot coincides with a magnetic feature, the intensity of the polarization spectra is lowered. By not including Stokes I, possible temperature inhomogeneities are ignored and the low amplitude of the polarization profiles can be misinterpreted as a weak magnetic field. The same set of Stokes V profiles can correspond to different magnetic field configurations since Stokes V is not sensitive to the azimuth angle of the magnetic field. We therefore performed an observational study where we successfully identified the first cool star target suitable for four Stokes parameter ZDI. We have developed a new ZDI methodology in order to correctly model LSD Stokes QU profiles. The reconstructed surface temperature and magnetic field maps show that stronger and more complex magnetic features appear when Stokes QU are taken into account compared to using only Stokes IV. It is also shown that the same set of Stokes IV profiles can be fitted equally well to very different magnetic field configurations, and that Stokes V does not seem sensitive to complex field structures.

Magnetic Cycles of Solar-Type Stars

Sandra Jeffers (Goettingen University)

S. Boro Saikia (Goettingen University), S.C. Marsden (University of Southern Queensland), P.Petit (IRAP, Toulouse University), Julien Morin (University of Montpellier), A.A. Vidotto (Trinity College Dublin)

Abstract

The BCool project is an international collaboration studying the magnetic activity of low-mass stars of main-sequence stars, where we use spectropolarimetric observations to directly characterise the large-scale magnetic fields of cool stars using Zeeman-Doppler imaging. From our long-term monitoring of the large-scale magnetic field over nearly 10 years, we are starting to see cyclic behaviour in several targets. In this presentation I will show our results and highlight a few cases we find surprising cyclic behaviour compared to the Sun.

Imaging Stellar Surfaces With Near-Infrared Interferometry

Comparison to Doppler Imaging Results

Heidi Korhonen (DARK, Niels Bohr Institute, University of Copenhagen, Denmark)

Rachael M. Roettenbacher (Department of Astronomy, University of Michigan, USA), John D. Monnier (Department of Astronomy, University of Michigan, USA)

Abstract

Stars appear as point sources in our telescopes and studying their surface features is very demanding. Last couple of decades we have been able to use Doppler imaging technique for indirectly resolving different temperatures and abundances on stellar surfaces. The results have shown us that cool spots on active stars are large, long lived features that usually occur at high latitudes. During the last years a breakthrough using long baseline infrared interferometers has occurred. Images with milli-arcsecond resolution can now be produced, and also cool temperature spots on active giants can be imaged. Here we present the latest high resolution interferometric images obtained of active giants using the MIRC instrument at CHARA Array, compare these images to the results from Doppler imaging, and discuss the obtained starspot hemispheres and latitudes.

Magnetic Fields of Young Cool Stars

Colin Folsom (IRAP)

Abstract

Young solar-type stars evolve dramatically across the pre-main sequence and through the early main sequence, displaying large structural changes, the halting of accretion, and large changes in their rotation rates. This evolution has important consequences for the dynamos operating in these stars, impacting the magnetic fields displayed at their surface. In turn, magnetic fields play a key role in the rotational evolution and accretion in these stars. Observing campaigns have studied the large scale magnetic fields of a significant number of stars throughout this evolutionary time span. These include classical T Tauri stars from MaPP, weak-line T Tauri stars from MaTYSSE, zero-age main sequence stars from Toupies, and older field stars from BCool. The targets observed span not just a range of ages, but also ranges of rotation rates and masses. While many of these studies are not yet complete, there is a clear trend towards decreasing average large-scale magnetic field strength with age, and a tight correlation between large-scale magnetic field strength and Rossby number. Comparing the magnetic properties of these samples, it appears that the magnetic evolution of solar-type stars during the pre-main sequence is primarily driven by structural changes, while it closely follows the stars' rotational evolution on the main sequence.

Magnetic Fields of Weak-Line T Tauri Stars

Belinda Nicholson (European Southern Observatory)

Gaitee Hussain (European Southern Observatory), Jean-Francois Donati (Université de Toulouse)

Abstract

The magnetic field behaviour of weak-line T Tauri stars (wTTSs) is poorly understood. Magnetic fields are known to play an important role in all stages of pre-main sequence stellar evolution, particularly in the accreting, classical T Tauri star (cTTS) phase, where it appears to control the dissipation of angular momentum and the funnelling of matter onto the stellar surface. Studies of the magnetic field topologies of cTTSs show a wide variety in their complexities and strengths; correlating strongly with the internal structure. However, relatively few studies have been done on the magnetic fields of wTTSs, and therefore to evaluate the effect that the presence, or lack thereof, of accretion has on stellar magnetic fields. We present here the preliminary results of the brightness and magnetic field mapping of two wTTSs, TWA 9A and V1095 Sco; stars with similar masses and spectral types, but differing ages and rotation periods. Both have been observed with HARPS-Pol spectropolarimeter on the ESO 3.6m telescope as part of the MaTYSSE project, which aims to characterise the magnetic field behaviour of wTTSs.

Magnetic Fields of Low-Mass Stars

Julien Morin (Univ. Montpellier)

Abstract

Magnetic fields, their generation by dynamo effect and the activity phenomena they induce are central to the physics of cool stars and their planetary systems throughout their evolution. Among cool stars, the least massive ones largely dominate the stellar population in the solar neighborhood, with most planets in the Milky Way likely orbiting a M dwarf. In this review I will briefly remind the main theoretical puzzles we want to address by studying the magnetic fields of low-mass stars, such as probing the dynamo response to the partly- to fully-convective and the star-brown dwarf transitions. After a summary of photospheric magnetic field measurements collected mostly during the past 10 years, the connection with magnetic field measurements of other stars (in particular young stars) and with activity measurements performed across the electromagnetic spectrum will be discussed. Finally, I will present how future instruments operating in the near infrared will contribute to the next advances in the field.

Beyond the Saturation

Detecting the Strongest Magnetic Fields in M Dwarf Stars.

Denis Shulyak (Goettingen University)

Alexander Engeln (Goettingen University), Ansgar Reiners (Goettingen University)

Abstract

Low mass stars generate activity via convective dynamos. This activity, viewed in terms of X-ray fluxes, increases with stellar rotation but saturates at rotation periods shorter than a few days. Dynamo models predict that maximum magnetic flux a star can generate scales with convective energy stored in its envelope. Available measurements indicate that fields stronger than about 4 kG were never detected even in fastest rotating stars. This was viewed as an evidence for the magnetic field saturation. We analyzed data available from ESPaDOnS/NARVAL (CFHT, Hawaii) and recently commissioned CARMENES (Calar Alto, Spain) instruments to measure magnetic fields in most active M dwarfs. We show for the time an evidence of a 7 kG average magnetic field in the star WX UMa. Our finding raises a number of fundamental questions about magnetism in these cool stars.

Tomographic Imaging

The Sun as a Test Case

Rim Fares (INAF-OACT)

Andrew Cameron (University of St Andrews), Joe Llama (University of St Andrews), Moira Jardine (University of St Andrews)

Abstract

Zeeman-Doppler Imaging continues to provide a wealth of information on stellar large-scale magnetic surface flux distribution. This technique suffers, however, from intrinsic limitations, e.g. the small-scale fields are not resolved, the strong fields in dark spots are suppressed by their low surface brightness, and the signatures of small-scale features can cancel out in some field geometries. We use the Sun to test the consequences these limitations have on our ability to reliably reconstruct large-scale magnetic maps. Using magnetograms, Dopplergrams and continuum images from the HMI instrument aboard the Solar Dynamics Observatory (SDO), we calculate Stokes I and V profiles for the Sun as a star. We then use these calculated profiles as input data for our ZDI code, to reconstruct a large-scale magnetic map. These maps are then benchmarked against the observed solar maps to assess the effect missing small-scale fields has on the map reconstruction. I will discuss the technique we adapted and the results we obtained.

Solar and Stellar Spectropolarimetry

A Comparison

Arturo Lopez Ariste (IRAP)

Abstract

The history of exchanges between solar and stellar spectropolarimetry has been long and fruitful. This is particularly true for the study of stellar surface magnetism. The initial difficulties of stellar spectropolarimetry advised to start with the simplest of models: Zeeman effect in circular polarisation and the weak field approximation. As we advance in our understanding of these techniques, more and more tools from solar spectropolarimetry can be adapted to stellar conditions. I will review how stellar spectropolarimetry is getting rid of the weak field approximation, how it can add Zeeman linear polarimetry to its diagnostic toolbox, how linear polarisation of non-magnetic origin can be used to image stellar surfaces or how profile asymmetries can be used to get information of radial variations of the magnetic field.

MONDAY

Star Clusters from Space, from the Ground, and Over Time

The Potential of Gaia

Jos de Bruijne (ESA)

Abstract
Gaia is on track for a first data release in late summer 2016. This presentation outlines the status of the mission and presents an overview of the data products to be released with a particular emphasis on open clusters.

Short Timescale Variables in Stellar Clusters

From Gaia to Ground-Based Telescopes

Maroussia Roelens (University of Geneva)

Abstract
Combined studies of variable stars and stellar clusters open great horizons, and they allow us to improve our understanding of stellar cluster formation and stellar evolution. In that prospect, the Gaia mission will provide astrometric, photometric and spectro-photometric data for about one billion stars of the Milky Way. This will represent a major census of stellar clusters, and it will drastically increase the number of known variable stars. The Gaia peculiar scanning law particularly offers the opportunity to investigate the rather unexplored domain of short timescale variability (from tens of seconds to a dozen of hours), bringing invaluable clues to the fields of stellar physics and stellar aggregates. We assess the Gaia capabilities in terms of short timescale variability detection, using extensive light curve simulations for various variable types. We show that Gaia can detect periodic and transient variability phenomena with amplitude variations larger than a few millimagnitudes. Additionally, we plan to perform subsequent follow-up of variables stars detected in clusters by Gaia to better characterize them. Hence, we develop a pipeline for the analysis of high cadence photometry from ground-based telescopes such as the 1.2 m Euler telescope (La Silla, Chile) and the 1.2 m Mercator telescope (La Palma, Canary Islands).

Cool Young Stars in the Time Domain

The View With K2

Ann Marie Cody (NASA Ames Research Center)

Abstract
In operation since 2014, the K2 mission is now acquiring high cadence, high precision, long time baseline on thousands of stars in the ecliptic plane. Unlike its predecessor the Kepler mission, K2 is observing a number of young to intermediate age star clusters. This provides the chance to not only look for relatively young planets, but to also study starspot evolution, accretion, and inner circumstellar disk dynamics on several month timescales. I will provide an overview of our K2 cluster photometry pipeline and highlight the variable processes evident in the first few campaigns, focusing on the pre-main-sequence stars observed in Upper Scorpius and rho Ophiuchus during Campaign 2.

The Gaia-Eso Survey

Exploring the Galactic Metallicity Gradient Using Star Forming Regions and Young Open Clusters

Lorenzo Spina (Universidade de São Paulo)

Abstract

Star Forming Regions and Young Open Clusters are the latest products of the Milky Way, therefore the study of their metal content can provide strong observational constraints on the Galactic chemical evolution. In addition, these young associations of stars have not had time to disperse through the Galactic disk, thus they are key objects in order to trace the present chemical pattern of the Galactic disk. The Gaia-ESO Survey is providing a large data set of precise and homogeneous chemical abundances of stellar clusters located at different Galactic radii. In my presentation I will provide a summary of the current status of the abundance determinations for the Star Forming Regions and Young Open Clusters observed by the Survey, that shades new light on the current metallicity gradient of the interstellar medium within the thin disk.

Stellar Angular Momentum Over Time

Sean Matt (University of Exeter)

Abstract

While on the main sequence, the structure and energy budget of cool stars change relatively little. By contrast, their angular momentum content varies by orders of magnitude, and observational studies of clusters are revealing a strong and clear mass-dependence to this spin-evolution. At the same time, we are still working to understand the complex relationships between rotation, convection, magnetic activity, and mass loss. I will discuss an emerging self-consistent picture that links all of these processes together and to the overall evolution of Sun-like and low-mass stars. This progress is due to large and diverse new datasets (especially from clusters), advances in physical models for the loss of angular momentum, and the incorporation of these models into long-term stellar evolution calculations.

Testing the Rotation-Activity Relation With the Hyades and Praesepe

Stephanie Douglas (Columbia University)

Abstract
As the nearest open cluster to the Sun, the Hyades is an important benchmark for calibrating stellar properties such as rotation and magnetic activity. Its proximity, however, means that cluster members are scattered across a wide area of the sky; previous studies of rotation in the Hyades relied on wide-area surveys designed to discover transiting exoplanets. I will present rotation periods measured using K2 data of the Hyades, including the first rotation periods of less than 1 day for cluster members and for fully convective Hyads. Discrepancies between Hyades data and gyrochronology models imply that we still do not fully understand how magnetic fields affect stellar spin-down. I will discuss how we can use the Hyades and the co-eval Praesepe cluster to test theories of stellar magnetic fields.

Rotation Periods in the Pleiades With K2

Luisa Rebull (IPAC / Caltech)

Abstract
The rotation rates of Pleiades members have been studied for years, and, because of its age of $\sim$125 Myr, is one of the clusters anchoring many of the models for rotation evolution. With the K2 data, we can probe the rotation rate of more members, to smaller amplitudes, and with a far better cadence, than has even been probed before. What the K2 data allow that no previous dataset has allowed is to measure not only rotation periods but also to measure the shape of the light curve and to often detect evidence of multiple periods due to differential rotation, spot evolution or binarity. The general relationship between P and V-K (as a proxy for mass) follows the overall trends found in other Pleiades studies. There is a slowly rotating sequence for 1 < V-K < 3.5 (spectral types F, G and K); most of these stars show evidence for differential rotation and/or spot evolution. Most of the stars with V-K > 5 (spectral type > M3.5) are rapidly rotating; in general, these stars show little evidence for differential rotation or spot evolution. There is a "transition region" (3.5 < V-K < 5; spectral types M0 to M3) in which there seems to be a disorganized relationship between P and V-K; in many of these cases, one can see slow changes in the light curve shape over the K2 campaign.

Ruprecht 147 and the Quest to Date Middle-Aged Stars

Jason Curtis (Pennsylvania State University)

Abstract

Ages of stars are difficult to infer because stars change very little during the majority of their lifetimes. However, stars are observed to spin down over time due to magnetic braking, which weakens the magnetic dynamo as well. This spin down has led to a new age dating method called gyrochronology, which has been successfully calibrated for Sun-like stars up to 2.5 Gyr, but is still undetermined at older ages and lower masses. The decay of magnetic activity has also been utilized to empirically calibrate an age relationship at ages less than 600 Myr with nearby young star clusters (e.g., Hyades), and pinned down at 4 Gyr with M67, but the relationship is basically unconstrained at intermediate ages and sub-Solar masses. Advances in observational facilities have brought distant clusters into view, while the discovery of Ruprecht 147 has provided a new benchmark that is the oldest nearby cluster (3 Gyr, 300 pc, Curtis et al. 2013), and which provides a bridge across this historic age gap. I will present new, high quality chromospheric activity data for NGC 752 at 1.5 Gyr and Ruprecht 147 at 3 Gyr. The stars of Ruprecht 147 will demonstrate the typical activity level and variability experienced by the Sun at a time when multicellular life first evolved on Earth. I will also re-evaluate the M67 data by considering contamination by the interstellar medium, with implications for the frequency of Maunder Minima. Finally, I will discuss a new opportunity to investigate stellar spin down and variability in GKM dwarfs with the K2 Survey of Ruprecht 147, and will present preliminary results of our transit and rotation programs, along with chromospheric and coronal activity diagnostics for the cluster's Solar analogs.

The Pre-Gaia Search for Young Objects in the Solar Neighborhood

Lison Malo (Canada-France-Hawaii Telescope)

Abstract

Using the BANYAN I and BANYAN II tools, we identified more than 500 candidate members in nearby young kinematic groups. As part of the follow-up programs, we measured radial velocity and confirmed signs of youth (Halpha, X-ray emission, low surface gravity, lithium) for more than 150 red objects using optical and near-infrared spectroscopy. An accurate determination of the age of those objects requires a comparison of their fundamental properties to those of evolutionary models, which take into account the impact of their fully convective interior. As young low-mass objects display strong magnetic activity, the inclusion of magnetic fields in evolutionary models is a key step towards the accurate determination of their fundamental properties. We present the isochronal age determination using the Dartmouth magnetic evolutionary models and ESPaDOnS (soon SPIRou) instrument, and show that including magnetic fields generally increases the isochronal age, which better agree with the lithium depletion boundary method.

The Gaia-Eso Survey

Addressing Extinction and Reddening Towards NGC 6530

Loredana Prisinzano (INAF - Osservatorio Astronomico di Palermo)

Abstract

Accurate knowledge of the amount of interstellar extinction and its properties is crucial to determine fundamental stellar parameters, such as luminosities, masses and ages. This can be challenging in case of young clusters surrounded by or embedded in the original molecular gas. NGC 6530 is a rich young star forming region located towards a concentration of the native molecular gas. As a consequence, it is affected by a significant and variable reddening, as it has been reported in the literature, even with several hints of an anomalous reddening law. Several and also different literature results have been found about the reddening properties in this region. The Gaia-ESO survey data of NGC 6530 gives us a unique opportunity to address this issue. By using Gaia-ESO fundamental parameters and literature optical photometry, we derive the reddening law across the NGC 6530 field. We find that both extinction and reddening show a spatial pattern that is consistent with the density map of the Lagoon Nebula, allowing us to trace its tridimensional structure. Our results are crucial for deriving other stellar properties and then understanding the star formation history of this cluster.

MONDAY

The Brown Dwarf to Exoplanet Connection

On Finding Isolated Planetary Mass Objects and Brown Dwarfs

Jonathan Gagné (Carnegie DTM)

Abstract
I will present the motivations and current efforts to identify and characterize planetary-mass objects that are isolated in space. Such objects, which masses span the deuterium burning limit, can inform us on the physical properties, evolution and atmospheres of giant, gaseous exoplanets detected by direct imaging. The absence of a bright host star makes it much easier to study these isolated objects with high-resolution spectroscopy.

I will then briefly present an update on the current status of the BANYAN All-Sky-Ultracool (BASS-Ultracool) survey, which aims at discovering young and planetary-mass T dwarfs in the solar neighborhood. Only a few objects of this kind are currently known, and they have the potential to inform us on the physical processes that drive the L/T transition through a population study of L/T transition objects at different ages.

A Nearby Brown-Dwarf Triple System With a Planetary Mass Companion

Jordan Stone (U of Arizona)

Abstract
Recently, Gauza et al. reported the discovery of a companion to the late M-dwarf, VHS J125601.92−125723.9 (VHS 1256−1257). The companion's absolute photometry suggests its mass and atmosphere are similar to the HR 8799 planets. However, as a wide companion to a late-type star, it is more accessible to spectroscopic characterization. We discovered that the primary of this system is an equal-magnitude binary. For an age $\sim$ 300 Myr the A and B components each have a mass of $64.6^{+0.8}_{-2.0}$ M_{Jup}, and the b component has a mass of $11.2^{+9.7}_{-1.8}$, making VHS 1256−1257 only the third brown dwarf triple system. There exists some tension between the spectrophotometric distance of 17.2 ± 2.6 pc and the parallax distance of 12.7 ± 1.0 pc. At 12.7 pc VHS 1256−1257 A and B would be the faintest known M7.5 objects, and are even faint outliers among M8 types. If the larger spectrophotmetric distance is more accurate than the parallax, then the mass of each component increases. In particular, the mass of the b component increases well above the deuterium burning limit to ~ 35 M_{Jup} and the mass of each binary component increases to 73^{+20}_{-17} M_{Jup}. At 17.1 pc, the UVW kinematics of the system are consistent with membership in the AB Dor moving group. The architecture of the system resembles a hierarchical stellar multiple suggesting it formed via an extension of the star formation process to low masses. Continued astrometric monitoring will resolve this distance uncertainty and will provide dynamical masses for a new benchmark system.

Inferring Formation History From Atmospheric Characterization of the First T Dwarf Exoplanet, GJ 504b

Caroline Morley (UC Santa Cruz)

Abstract
GJ 504 b, a $\sim$500 K directly-imaged planet orbiting a nearby G-star, has near-infrared colors that are discrepant with the field brown dwarf sequence. A detailed comparison model shows that the planet atmosphere is higher metallicity than its host star. Since planet formation can create objects with non-stellar metallicity, while binary star formation cannot, this result suggests that GJ 504 b formed like a planet, not like a binary companion.

Characterization the Lowest Mass Directly Imaged Planet 51 Eri B

Abhijith Rajan (Arizona State)

Abstract
The Gemini Planet Imager Exoplanet Survey last year discovered the lowest mass imaged planet. 51 Eridani b is a 2 Jupiter mass planet orbiting a 20 Myr F0V star at 13 au. In this talk we present the follow-up spectrophotometric characterization combining GPIES spectra with mid-infrared photometry. As part of the characterization campaign we have observed the planet in the crucial K-band combined with improved L and M-band data to help constrain the fundamental physical parameters of the planet. In the discovery paper, the best fitting models used a combination of clear and cloudy models with an effective temperature of 700 K. In this analysis we are using both forward modeling retrievals to retrieve the T-P profile and derive abundances as well as customized model grids that take into account opacity species expected to condense at these low temperatures, such as Na2S and KCl. In this presentation we will summarize the new data along with new techniques used to better constrain the photometry and the error analysis along with a summary of the modeling approach used to determine the parameters such as the effective temperature, surface gravity, C/O ratio, presence of patchy clouds for this exciting young planetary system.

WISEA J114724.10-204021.3

A Free-Floating Planetary Mass Member of the TW Hya Association

Michael Cushing (U of Toledo)

Abstract
Because young, late-type brown dwarfs display similar spectroscopic properties as young, directly-imaged, giant exoplanets, they provide a unique opportunity to enrich our understanding of substellar evolution away from the glare of a host star. WISEA 1147−2040 was discovered as part of a targeted search for young, late-type brown dwarfs, and further investigation revealed a high probability of belonging to the young (∼10 Myr) TW Hya Association. We confirmed the young age of WISEA 1147−2040 through the examination of low-gravity spectral features in the near-infrared and determined a spectral type of ∼L7. Membership in the TW Hya Association implies a very low mass for WISEA 1147−2040 (5-10 Mjup), making it one of the youngest and lowest-mass free-floating objects yet found in the Solar neighborhood. As such, WISEA 1147−2040 provides an exceptional laboratory for exploring the chemistry and cloud structure in young, planetary mass objects.

Discovery of Young L Dwarfs in Taurus and Scorpius-Centaurus

William Best (U of Hawaii)

Abstract
Brown dwarfs younger than $\sim$ 10 Myr are valuable laboratories for empirically testing both the youngest substellar evolutionary models and the lowest-gravity atmospheric models. Young brown dwarfs with masses less than $\sim 15\ M_{\rm Jup}$ also serve as vital templates for understanding directly imaged exoplanets. We have discovered two free-floating L dwarfs with estimated masses $\sim 6\ M_{\rm Jup}$ in the $\sim 1 - 2$ Myr old Taurus star-forming region, including the coolest substellar member of Taurus found to date, using the Pan-STARRS and WISE surveys. These planetary-mass L dwarfs are among the lowest mass free-floating objects ever discovered. We have also discovered six brown dwarfs with masses $\sim 15 - 36\ M_{\rm Jup}$ in outlying regions of the $\sim 10 - 20$ Myr old Scorpius-Centaurus OB association. These discoveries provide strong evidence that isolated planetary-mass objects can form as part of normal star-formation processes, and empirical data to constrain our understanding of the early evolution of very low-mass brown dwarfs and giant planets. Finally, we have used multi-epoch Pan-STARRS data to measure the first large sets of proper motions for the lowest-mass stars, brown dwarfs, and planetary-mass objects in Taurus and Upper Scorpius.

Characterizing Young Brown Dwarfs Atmospheres With Polarization Data

Elena Manjavacas (Instituto de Astrofisica de Canarias)

Abstract
Polarization of brown dwarfs has been linked to the scattering by dust grains known to cover their atmospheres, but it is not known if it is the consequence of rotationally induced flattening or large scale cloud patterns. Models predict a higher linear polarization for young brown dwarfs, but this polarization has not been systematically investigated yet. We used CAFOS in the 2.2 m telescope of CAHA (Spain), to measure polarization together with variability, to disentangle effects of flattening from asymmetric dust distribution. Our observations archived accuracies of 0.04% in linear polarization. Through multiwavelength observations we have set constrains on the dust grains characteristics.

Cloud-Driven Variability on Young Brown Dwarfs and Giant Exoplanets

Beth Biller (Royal Observatory Edinburgh)

Abstract
Quasi-periodic variability has now been robustly observed in a range of L and T type field brown dwarfs, primarily at near-IR and mid-IR wavelengths, and for the first time ever in planetary mass objects both as companions and free-floating (Biller et al. 2015, Zhou et al. 2016). The probable cause of this variability is surface inhomogeneities in the clouds of these objects, causing a semi-periodic variability signal when combined with the rotational modulation of the 3 − 12 hour period expected for these objects. Variability at similar or even higher amplitudes may be expected for young brown dwarfs and giant exoplanets, which share similar T_{eff} as field brown dwarfs, but have considerably lower surface gravities. Variability studies of these objects relative to old field objects is then a direct probe of the effects of surface gravity on atmospheric structure. I will discuss ongoing efforts to characterise variability from these young objects, both for free-floating objects and companions to stars.

Cloudless Atmospheres for L/T Dwarfs and Extrasolar Giant Planets

Pascal Tremblin (CEA Saclay)

Abstract
The admitted, conventional scenario to explain the complex spectral evolution of brown dwarfs (BDs) since their first detection 20 years ago has always been the key role played by micron-size condensates, called "dust" or "clouds," in their atmosphere. This scenario, however, faces major problems, in particular the J-band brightening and the resurgence of FeH absorption at the L to T transition, and a physical first-principle understanding of this transition is lacking. We propose a new, completely different explanation for BD and extrasolar giant planet (EGP) spectral evolution, without the need to invoke clouds. We show that, due to the slowness of the CO/ CH4 and N2/NH3 chemical reactions, brown dwarf (L and T, respectively) and EGP atmospheres are subject to a thermo-chemical instability similar in nature to the fingering or chemical convective instability present in Earth oceans and at the Earth core/mantle boundary. The induced small-scale turbulent energy transport reduces the temperature gradient in the atmosphere, explaining the observed increase in near-infrared $J - H$ and $J - K$ colors of L dwarfs and hot EGPs, while a warming up of the deep atmosphere along the L to T transition, as the CO/CH4 instability vanishes, naturally solves the two aforementioned puzzles, and provides a physical explanation of the L to T transition. This new picture leads to a drastic revision of our understanding of BD and EGP atmospheres and their evolution.

Atmospheric Retrievals in the Cloudy Regime of Free-Floating Planetary Mass Objects and Directly Imaged Exoplanets

Ben Burningham (NASA AMES)

Abstract
Spectral retrieval of atmospheric parameters such as temperature profiles and gas mixing ratios provides an superb opportunity to test and improve grid based forward models in a way that simple model fitting of substellar spectra cannot offer. Originally developed for analysis of reflection and emission spectra of solar system planets, and adapted for transit spectra of exoplanets, significant progress has recently been made applying these methods to emission spectra of cool brown dwarfs and self-luminous exoplanets. Retrieving atmospheric parameters of directly imaged exoplanets and young isolated planetary mass objects presents a number of challenges, chief of which is the presence of thick clouds. Clouds obscure the deeper atmosphere and create degeneracies between cloud properties and the thermal profile, and also the retrieved abundances of certain key absorbers. In this contribution I will outline the latest results of an effort to construct a framework for coping with these challenges, exploring cases of field L dwarfs and isolated planetary mass objects using both simple grey cloud approximations and more sophisticated retrievals accounting for the Mie scattering properties of expected condensates.

Clues on the Origins of Planetary Mass Companions From ALMA

Jenny Patience (Arizona State)

Abstract
Direct imaging surveys have revealed the existence of a population of planetary mass companions such as 2M1207b and HD 106906b, however the origins of these objects are unknown. Observable properties may determine whether formation occurs in a disk through core accretion or gravitational instability akin to planet formation, or directly from a molecular cloud core similar to binary stars. By observing young systems in star-forming regions at sub-mm wavelengths, it is possible to investigate the disks around young stars and brown dwarfs to gauge their viability for planet formation. With ALMA observations at 890 microns, we observed a sample of 24 Class II M-stars and brown dwarfs with far-IR detections from Herschel. One of the targets is composed of a low mass star and candidate planetary mass companion. By investigating the relative alignment of the newly-detected and spatially resolved gas disks in this pair, we investigate different formation scenarios. For the remaining targets, the amount of mass in the disks available for planet formation is estimated from the flux densities and compared with the masses of known companions such as 2M1207b and the average heavy element mass in Kepler planets.

Observing Planets With JWST/NIRCAM

Chas Beichman (NExSci)

Abstract
With direct imaging, coronagraphy and grism spectroscopy, the NIRCam instrument on JWST will open a dramatic new parameter space of sensitivity, spectral resolution and wavelength coverage for exoplanets. I will describe the NIRCam team's program to characterize the physical properties of exoplanets with coronagraphy, direct spectroscopy, and transit spectroscopy. NIRCam enables searches for Saturn-mass planets in systems known to host Jovian-mass planets as well as for Uranus-mass planets orbiting the nearest, youngest M stars. I will also discuss how this program relates to a second NIRCam program to study brown dwarfs which is being led by Tom Roellig and which will be discussed at Cool Stars.

MONDAY

Mass-Losing AGB Stars and Supergiants

Session 1
From Waves to Winds: Gas Dynamics in Evolved Stars

Chair: Patricia Whitelock

The Coolest (Sur)faces We Have Seen So Far in the Infrared

Claudia Paladini (ULB)

Abstract

In the last decade, we have been able to observe the envelopes of Asymptotic Giant Branch and Red Supergiant stars by several different means. Many aspects of the evolution of these cool objects have seen several breakthroughs, thanks also to the high angular resolution observations able to reach down to the stellar surface. However the spatially resolved observations were for many years only limited to very few points across the stellar discs. Asymmetric structures have been detected, but their interpretation has been difficult and highly non-unique. With the advancement in the instrumentations and with the increasing amount of apertures available, the new generation of interferometers allows today to reconstruct the brightness distribution of the surface of these stars with incredible details. Convective patterns and asymmetric ejections of the size of the astronomical unit can be finally characterised. 3D models are slowly catching up, and are now ready to be challenged by these new observations. In this presentation I will review the results achieved by using high angular resolution techniques in the infrared. I will discuss the recently obtained images of the stellar surface of AGBs and RSGs, and I will conclude highlighting how our field of research will benefit from the advent of the second generation of VLTI instruments. There is enough to keep us busy for the next ten years.

Pulsation Properties of AGB Star 3-D Model Grid

Sofie Liljegren (Uppsala Universitet)

Abstract

3D models of AGB stars have revealed complex structures, with self-excited pulsations. To fully understand the implications of different stellar parameters a grid of models of AGB stars, based on 3D star-in-a-box simulations using CO5BOLD, has been calculated. This grid contains 8 models with effective temperatures ranging from 2500K to 2800K and luminosities from 5000 to 10000 solar luminosities. The mass of all models is kept at one solar mass. With several models of different stellar parameters it is possible to extract pulsation properties, such as period and radius, and investigate the resulting trends. This is used to compare with observations and corresponding properties of 1D models, where good consistency is found. These results indicate that the 3D models give a satisfactory description of the stellar interior, and could be used to investigate the interplay between self-excited pulsation, shocks and dust creation.

VLTI/PIONIER Imaging Observations of the AGB Star R Sculptoris

Markus Wittkowski (ESO Garching, Germany)
C. Paladini (Institut d'Astronomie et d'Astrophysique, Brussels, Belgium), et al.

Abstract
We present near-infrared H band interferometric imaging observations of the carbon AGB star R Scl with the goals of (1) constraining and testing available dynamic atmosphere and wind models by near-infrared interferometry, (2) revealing the detailed morphology of the stellar atmosphere and innermost mass-loss region, and (3) constraining fundamental stellar properties of R Scl, which may further constrain the binary companion model. Our images reveal one dominant surface spot and a spiral-like surface structure, which may be caused by large-scale convection cells and/or localized mass-loss.

Wind Models of M-Type AGB Stars in the LMC

Sara Bladh (University of Padova)

Abstract
Time-dependent wind models have successfully been able to reproduce both dynamical and photometric observations of C-type and M-type AGB stars in the Milky Way (e.g. Eriksson et al. 2014, Bladh et al. 2015). In the dynamical wind models for C-type AGB stars the outflows are predominately driven by photon absorption on amorphous carbon grains and in the models for M-type AGB stars the stellar winds are triggered by photon-scattering on Fe-free silicates. What happens to the wind properties of AGB stars in a low metallicity environment such as the LCM or SMC? C-type AGB stars produce their own carbon during the AGB phase and the mass-loss rates should therefore not be significantly affected by metallicity. The outflows in M-type AGB stars, however, are driven by dust material consisting of elements that cannot be produced by the stars themselves. A low metallicity environment could for that reason have a strong impact on the mass loss of these stars. In order to investigate the properties of M-type AGB stars in a low metallicity environment we here report the first tentative results from a set of wind models for M-type AGB stars with metallicity similar to that of the LMC. The grid is set-up much like the previous grid of wind models with solar metallicity (Bladh et al. 2015). The dynamical properties of this set verify the assumption that a low metallicity environment affects the mass loss of M-type AGB stars: the models produce stellar winds only for very luminous AGB stars, the resulting wind velocities are very low and the mass-loss rates span a narrow range. Current measurements of the mass-loss rates of M-type AGB stars in LMC, although uncertain, indicate lower mass-loss rates and higher wind velocities (Gullieuszik et al. 2012).

Session 2
From Waves to Winds: Gas Dynamics in Evolved Stars

Chair: Albert Zijlstra

AGB and RSG Stars

From the Radio to the Sub-mm

Elizabeth M. L. Humphreys (ESO Garching)

Abstract

Radio and submillimetre interferometry has enabled the study of Asymptotic Giant Branch (AGB) and Red Supergiant (RSG) stars from the stellar photosphere to the outer wind, at up to sub-milliarcsecond resolution. In this talk, I will focus on VLBI and ALMA observations of the gas dynamics of the stellar extended atmospheres / inner circumstellar envelopes (CSEs), where shocks are believed to play an important role in levitating gas to larger radii, enabling dust formation. I will also show submm continuum and maser observations that provide indications of asymmetry, clumpiness and inhomogeneity in the inner CSE, with mass loss occurring in localised directions. Finally, I will discuss evidence for dynamically important magnetic fields permeating the CSE, and the questions that this generates.

Long Baseline Radio Continuum Observations of Betelgeuse

Understanding Mass Loss in Red Supergiants

Eamon O'Gorman (Dublin Institute for Advanced Studies)

Pierre Kervella (Observatoire de Paris; Universidad de Chile), Leen Decin (Leuven), Anita Richards (Manchester), Iain McDonald (Manchester), Andrea Chiavassa (Observatoire de la Côte d'Azur), Xavier Haubois (ESO), Guy Perrin (Observatoire de la Côte d'Azur), Graham Harper (Colorado), Miguel Montarges (IRAM), Keiichi Ohnaka (UCN Chile), Jan Martin Winters (IRAM), Arancha Castro-Carrizo (IRAM)

Abstract

Spatially resolved cm/mm/sub-mm continuum observations can be a powerful means by which to study the partially ionized extended atmospheres around red supergiants as they allow us to probe the essential region where mass loss is initiated. To date, only Betelguese has been spatially resolved at cm and mm wavelengths with the data showing that the atmosphere is highly extended and that the mean gas temperature beyond 2 stellar radii is cool (Tgas < 3000 K). Here, I present the initial results of our ALMA long baseline and e-MERLIN continuum observations of Betelgeuse's extended atmosphere which probe it at unprecedented angular resolution and sensitivity.

Surface Magnetic Field Detection in M-Type Supergiant Stars

The Non Uniqueness of Betelgeuse

Benjamin Tessore (University of Montpellier - LUPM)
E. Josselin, A. Lébre & J. Morin

Abstract

Red supergiant stars (RSG) can be considered as the massive counterparts of AGBs, sharing properties such as extended atmospheres, prodigious mass loss, and a chemically complex circumstellar envelopes. They are also known to present few giant convective cells at the photospheric level. In 2010, a weak magnetic field has been detected at the surface of Betelgeuse. Until recently this was the only M-type supergiant with a direct detection of a surface field. With the spectropolarimeter Narval (TBL Pic du Midi, France) we have initiated in spring 2015 a 2-year campaign dedicated to a sample of cool evolved stars, including several red supergiant stars (RSG). We present detection of surface magnetic field in RSGs obtained from circular polarisation data and multiline analysis technics. Because of their slow rotation (and thus high Rossby number, up to 100!) convection in these stars is not expected to efficiently generate a global magnetic field. Our detections may thus rather point toward local transitory fields, which may play a role in the mass loss mechanism. I will also introduce the diagnosis induced by linear polarisation in these stars, focusing on the Betelgeuse twin Erakis.

The Dynamic Atmospheres of Carbon Rich Giants

Constraining Models via Interferometry

Josef Hron (University of Vienna, Austria)
Gioia Rau (Univ. of Vienna, Austria), Claudia Paladini (Universite' libre de Bruxelles), Bernard Aringer (Astronomical Observatory of Padova - INAF), Kjell Eriksson (Uppsala University), Walter Nowotny (Univ. of Vienna)

Abstract

Dynamic models for the atmospheres of C-rich Asymptotic Giant Branch stars are quite advanced and have been overall successful in reproducing spectroscopic and photometric observations. Interferometry provides independent information and is thus an important technique to study the atmospheric stratification and to further constrain the dynamic models. We observed a sample of six C-rich AGBs with the mid infrared interferometer VLTI/MIDI. These observations, combined with photometric and spectroscopic data from the literature, are compared with synthetic observables derived from dynamic model atmospheres (DMA, Eriksson et al. 2014). The SEDs can be reasonably well modelled and the interferometry supports the extended and multi-component structure of the atmospheres, but some differences remain. We discuss the possible reasons for these differences and we compare the stellar parameters derived from this comparison with stellar evolution models. Finally, we point out the high potential of MATISSE, the second generation VLTI instrument allowing interferometric imaging in the L, M, and N bands, for further progress in this field.

TUESDAY

plenary session

The Current Status and Frontiers of Modeling Substellar Atmospheres

Caroline Morley (UC Santa Cruz)

Abstract

Modeling of substellar atmospheres is crucial for understanding their properties from observations, including determining their temperatures, masses, compositions, and atmospheric circulation. I will review what we (think we) understand about brown dwarf and exoplanet atmospheres from the past two decades of atmosphere studies. Model atmospheres have provided templates at different effective temperatures, gravities, and metallicities to compare to observations, allowing us to connect their spectra to these physical properties. We have learned about mixing in substellar atmospheres by comparing to models that include disequilibrium chemistry. Clouds play a key role in shaping the spectra of brown dwarfs and planets, from refractory iron and silicate clouds in hot objects to volatile clouds in colder objects. l will discuss the current frontiers of substellar atmosphere modeling, including studies of the coldest objects and the youngest objects, studies of variable objects, and the development of data-driven retrieval algorithms. Models for cold objects have been developed, which include the effects of water ice clouds; these models have been compared to spectral observations of the coldest known brown dwarf. The youngest objects include planet-mass brown dwarfs and directly-imaged planets; gravity may strongly effect the chemistry and cloud formation on these objects. Brown dwarfs of all spectral types have now been observed to be variable, and atmospheric circulation models will be important to understand this variability. Lastly, new data-driven modeling techniques have been pioneered in the past three years that allow us to study new properties of atmospheres that grid models cannot probe.

Characterizing Physical Processes in Late T-Dwarfs With Atmospheric Retrieval

Michael Line (NASA-Ames)

Mark Marley (NASA-Ames), Ben Burningham (NASA-Ames), Jonathan Fortney (UC-Santa Cruz)

Abstract

Recent advances in atmospheric retrieval techniques applied to brown dwarf spectra have allowed us to extract detailed information about their thermal structures and molecular abundances beyond the classic "logg-Teff" grid model fits. With these new diagnostic modeling tools we can gain a deeper understanding of the physical and chemical processes operating in substellar atmospheres. In Line et al. (2015) we applied powerful Bayesian atmospheric retrieval tools to the SpeX low-res spectra of two benchmark brown dwarf systems. In that investigation we were able to demonstrate the validity of the approach by obtaining similar metallicities, C-to-O ratios, and ages for the brown dwarf companions to their host stars. Here, we more widely apply this approach to the low-res SpeX spectra of 11 late T-dwarf objects (T7-T8) in order to identify diagnostic trends indicative of particular physical processes. Given the retrieved thermal profiles, we determine which regions of the atmosphere are in or out of radiative equilibrium and where the radiative convective boundary occurs. We also show trends in the retrieved composition with temperature. One exciting find is an increasing trend in the alkali metal abundance with increasing temperature–an additional line of evidence supporting the "rainout" processes predicted to occur in substellar atmospheres. We also show that these late T-dwarfs are definitively cloud free within a simple gray cloud framework. This investigation demonstrates the power of atmospheric retrieval tools applied to quality spectra of small sample of objects and lay's the groundwork for future studies involving brown dwarfs,self-luminous directly imaged planets, and upcoming hi-quality transiting planet data from JWST and beyond.

Implications From Photometric and Spectroscopic Variability Monitoring of Substellar Atmospheres

Stanimir Metchev (University of Western Ontario, Canada)

Daniel Apai (University of Arizona, USA) Jacqueline Radigan (Space Telescope Science Institute, USA) Adam Burgasser (University of California, San Diego)

Abstract

Variations in the brightness of brown dwarfs and extrasolar planets offer a highly effective probe of ultra-cool atmospheres. Phase mapping of rotating objects reveals longitudinal variations, while wavelength-dependent monitoring enables a vertical probe of cloud layers and of temperature-pressure profiles. Such differential approaches are effective because they measure perturbations around an otherwise constant set of conditions, and so carry higher precision in determining atmospheric relations than is attainable by forward or inverse atmospheric modelling efforts. A most dramatic demonstration of the power of brown dwarf variability observations has been the resolved surface flux map of the secondary component in the nearest substellar binary, Luhman 16B. The past four years have seen a resurgence of brown dwarf variability science, often with superior precision using Spitzer and Hubble. Over 80 L, T, and Y dwarfs have now been monitored extensively and precisely, in sequences as long as 20 hours per object, and over time scales spanning minutes to years. With unbiased variability detection rates of approximately 50%, it is now possible to consider the role of surface inhomogeneities—hot spots, clouds, bands, and large-scale storms—in a statistical sample that spans a range of atmospheric conditions. Tantalizing evidence has already emerged for dependencies on effective temperature, surface gravity, rotation period, and viewing geometry. I will present an overview of the results from brown dwarf variability studies, and will highlight the key implications for the astrophysics of substellar atmospheres.

"What's Eating Those Starspots?"

Determining a Relationship Between Starspot Size and Their Decay Timescale With Respect to Stellar Spectral Type

Helen Giles (University of Geneva)
Andrew Cameron (University of St. Andrews)

Abstract

Wide-field surveys such as Kepler have produced reams of data suitable for investigating stellar activity of cooler stars. Starspot activity on these stars produces quasi-sinusoidal light curves whose phase and amplitude vary as active regions grow and decay over time. Here we investigate, firstly, whether there is a correlation between the size of starspots - assumed to be related to the amplitude of the sinusoid - and their decay timescale and, secondly, whether any correlation varies depending on the stellar effective temperature. To determine this, an autocorrelation function (ACF) was produced for samples of stars from Kepler and fitted with an apodised periodic function, using a Monte Carlo Markov Chain (MCMC) to measure the periods and decay timescales of the light curves. The light curve amplitudes, representing spot size were measured from the root-mean-squared scatter of the normalised light curves. Additionally we measured the amplitude of the shorter-timescale "flicker" caused by granular convection. The results show a correlation between the decay time of star spots and their inferred size, and that it heavily depends on the temperature of the star. Cooler stars have spots that last much longer, in particular for stars with longer rotational periods. This is consistent with current theories of diffusive mechanisms causing star spot decay. We also find that the Sun is not unusually quiet for its spectral type - stars with similar rotation periods and temperatures tend to have (comparatively) smaller star spots. I will go through the motivation of the project, the Kepler target selection, the methods used to fit the autocorrelation functions and discuss the key points of interest that emerge from the results.

Gaia Benchmark Stars

Providing a Reference Scale for Spectroscopic Surveys of the Milky Way

Paula Jofré (Institute of Astronomy, Cambridge University)

Abstract

The Gaia benchmark stars are a set of 40 typical Milky Way stars whose stellar parameters are currently used as calibrator pillars for the automatic characterisation of large spectroscopic surveys such as Gaia-ESO. Since these stars are very different from each other, this small sample is ideal for performing highly detailed analyses for a large variety of type of stars, allowing us to learn about deep aspects of spectroscopy beyond the Sun. In this talk, I will present current activities related to the analysis of Benchmark stars, and discuss the applications of our work in the context of future large spectroscopic surveys such as 4MOST and weave.

[C/N] Ratios in Red Giants as a Function of Mass and Metallicity

Comparison With Theory

Marc Pinsonneault [for Jennifer Johnson] (Ohio State University)
APOKASC team

Abstract

Recent work has shown a strong correlation between the [C/N] ratios measured by the the APOGEE survey and the masses, metallicities, and evolutionary states of red giant and red clump stars. The existence of these correlations is predicted by theory, but the absolute values of [C/N] as a function of mass, metallicity, and position on the giant branch are sensitive to numerous systematic effects, both observational and theoretical. We will present a comparison between the measured [C/N] ratios and theoretical predictions for the APOKASC sample, where the masses, compositions, and evolutionary states of the stars are known as a result of a joint analysis of seismic and spectroscopic data. Discrepancies between the predicted and observed values point to incorrect physics in terms of diffusion and mixing in stellar models and to incorrect absolute abundances in C and N for stellar abundance measurements. Improvements in both areas is critical in this age of precision stellar astrophysics.

Trends With Condensation Temperature and Terrestrial Planet Formation

The Case of Zeta Reticuli

Vardan Adibekyan (Institute of Astrophysics and Space Sciences - IA)

E. Delgado-Mena (IA-Portugal), P. Figueira (IA-Portugal), S. G. Sousa (IA-Portugal), N. C. Santos (IA-Portugal), J. P. Faria (IA-Portugal), J. I. Gonzalez Hernandez (IAC-Spain), G. Israelian (IAC-Spain), G. Harutyunyan (AIP-Germany), L. Suarez-Andres (IAC-Spain), A. A. Hakobyan (BAO-Armenia)

Abstract

During the last decade astronomers have been trying to search for chemical signatures of terrestrial planet formation in the atmospheres of the hosting stars. Several studies suggested that the chemical abundance trend with the condensation temperature, Tc, is a signature of rocky planet formation. In particular, it was suggested that the Sun shows 'peculiar' chemical abundances due to the presence of the terrestrial planets in our solar-system. However, the rocky material accretion or the trap of rocky materials in terrestrial planets is not the only explanation for the chemical 'peculiarity' of the Sun, or other Sun-like stars with planets. In this talk I will make a very brief review of this topic, and present our last results for the particular case of Zeta Reticuli binary system: A very interesting and well-known system (known in science fiction and ufology as the world of Grey Aliens, or Reticulans) where one of the components hosts an exo-Kuiper belt, and the other component is a 'single', 'lonely' star.

How Much Can We Trust High-Resolution Spectroscopic Stellar Atmospheric Parameters and Abundances?

Sergi Blanco-Cuaresma (Université de Genève)

Thomas Nordlander (Department of Physics and Astronomy; Uppsala), Ulrike Heiter (Department of Physics and Astronomy; Uppsala), Paula Jofré (Institute of Astronomy; University of Cambridge), Thomas Masseron (Institute of Astronomy; University of Cambridge), Laia Casamiquela (Universitat de Barcelona), Hugo M. Tabernero (Universidad Complutense de Madrid), Shruthi Bhat (Christ University; India), Andy Casey (Institute of Astronomy; University of Cambridge), Jorge Meléndez (Universidade de São Paulo), Ivan Ramírez (McDonald Observatory and Department of Astronomy; University of Texas at Austin)

Abstract

The determination of atmospheric parameters and chemical abundances depends on the use of radiative transfer codes to compute synthetic spectra and/or derive abundances from equivalent widths (SPECTRUM, Gray & Corbally 1994; WIDTH, Kurucz 1993 & Sbordone et al. 2004; SME, Valenti & Piskunov 1996; Turbospectrum, Alvarez et al. 1998 & Plez 2012; MOOG, Sneden et al. 2012). However, to extract scientific conclusions about stellar aggregates or the Galaxy (for instance), it is common to mix results from different surveys/studies where different setups were used to derive parameters and abundances. These inhomogeneities can lead us to inaccurate conclusions. We studied one aspect of the problem: What differences originate from the use of different radiative transfer codes? Using exactly the same spectroscopic pipeline (based on iSpec, Blanco-Cuaresma et al. 2014), we executed a homogeneous analysis (based on iSpec, Blanco-Cuaresma et al. 2014) of the Gaia FGK Benchmark Stars and studied the level of agreement between the most popular radiative transfer codes.

TUESDAY

Variability of Solar/Stellar Magnetic Activity

Session 1
Solar/Stellar Variability: Observational Properties and Theory

Chairs: S. Criscuoli, D. Fabbian

Photometric Variability in the Sun and Sun-Like Stars

Mark Giampapa (National Solar Observatory)

Abstract

The rich array of solar magnetic field-related phenomena we see occurs not only on stellar counterparts of our Sun but in stars that represent significant departures in their fundamental parameters from those of the Sun. Though these phenomena appear energetically negligible when compared to the total luminosity of stars, they nevertheless govern the angular momentum evolution and modulate the radiative and particle output of the Sun and late-type stars. The term "The Solar-Stellar Connection" has been coined to describe the solar-stellar synergisms in the investigation of the generation, emergence and coupling of magnetic fields with the outer solar-stellar atmosphere to produce what we broadly refer to as magnetic activity. With the discovery of literally thousands of planets beyond our solar system, the Solar-Stellar-Planet Connection is quickly emerging as a new area of investigation of the impacts of magnetic activity on exoplanet atmospheres. In parallel with this rapid evolution in our perspectives is the advent of transformative facilities for the study of the Sun and the dynamic Universe. The primary focus of this invited talk will be on photometric variations in solar-type stars and the Sun. These brightness variations are associated with thermal homogeneities typically defined by magnetic structures that are also spatially coincident with key radiative proxies. Photometric variability in solar-type stars and the Sun includes transient brightening, rotational modulation by cool spots and cycle-related variability, each with a characteristic signature in time and wavelength. The emphasis of this presentation will be on the relationship between broadband photometric variations and magnetic field-related activity in solar-type stars and the Sun. Facets of this topic will be discussed both retrospectively and prospectively as we enter a revolutionary, new era for astronomy.

Probing Stellar Magnetism With Space Photometry of Solar-Like Stars and Solar Analogs

Rafael A. Garcia (Laboratoire AIM, CEA/DRF-CNRS, Université Paris 7 Diderot, IRFU/SAp, Centre de Saclay, 91191 Gif-sur-Yvette, France)

D. Salabert (Laboratoire AIM Paris-Saclay, CEA/DRF-CNRS-Universite Paris Diderot, IRFU/SAp, Centre de Saclay, 91191 Gif-sur-Yvette cedex, France), J. Ballot (Universite de Toulouse, UPS-OMP, IRAP, 31400 Toulouse, France), P.G. Beck (Laboratoire AIM Paris-Saclay, CEA/DRF-CNRS-Universite Paris Diderot, IRFU/SAp, Centre de Saclay, 91191 Gif-sur-Yvette cedex, France), L. Bigot (Laboratoire Lagrange, UMR7293, Université de la Côte d'Azur, CNRS, Observatoire de la Côte d'Azur, Nice, France), E. Corsaro (Laboratoire AIM Paris-Saclay, CEA/DRF-CNRS-Universite Paris Diderot, IRFU/SAp, Centre de Saclay, 91191 Gif-sur-Yvette cedex, France), O. Creevey (Laboratoire Lagrange, UMR7293, Université de la Côte d'Azur, CNRS, Observatoire de la Côte d'Azur, Nice, France), R. Egeland (High Altitude Observatory, National Center for Atmospheric Research, PO Box 3000, Boulder, CO 80307-3000, USA), A. Jimenez (Instituto de Astrofisica de Canarias, 38205, La Laguna, Tenerife, Spain), S. Mathur (Space Science Institute, 4750 Walnut street Suite #205, Boulder, CO 80301, USA), T. Metcalfe (Space Science Institute, 4750 Walnut street Suite #205, Boulder, CO 80301, USA), J. do Nascimento (Universidade Federal do Rio Grande do Norte, UFRN, Dep. de Física, DFTE, CP1641, 59072-970, Natal, RN, Brazil), P.L. Palle (Instituto de Astrofisica de Canarias, 38205, La Laguna, Tenerife, Spain), F. Perez-Hernandez (Instituto de Astrofisica de Canarias, 38205, La Laguna, Tenerife, Spain), C. Regulo (Instituto de Astrofisica de Canarias, 38205, La Laguna, Tenerife, Spain)

Abstract

The surface magnetic field has substantial influence on various stellar properties that can be probed through various techniques. With the advent of new space-borne facilities such as CoRoT and Kepler, uninterrupted long high-precision photometry is available for hundred of thousand of stars. This number will substantially grow through the forthcoming TESS and PLATO missions. The unique Kepler observations –covering up to 4 years with a 30-min cadence– allows studying stellar variability with different origins such as pulsations, convection, surface rotation, or magnetism at several time scales from hours to years. We study the photospheric magnetic activity of solar-like stars by means of the variability induced in the observed signal by starspots crossing the visible disk. We constructed a solar photometric magnetic activity proxy, Sph from SPM/VIRGO/SoHO, as if the Sun was a distant star and we compare it with several solar well-known magnetic proxies. The results validate this approach. Thus, we compute the Sph proxy for a set of CoRoT and Kepler solar-like stars for which pulsations were already detected. After characterizing the rotation and the magnetic properties of $\sim$300 solar-like stars, we use their seismic properties to characterize 18 solar analogs for which we study their magnetism. This allows us to put the Sun into context of its siblings.

Measurements of Absolute Calcium II H & K in FGKM Stars

Christopher Marvin (University of Goettingen)

A. Reiners(University of Goettingen), G. Anglada-Escudé (Queen Mary University of London), S. Boro Saikia (University of Goettingen), S. Jeffers (University of Goettingen)

Abstract

M dwarfs are the most numerous stars in the universe, yet they still lack absolute chromospheric Ca II H and K (R'_{HK}) calibrations to effectively compare their activity with FGK stars. We scale high-S/N, high-resolution template spectra, obtained by co-adding multiple HARPS spectra of the same star, to PHOENIX stellar atmosphere models, and obtain chromospheric line measurements of Ca II H & K in physical units of 106 M dwarfs. We also derive new Mt. Wilson S-index to R'_{HK} conversions appropriate for cooler stars, ranging from $0.82 \leq (B-V) \leq 2.00$. We establish a chromospheric activity database by combining archival data of FGK stars and using our technique to extend absolute chromospheric measurements to M dwarfs. Our results show that using model atmospheres provide a reliable way to scale uncalibrated spectra and also estimate photospheric flux for M dwarfs, but note that accurate stellar parameter determination is essential to compare chromospheric emission of different spectral types.

Radial-Velocity Variability of the Sun as a Star With HARPS and HARPS-N

Raphaëlle Haywood (Harvard Observatory)

the HARPS-N science team

Abstract

Since we can resolve the surface of the Sun directly, we can explore the origin of radial-velocity variations induced by individual solar surface features such as faculae/plage, sunspots and granulation. I will present my recent investigation of the radial-velocity variations of the Sun as a star, based on high-resolution HARPS spectra of reflected sunlight and simultaneous images from the Solar Dynamics Observatory. We found that faculae are the dominant source of activity-induced radial-velocity variations, via suppression of convective blueshift. We investigated possible proxies for activity-induced radial-velocity variations and found that optical lightcurves can only provide a partial representation of these signals; the full-disc magnetic flux, however, is an excellent tracer. In addition to this dataset, the HARPS-N spectrograph has been operating with a new solar telescope feed since 2015 July. I will present results from the first year observations, which show radial-velocity variations of up to 7-8 m/s. Identifying proxies for solar radial-velocity variations is key to understanding the radial-velocity variability of other Sun-like stars, and is also essential for other investigations such as exoplanet detection surveys.

Photospheric Acne at the Bottom of the Main-Sequence

Doppler Images of M4.5 - M9V Stars

John Robert Barnes (Open University)

Haswell C. A. (Open University - UK), Jenkins J. S. (Departamento de Astronomía - Chile), Jeffers S. V. (Georg-August-Universität - Germany), Jones H. R. A. (University of Hertfordshire - UK), Lohr M. E. (Open University - UK), Pavlenko Ya. V. (Main Astronomical Observatory of the National Academy of Sciences of Ukraine - Ukraine)

Abstract

Starspots are an important manifestation of stellar activity and yet their distribution patterns on the lowest mass stars is not well known. Time series spectra of fully convective M dwarfs taken in the red-optical with UVES reveal numerous line profile distortions which are interpreted as starspots. We derive Doppler images for four M4.5V - M9V stars and find that contrast ratios corresponding to photosphere-spot temperature differences of only 200-300 K are sufficient to model the timeseries spectra. Although more starspot structure is found at high latitudes, spots are reconstructed at a range of phases and latitudes with mean spot filling factors of only a few per cent. The occurrence of low-contrast spots at predominantly high latitudes is in general likely to be responsible for the low amplitude photometric variability seen in late-M dwarfs. The recovered starspot patterns are used to assess their effect on precision radial velocity surveys aimed at detecting planets around this population of stars.

Session 2

Stellar Magnetism and its Impact on the Surrounding Environment

Chairs: A. Vidotto, H. Korhonen

Magnetic Fields on Solar-Type Stars

The Solar-Stellar Connection

Stephen Marsden (University of Sothern Queensland)

Abstract

Our understanding of solar magnetic fields is significantly more detailed than we can achieve for other stars. However, over the last few decades, techniques such as Zeeman Doppler Imaging (ZDI), have delivered major advances in the study of stellar magnetic fields, to the point where we can now map the global surface magnetic topology of other stars and use these to model the coronal magnetic fields and even the stellar wind produced by the star. These advances now allow us to compare the Sun with other solar-type stars and make increasingly detailed comparisons of the behaviour and generation of their dynamo magnetic fields. In this review I will give an overview of what ZDI has taught us about the magnetic fields of other stars and how our study of the Sun can inform our understanding of the dynamos operating across a range of solar-type stars.

The Effects of Stellar Activity on Detecting and Characterising Planets

Suzanne Aigrain (University of Oxford)

Abstract

Intrinsic stellar variability associated with magnetic activity, rotation and convection, affects the detection of exoplanets via the transit and radial velocity methods, and the characterisation of their atmospheres. I will review the increasingly sophisticated methods developed in the last few years to mitigate this problem, and outline how stellar variability is likely to impact the field of exoplanets in the future. Planetary transits last a few hours, much shorter than the rotational modulation of star spots (day to weeks), but smaller-scale variability is nonetheless an important limiting factor in our ability to detect transits of Earth analogs in Kepler and Plato data. In radial velocity, the problem is even more severe, as the planet's signal occurs on the orbital timescale, which can coincide with the range expected for stellar rotation periods or activity cycles - but the spectra used to extract radial velocities contain a wealth of information about stellar activity that can be used to disentangle the two types of signals. Finally, when using transits or phase curves to probe the composition and dynamics of planetary atmospheres, star spots must be accounted for very carefully, as they can mimic or mask planetary atmosphere signals. On the positive side, the sensitivity of planet search and characterisation experiments to stellar activity means that they are a treasure trove of information about stellar activity. The continued success of exoplanet surveys depends on our making the best possible use of this information.

The Impact of Stellar Activity on High Energy Exoplanet Transits

Joe Llama (University of St Andrews)
Evgenya Shkolnik (ASU), Moira Jardine (St Andrews)

Abstract
High energy (X-ray / UV) observations of transiting exoplanets have revealed the presence of extended atmospheres around a number of systems. At these energies, stellar radiation is absorbed in the upper atmosphere of the planet, making X-ray / UV transits an exciting tool for investigating the composition of exoplanetary atmospheres. However, the effects of stellar activity on transits at these wavelengths is far from understood. In X-rays the stellar disk appears limb-brightened, and active regions appear as extended bright features that evolve on a much shorter timescale than in the optical. This makes measuring the true planet-to-star radius ratio challenging. The Sun offers a unique opportunity to study the impact of stellar activity on high energy transits. Using disk resolved soft X-ray and UV images from NASA's Solar Dynamics Observatory taken over the last solar cycle I will show how both occulted and unocculted active regions can mimic an inflated planetary atmosphere by changing the depth and shape of a transit profile. I will also show how the disk integrated Lyman-α Solar irradiance varies on both short and long timescales and how this variability can also impact our ability to recover the true radius ratio of a transiting exoplanet. Finally, I will present techniques to overcome these challenges in high-energy transits.

Simulating the Environment Around Planet-Hosting Stars

Julián David Alvarado-Gómez (European Southern Observatory)
Gaitee Hussain (European Southern Observatory), Ofer Cohen (Harvard-Smithsonian Center for Astrophysics), Jeremy J. Drake (Harvard-Smithsonian Center for Astrophysics), Cecilia Garraffo (Harvard-Smithsonian Center for Astrophysics), Jason Grunhut (European Southern Observatory), Tamas I. Gombosi (Center for Space Environment Modeling, University of Michigan)

Abstract
Recent developments in instrumentation and observational techniques have opened a new window for stellar magnetic field studies. In particular Zeeman Doppler Imaging (ZDI) is now routinely used to recover the large-scale magnetic field topologies of stars different from the Sun, including several planet-hosting stars. These stellar magnetic fields intimately affect the environment around late-type stars by driving the coronal high-energy radiation (EUV/X-rays), transient events (e.g. flares and coronal mass ejections), and the development of stellar winds and astrospheres. These elements can have a strong impact in the evolution of planetary systems via star-planet interactions and erosion of exoplanetary atmospheres. In this context, the results from ZDI data-driven, detailed 3D MHD modeling of the coronal conditions and circumstellar environment around three planet hosting stars are presented. For one of the considered systems (HD 1237), we investigate the interactions of the magnetized stellar wind with the exoplanet, assuming a Jupiter-like magnetosphere around it.

Predicting the Wind Speeds of Solar-Like Stars

Moira Jardine (University of St Andrews)

Victor See (University of St Andrews), Aline Vidotto (Trinity College, Dublin)

Abstract

Some aspects of stellar magnetic activity such as X-ray emission are relatively easy to observe, while others, such as the geometry of the magnetic field are rather more difficult. Indeed, typically only the large-scale (or low-order) components of the field can be mapped. Most elusive of all is the hot, tenuous stellar wind, yet the wind speed is a crucial quantity governing the angular momentum loss of the star. We demonstrate, however, that wind speeds can be predicted reliably even from fairly low-resolution magnetograms. We use an empirically-derived model of the solar wind that predicts the distribution of wind speeds based on surface magnetograms. Using solar magnetic field measurements spanning several magnetic cycles, we demonstrate how changes in the surface magnetic field on various lengthscales affect the coronal structure and hence the wind speed. We find that only low-order field components are needed to characterise the wind speed. We compare the variations in wind speed with variations in the X-ray emission over several cycles and show that while the small-scale field has a significant effect Lx, it has little effect on the wind speed. This suggests that the large number of stellar magnetograms that are becoming available can be used to predict the stellar wind speeds.

TUESDAY

Star Clusters from Space, from the Ground, and Over Time

Clusters as Benchmarks for Measuring Fundamental Stellar Properties

Cameron Bell (ETH Zürich)

Abstract

Star clusters have long represented benchmarks with respect to the determination of fundamental stellar parameters, in large part due to the underlying assumption that members within such ensembles share several common properties; namely they are coeval, have the same chemical composition and are located at roughly the same distance. By studying a given cluster we can infer the mass dependence of astrophysical phenomena at a given epoch and by studying several clusters spanning a range of ages we can track how such phenomena evolve with time, as well as investigate second-order effects such as the local environment. In this review I will focus on young star clusters (those with ages less than or approximately equal to that of the Pleiades) and discuss several methods employed to estimate fundamental stellar parameters. Specifically, I will focus on the use of stellar evolutionary models to determine the ages and masses of stars and discuss the limitations of such models, the use of eclipsing binaries in helping to constrain evolutionary models, and the use of large-scale spectroscopic surveys (e.g., Gaia-ESO and APOGEE) in calculating atmospheric parameters such as effective temperature, surface gravity and chemical composition. Finally, I will attempt to bring together recent studies to highlight the potential for sub-grouping and age spreads within a given cluster, thereby demonstrating that our traditional view of young star clusters is perhaps too simplistic.

The Mass-Radius Relation of Young Stars

Adam Kraus (University of Texas, Austin)

Abstract

Evolutionary models of pre-main sequence stars remain largely uncalibrated, especially for masses below that of the Sun, and dynamical masses and radii pose valuable tests of these theoretical models. Stellar mass dependent features of star formation (such as disk evolution, planet formation, and even the IMF) are fundamentally tied to these models, which implies a systematic uncertainty that can only be improved with precise measurements of calibrator stars. I will describe the discovery and characterization of 15 eclipsing binary systems in the Upper Scorpius star-forming region from K2 Campaign 2 data, spanning from B stars to the substellar boundary. We have obtained complementary RV curves, spectral classifications, and high-resolution imaging for these targets; the combination of these data yield high-precision masses and radii for the binary components, and hence a dense sampling of the (nominally coeval) mass-radius relation of 10 Myr old stars. We already reported initial results from this program for the young M4.5 eclipsing binary UScoCTIO 5 (Kraus et al. 2015), demonstrating that theoretically predicted masses are discrepant by $\sim$50% for this pair of low-mass stars. Precise radii allow us to isolate the source of the discrepancy: models of young stars do not predict luminosities that are too low, as is commonly thought, but rather temperatures that are too warm.

Open Cluster Lithium as a Strong Test of Core-Envelope Re-Coupling Timescales

Garrett Somers (Ohio State University)

Abstract

Rotational mixing is a prime candidate for explaining the gradual depletion of light elements from the photospheres of cool stars during the main sequence. However, previous mixing calculations have relied primarily on incomplete treatments of angular momentum (AM) transport in stellar interiors, which do not predict the rotational evolution of open clusters. In order to produce new mixing calculations, we modify our rotating stellar evolution code to include an additional source of AM transport, a necessary ingredient for explaining the open cluster rotation pattern. With this machinery, we show for the first time that the main sequence evolution of surface rotation in open clusters and the evolving abundance of lithium in cool stars can be simultaneously predicted. Our mixing-derived core-envelope coupling strengths agree well with previous work, confirming the reliability of our mixing calculations. Using Li abundances, we argue that the timescale for core-envelope re-coupling during the main sequence is a strong function of mass, thus placing an important constraint on models seeking to identify the mechanism responsible for core-envelope coupling. We discuss implications of this finding for stellar physics, including the viability of gravity waves and magnetic fields as agents of AM transport.

Toward the Absolute Age of M92

Jieun Choi (Harvard University)

Abstract

Globular clusters provide a fundamental link between stars and galaxies. For example, it has been suggested that ultra faint dwarf galaxies formed all of their stars prior to the epoch of reionization, but this conclusion hinges entirely on the striking similarity of their stellar populations to the ancient, metal-poor globular cluster M92. The accurate measurement of absolute ages of ancient globular clusters therefore has direct implications for the formation histories of the smallest galaxies in the Universe. However, a reliable determination of the absolute ages of globular clusters has proven to be a challenge due to uncertainties in stellar physics and complications in how the models are compared to observations. I will present preliminary results from a comprehensive study to measure the absolute age of M92 using high-quality HST archival imaging data. We pair our new MESA Isochrones and Stellar Tracks (MIST) models with a full CMD fitting framework to jointly fit multi-color CMDs, taking into account the uncertainties in abundances, distance, and stellar physics. The goal of this project is two-fold. First, we aim to provide the most secure absolute age of M92 to date with robustly estimated uncertainties. Second, we explore and quantify the degeneracies between uncertain physical quantities and model variables, such as the distance, mixing-length-alpha parameter, and helium abundance, with the ultimate goal of better constraining these unknowns with data from ongoing and future instruments and surveys such as K2, Gaia, TESS, JWST, and WFIRST.

The Diagnostic Potential of Spatial and Kinematic Tracers

Richard Parker (Liverpool John Moores University)

Abstract
The advent of facilities such as ALMA, Gaia, and ground-based surveys such as GES and IN-SYNC will soon result in a deluge of information on the spatial and kinematic distributions of stars in both young and old star clusters. These distributions can be used to determine the dynamical history of a star cluster and hence they place strong constraints on the initial conditions of star formation in a given cluster. I will review the diagnostics available to attack this problem, starting from the spatial information and progressing to the kinematic information. I will conclude by highlighting some outstanding issues that we must address in the immediate future.

The IN-SYNC Orion Survey

Nicola Da Rio (University of Florida)

Abstract
I will present the results of the SDSS IN-SYNC Orion survey, a high resolution infrared spectroscopy of the young stellar population in the Orion A cloud. We obtained accurate stellar parameters and radial velocities for $\sim$3000 objects in the region, down to the H-burning limit, from the dense Orion Nebula Cluster - the prototypical nearby region of active massive star formation - to the low-density environments of the L1641 region. From a number of independent indicators, we confirm a substantial age spread throughout the region, which on the other hand shares a common mean age. Based on kinematic arguments, we suggest that the older population of young sources in south of the ONC is not separate population. Using kinematics, stellar parameters, and surface gravity constraints, we identify few hundreds of new candidate young members, most of which are diskless sources in poorly studied areas of the cloud. We find evidence for kinematic subclustering along the star forming filament, where the stellar component remains kinematically associated to the gas; in the ONC we find that the stellar population is supervirial and currently expanding. These results are in agreement with structural analyses of the spatial distribution of sources in the ONC, which I will also outline.

Structure and Dynamics of Young Star Clusters With the Gaia-Eso Survey

Rob Jeffries (Keele University)

Abstract
The physical mechanisms driving the formation of star clusters and their early dynamical evolution are not yet fully understood. Recent theoretical and numerical studies show that unbiased analysis of the structural and kinematical properties of young (1-10 Myr) star clusters are required to constrain different models. The Gaia-ESO Survey is measuring precise radial velocities ($\sim$0.2-0.3 km/s), stellar parameters (e.g., effective temperatures and gravities) and other age indicators (e.g., Li abundance) for unbiased samples of the stellar population of several young star clusters. I will present some of the first results from the survey, which show that we are able to resolve the internal kinematics of the clusters and put in evidence how dynamical properties of nearby young star clusters are more complex than previously thought.

Substructure in the Scorpius-Centaurus OB Association

Mark Pecaut (Rockhurst University)

Abstract
OB associations are remnants of star formation on a large scale, producing everything from O- and B-type stars, down to the lowest mass brown dwarfs. OB associations represent the typical mode of star formation in the Galaxy. But is this process monolithic? We present the results of a survey for new, solar mass (0.7 - 1.3 Msun) members of Sco-Cen, the nearest OB Association to the Sun ($\sim$100-200 pc, 10-20 Myr; de Zeeuw et al. 1999, Mamajek et al. 2002, Pecaut et al. 2012). We identify $\sim$150 new members and place the known B/A/F/G/K/M-type members on the Hertzsprung-Russell diagram. From these data, we construct an age map of Sco-Cen, occupying approximately 2,000 square degrees on the sky. These results indicate there is substantial substructure in Sco-Cen, and present the possibility that star formation on the largest scales can be considered a collection of many individual, small-scale star formation events along a giant molecular cloud.

Exploring Gyrochronology With LSST

Ruth Angus (University of Oxford)

Abstract
The Large Synoptic Survey Telescope (LSST) will provide sparse but precise ground-based photometry for billions of field and cluster cool dwarfs. We explore LSST's potential for large-scale rotation period measurement with an emphasis on applications to gyrochronology, the method of inferring stellar ages from rotation periods. With its ten year baseline, LSST light curves will be sensitive to long rotation periods which are characteristic of old and low-mass stars. New asteroseismic data from the Kepler spacecraft have revealed that magnetic braking may cease at around Solar Rossby number, implying that gyrochronology is not applicable to old stars. By measuring rotation periods of old, slowly rotating, low-mass stars we can decisively test the age-rotation relations at all ages. Of particular interest are the open clusters with precisely measured isochronal ages. These clusters will allow us to recalibrate the age-rotation relations in the old, low-mass regime, provided we can measure the photometric rotation periods of their members. Using representative distributions of stellar ages and spectral types from TRILEGAL outputs, we simulate thousands of light curves using a gyrochronology relation, a simple star-spot model and approximate LSST cadence. By running a rotation period recovery pipeline, we predict the number of accurately measured cool dwarf rotation periods expected from LSST as a function of spectral type, magnitude and rotation period.

The TESS Open Cluster Survey

Søren Meibom (Harvard-Smithsonian Center for Astrophysics)

Abstract
NASA's Transiting Exoplanet Survey Satellite (TESS) will launch in 2017. TESS is an all-sky survey over 2 years, covering the Northern and the Southern hemispheres with 2-minute cadence highly precise photometric observations. The TESS Open Cluster Survey (TOCS) is a project to ensure TESS observations of thousands of cool stars in dozens of galactic open clusters with ages from the PMS to billion of years. TOCS will provide a unique opportunity for studies of stellar variability and activity in clusters (e.g., stellar rotation, differential rotation, flares, pulsations and asteroseismology) and will lay the foundation for a statistical study of the frequency and nature of cluster planets. A TOCS working group is being formed to help construct lists of cluster stars to be included in the TESS target list and to lead open cluster research using TESS data. Researchers with a desire and ability to contribute to TOCS can apply to join the TOCS working group. TOCS promises to supply the astrophysical community with data for cool stars in clusters that will lead to exciting advances and new avenues for cool star research. In my talk I will give an overview of TOCS and the primary science goals, lay out the structure of the TOCS working group, and give details on the collaborative effort, and the criteria used, to select clusters and cluster stars for the TESS target list.

TUESDAY

Flares in Time-Domain Surveys

Session 1

Chair: Adam Kowalski

The Kepler Catalog of Stellar Flares

James Davenport (Western Washington University)

Abstract

I will present results from our automated survey of stellar flares using the entire Kepler dataset. This program has produced over 200,000 flare candidates, the largest census of such events to date. Flares in our sample exhibit a wide range of energies and morphologies, including complex multi-peaked events, and possible quasi-periodic oscillations. Matching our flare stars to Kepler rotation periods, we find a decline in the energy emitted in flares as stars spin down. For a subset of Kepler M dwarfs with low resolution follow-up spectra, we also find a correlation between Halpha luminosity and the energy emitted in flares. These two results give the first definitive evidence of flare rates declining over stellar time, indicating flares are intimately connected to the age–rotation–activity evolution of the global stellar dynamo.

Superflares on Solar-Type Stars Found From Kepler Data

Yuta Notsu (Kyoto University)

Abstract

We searched superflares on solar-type stars (G-type main sequence stars) using the Kepler 1-min and 30-min cadence data. Superflares release total energy $10 - 10^4$ times greater than that of the biggest solar flares with energy of $\sim 10^{32}$ erg. We found 187 superflares on 23 stars from 1-min cadence data (Q0-17) and more than 1500 superflares on 279 stars from 30-min cadence data (Q0-6) (Maehara+2012, Nature; Shibayama+2013, ApJS; Maehara+2015, EPS). Using these data, we found that the occurrence frequency (dN/dE) of superflares is expressed as a power-law function of flare energy (E) with the index of -1.5 for $10^{33} < E < 10^{36}$ erg. Most of superflare stars show quasi-periodic light variations with the amplitude of a few percent, which can be explained by the rotation of the star with large starspots (Notsu+2013, ApJ). This assumption is supported by the spectroscopic results with the measurement of vsini and chromospheric activities using Subaru/HDS (Notsu+2015a&b, PASJ). The bolometric energy released by flares is consistent with the magnetic energy stored around such large starspots. Furthermore, our analyses indicate that the occurrence frequency of superflares depends on the rotation period, and that the flare frequency increases as the rotation period decreases. However, the energy of the largest flares observed in a given period bin does not show any clear correlation with the rotation period (Notsu+2013, ApJ).

FUV Emission Line Flares on M and K Dwarfs in the MUSCLES Survey

Parke Loyd (University of Colorado, Boulder)

Abstract
The MUSCLES HST Treasury Survey recently acquired spectrophotometric FUV and X-ray data for 4 K dwarfs and 7 M dwarfs hosting planets. None of these stars are presently labeled flare stars, though ϵ Eri is known to have high chromospheric activity. To characterize the volatility of the stellar high-energy radiation, we searched these data for evidence of flares, focusing on the bright FUV emission lines of C II, Si III, Si IV, and N V that were simultaneously observed for $\sim$4 hours per target with HST COS. The search revealed clear flares on 5/7 of the M dwarfs and 1/4 of the K dwarfs including two strong flares (peak flux >10 quiescent levels) on GJ 876 and one on GJ 832. Tracing the evolution of the three strong flares in C II, Si III, Si IV, and N V emission reveals roughly coincident rises in C II, Si III, and Si IV trailed by a muted response in N V. Taken together, the MUSCLES flares follow a consistent power law relationship in frequency versus absolute radiated energy. This talk will share and explore this new body of spectrally and temporally resolved flare data.

SDO/HMI White-Light Flares and Their Associated Manifestations

Juan Carlos Martinez Oliveros (University of California, Berkeley)

Abstract
The white-light continuum of a solar flare was the first manifestation of a solar flare ever detected. Nevertheless, its mechanisms remain unknown, even today. Improved observations confirm the identification of white-light continuum emission and hard X-rays during the impulsive phase of a solar flare, both in space and in time, to within the observational limits. We describe previous results (Martinez Oliveros 2011) and place them in the context of the three extreme-limb events (within about 1°) reported by Krucker et al. (2015). The electrons responsible for hard X-ray bremsstrahlung coincide with the most intense flare energy release, but we do not presently understand the physics of energy transport nor the nature of particle acceleration apparently taking place at heights below the preflare temperature minimum. Also, we will show at least at two distinct kinds of sources appeared (chromospheric and coronal), in the early and later phases of flare development, in addition to the white-light footpoint sources commonly observed in the lower atmosphere, which might imply the participation of cooler sources that can produce free-bound continua and possibly line emission detectable by HMI.

Quasi-Periodic Pulsations in Stellar Flares

Chloe Pugh (Warwick University)

Abstract
Quasi-periodic pulsations (QPPs) in solar flares have been widely observed, and can be used as a coronal plasma diagnostics tool. More recently, QPPs have been observed in flares of other stars, many of which are thousands of times more powerful than anything observed on the Sun. Stellar flares have been identified in the short-cadence light curves of over 200 Kepler stars, and examined for evidence of QPPs. Those showing evidence of pulsations have been analysed using the autocorrelation and wavelet techniques. QPP-like signatures have been detected in 56 flares, and of these 11 have clear damped oscillations which could be modelled. A statistical analysis suggests that the QPPs found in these stellar flares are consistent with those found in solar flares.

On the Behavior of Light Curves of Solar and Stellar Flares

Petr Heinzel (Academy of Sciences of the Czech Republic)

Abstract
Recently a large effort has been devoted to systematic modeling of solar and stellar chromospheric flares which are typically manifested by bright ribbons embedded in the lower atmospheric layers. However, apart from ribbons detectable in a broad range of the electromagnetic spectrum, overlying flare loops are also frequently observed on the Sun. They appear in various spectral lines and can be well resolved in the so-called eruptive flares. We will show how their appearance depends on the loop plasma conditions and parameters. We will also briefly review the efforts to model the radiation properties of such loops and namely of those which cooled down to chromospheric temperatures. Light curves of the flaring ribbons may differ from time evolution of the loop brightness and this can be easily detected on the Sun. However, on cool flare stars the measured light curves may contain an unresolved information about the temporal evolution of both ribbons and cool loops and we will demonstrate how this can be modeled. Based on that we will discuss the behavior of light curves of solar and stellar flares in various spectral lines of different species.

Session 2

Chair: James Davenport

Finding the Largest Flares on Ultracool Dwarfs With ASAS-SN

Sarah Jane Schmidt (Leibniz-Institut für Astrophysik Potsdam (AIP))

Abstract

Quiescent chromospheric activity, as measured through Halpha emission, is ubiquitous on ultracool (late-M and early-L) dwarfs, but the rate of white-light flares on these objects is still under investigation. Recent work with Kepler and K2 has revealed that flares occur less frequently than on more massive M dwarfs, but the strongest flares are sufficiently rare that they are unlikely to be observed in the 90 day observational windows. The All Sky Automated Search for Supernovae (ASAS-SN) survey scans the entire sky once every two days in V band down to $V > 17$. In addition to discovering hundreds of Supernovae, the ASAS-SN survey has also observed hundreds of stellar flares, including two particularly dramatic flares in the ultracool regime; a deltaV ~ -9 on an M8 dwarf, and a deltaV ~ -10 flare on an L1 dwarf. Both flares radiated over 10^{34} ergs in the V-band, placing them among the strongest observed white-light flares. While flares this strong are expected to occur less than once per year on individual ultracool dwarfs, the all-sky coverage of ASAS-SN presents a unique opportunity to detect strong flares ($\Delta V < -5$) on all ultracool dwarfs within ~ 100 pc. We discuss the two most dramatic ASAS-SN flares and present our initial constraints on the rate of large flares on ultracool dwarfs.

X-Ray Superflares on CC Eri

Subhajeet Karmakar (Aryabhatta Research Institute of Observational Sciences (ARIES))

Abstract

We present an in-depth study of two large stellar flares detected on active binary system CC Eridani by Swift observatory. The first flare (F1) triggered the Burst Alert Telescope (BAT) in the hard X-ray band on 2008 October 16. The rise-phase was only observed only with BAT, whereas the decay-phase was also observed simultaneously with X-Ray Telescope (XRT). The second flare (F2) was observed only in decay phase with both BAT and XRT on 2012 February 24. The e-folding decay time indicates a faster decay in hard X-ray band than in soft X-ray. The peak X-ray luminosity in $0.3 - 50.0$ keV reached up to 3×10^{32} erg/s and 5×10^{31} erg/s, which is ~ 3500 and ~ 600 times more than the quiescent value and larger than any other previously observed flares on CC Eri. Spectral analysis indicates a presence of three temperature corona with first two plasma temperatures remain constant during the flares at ~3 MK and ~10 MK. The flare-temperature peaked at 139 MK and 58 MK for F1 and F2, which is ~4 and ~2 times more than the minimum value. The abundances peaked at 2.0 and 1.2 solar abundances, which is larger than a factor 11 and 7 than quiescent values. Using hydrodynamic modeling we derive loop-lengths for both flares to be $5.6 \pm 0.7 \times 10^{10}$ cm and $5.5 \pm 0.7 \times 10^{10}$ cm, respectively. We model the K-alpha emission feature as fluorescence from the hot flare source irradiating the photospheric iron. Our preliminary estimations indicate the flare location on the stellar surface around an astrocentric angle of 70 degree.

The Frequency of dM-star X-Ray Flares From a Large-Scale XMM-Newton Sample

John Pye (University of Leicester)

Abstract
We present preliminary results from a uniform, large-scale survey of X-ray flare emission from dM stars, and provide estimates of flare occurrence rates. The 3XMM Serendipitous Source Catalogue together with several dM-star catalogues (primarily SDSS and LAMOST) have been used as the basis for this survey of X-ray flares from dM stars. The 3XMM catalogue and its associated data products provide an excellent basis for a ∼decade-long comprehensive and sensitive survey of stellar flares – both from targeted active stars and from those observed serendipitously in the half-degree diameter field-of-view of each observation. The standard 3XMM results and products have been augmented by the output of the EXTraS project (Exploring the X-ray transient and variable sky - http://www.extras-fp7.eu/). We present results from both target and serendipitous observations. The latter provide an unbiased (with respect to stellar activity) study of flare energetics and occurrence rates. We compare the dM-star X-ray flare rates with those for our previously published XMM/Tycho survey (Pye et al, 2015, A&A, 581, A28; which was weighted towards earlier-type, i.e. F – K stars) and published values from optical-band surveys.

F-Chroma Project

Observations and Modelling of Solar Flare Chromospheres

Arkadiusz Berlicki (University of Wroclaw)

Abstract
F-CHROMA is a collaborative project funded under the EU-Framework Programe 7, involving seven different European research Institutes and Universities. The main goal of F-CHROMA is the investigation of the physics of solar flares, with a particular focus on the physical conditions and emission of their chromospheric parts. During the project realization we will perform joint observations and analysis of space-based and ground-based observations of flares. In addition, physical parameters of flaring plasma will be determined using forward and semiempirical NLTE modelling techniques. A crucial component of F-CHROMA will be the dissemination effort to make results of these activities available to and usable by the community, including non-professional astronomers. We already produced a catalogue of ground-based solar flare observations, linked to available space-based counterparts, and make it available to the community. An important task in our dissemination plan is to involve amateur solar observers in our flare observing campaigns. Amateur astronomers can provide the observational data, especially time series of images, which we believe to have scientific values. We hope that this activity might also start a closer cooperation between amateur and professional solar physicists during the project realization and beyond. The first pro-am solar flare "F-HUNTERS" observing campaign was organized on September 19 – 27th, 2015 and there were many amateur astronomers involved in these observations. The second campaign will be organized in July 2016. Here we will present the main output of the F-CHROMA project and some results of the F-HUNTERS campaign.

A Multi-Wavelength View of Magnetic Flaring From PMS Stars

Ettore Flaccomio (INAF - Osservatorio Astronomico di Palermo)

Abstract
I will present results of a study of flaring from the young pre-main-sequence stars in the NGC2264 star forming region. Simultaneous observations with Chandra (X-rays), CoRoT (optical), and Spitzer (mIR) were obtained as part of the "Coordinated Synoptic Investigation of NGC2264" (CSI-NGC2264), providing an unprecedented view of stellar flaring. Tens of observed X-ray flares have counterparts in the optical and/or nIR bands. This allowed us to derive relations between the emitted energies, peak fluxes, and durations in the three bands. The picture that emerges is a complex one. Although flares are more prominent and easily detected in the X-ray band, much of the radiated energy is emitted at optical/UV wavelengths. The inner circumstellar disks, when present, appears to play a significant role in the observed nIR emission.

Recovering Flares in LSST

Suzanne Hawley (University of Washington)

Abstract
We have run some simulations of recovering flares in the sparsely sampled LSST data as part of the recent NOAO/LSST followup capabilities workshop, and will report on the results.

TUESDAY

Mass-Losing AGB Stars and Supergiants

Session 3
The Circumstellar Environment of Cool (Super)Giants

Chair: Susanne Höfner

"The Circumstellar Environment of AGB Stars and Supergiants"

Eric Lagadec (Observatoire de la Cote d'Azur)

Abstract
In the recent years, new high angular resolution instrument such as ALMA, SPHERE/VLT and VLTI/PIONIER started a small revolution in the study of circumstellar environment around evolved stars. We do not talk about sub-arcsecond observations any more but about milliarcsecs. This is revolutionising our view of the close environement of these stars, the way they interact with binary companions and the formation of discs. I will review the results obtained using these observational techniques and present new insights on the mass-loss process from evolved stars of low, intermediate and high masses.

High Spatial Resolution Studies of the Winds of Evolved Stars

Leen Decin (Institute of Astronomy, Leuven University)

Abstract
High spatial resolution observations have provided us with an amazing view on the winds of evolved cool giants and supergiants. The longstanding assumption of smooth spherically symmetric winds seems often not validated. Large scale structures in the form of spirals, circumstellar disks, bipolar outflows, bowshocks etc. are detected and smaller scale clumpiness seems omnipresent. These novel data challenge our understanding of the wind launching process. The observations serve as critical benchmark for 3D hydrodynamical models. Even more, these data push the theoretical models to include a higher form of complexity, in particular to incorporate a (more) consistent approach of chemistry, dynamics, and radiative transfer. In this talk, I will give a review of the recent observational results obtained with ALMA, SPHERE and Herschel. I will show how these data yield detailed information on the wind structure of evolved stars and elucidate which chemical and physical phenomena should be captured in theoretical wind models. I will summarize ongoing efforts to improve these theoretical models, both in terms of numerical modeling and based on novel laboratory experiments. I will show how these theoretical models serve as a guideline to further improve the observing strategies.

Constraining Dust Properties in Circumstellar Envelopes of C-Stars in the Small Magellanic Cloud

Optical Constants and Grain Size of Carbon Dust

Ambra Nanni (Dipartimento di Fisica e Astronomia "G. Galilei", Padova)

Paola Marigo (Dipartimento di Fisica e Astronomia "G. Galilei", Padova), Martin Groenewegen (Royal Observatory of Belgium, Brussel), Bernhard Aringer (Dipartimento di Fisica e Astronomia "G. Galilei", Padova), Léo Girardi (Osservatorio Astronomico di Padova), Giada Pastorelli (Dipartimento di Fisica e Astronomia "G. Galilei", Padova), Alessandro Bressan (SISSA, Trieste), Sara Bladh (Dipartimento di Fisica e Astronomia "G. Galilei", Padova)

Abstract

We present our recent investigation aimed at constraining the typical size and optical properties of carbon dust grains in Circumstellar envelopes (CSEs) of C-stars in the Small Magellanic Cloud. To achieve this goal, we apply our recent dust growth model, coupled with a radiative transfer code, to the CSEs of C-stars evolving along the TP-AGB, for which we compute spectra and colors. We then compare our modeled colors in the NIR and MIR bands with the observed ones, testing different assumptions in our dust model and employing several optical constants data sets for carbon dust available in the literature. Different assumptions adopted in our dust model change the typical size of the carbon grains produced. We finally constrain carbon dust properties by selecting the combination of typical grain size and optical constants which best reproduce several colors in the NIR and MIR at the same time. The approach is new and has never been adopted so far. We conclude that the complete set of selected NIR and MIR colors are best reproduced by small grains, with sizes between 0.06 and 0.1 microns, rather than by large grains of 0.2-0.4 microns. Remarkably, the inability of large grains to reproduce NIR and MIR colors seems independent of the adopted optical data set. We also find a possible trend of the typical grain size with the dust reddening in the CSEs of these stars. We finally emphasize that this work is preparatory to follow-up studies aimed at calibrating the TP-AGB phase through resolved stellar populations in star clusters and galaxies which include dusty, mass-losing evolved stars.

The Dustiest AGB Stars and RSG in the Magellanic Clouds

Olivia Jones (STScI)

Abstract

Using observations from the Herschel Inventory of The Agents of Galaxy Evolution (HERITAGE) survey of the Magellanic Clouds, we have found 32 evolved stars that are bright in the far-infrared. These sources span a wide range in luminosity and hence initial mass. We found 13 low- to intermediate-mass evolved stars, including asymptotic giant branch (AGB) stars, post-AGB stars, planetary nebulae, and a symbiotic star. We also identify 10 high mass stars, including 3 extreme red supergiants that are highly enshrouded by dust and detect 9 probable evolved objects which were previously undescribed in the literature. These sources are likely to be among the dustiest evolved objects in the Magellanic Clouds. The Herschel emission may either be due to dust produced by the evolved star or it may arise from swept-up interstellar medium material.

Session 4
The Circumstellar Environment of Cool (Super)Giants

Chair: Martha Boyer

Modelling the Interactions of Cool Giants With (Sub)stellar Companions

Implications for Mass-Transfer Rates and Outflow Geometries

Shazrene Mohamed (South African Astronomical Observatory)

Abstract

Cool, evolved stars, e.g., asymptotic giant branch stars and red (super)giants, lose copious amounts of mass and momentum through powerful, dense stellar winds. The interaction of these outflows with their surroundings results in highly structured and complex circumstellar environments, often featuring knots, arcs, shells and spirals. Recent improvements in computational power and techniques have led to the development of detailed, multi-dimensional simulations that have given new insight into the origin of these structures, and better understanding of the physical mechanisms driving their formation. In this talk, I review one of the main mechanisms that shapes the outflows of evolved stars: interaction with a companion. I will discuss both wind-wind interactions where the companion also ejects a stellar outflow, and mass-transfer interactions where the companion has a weak or insignicant outflow. I will also highlight the broader implications of these stellar wind interactions for other phenomena, e.g, for planetary nebulae, symbiotic and X-ray binaries, novae and supernovae.

Dust-Production Rates of AGB Stars in the Solar Neighborhood

Alfonso Trejo-Cruz (ASIAA)

Francisca Kemper (ASIAA), Sundar Srinivasan (ASIAA)

Abstract

Asymptotic Giant Branch (AGB) stars are a very important contributor to the total dust mass injected into the ISM in galaxies. Good estimations of the dust mass injection by AGB stars in the Magellanic Clouds have been achieved using Spitzer data (Riebel et al. 2012; Srinivasan et al, 2016). However, the last estimate of the dust injection rate in the Milky Way was done in the late '80s for a non-all sky sample (Jura & Kleinmann 1989). In this work we revisit the total dust mass-loss rate from AGB stars in the Solar neighborhood. It is especially hard to evaluate distances to dusty AGB stars in the Milky Way, as the highest mass-loss rate objects are not in the Hipparcos catalogue, due to circumstellar extinction. Using present-day all-sky infrared facilities (WISE, 2MASS, and others), we have constructed spectral energy distributions for all AGB stars within 1 kpc from the Sun. We use the GRAMS model grid (Sargent, Srinivasan & Meixner 2011; Srinivasan, Sargent & Meixner 2011) to estimate the dust production for this sample of AGB stars. Preliminary results show an increase in the number of known dusty objects within 1 kpc. An integrated dust production rate of $\sim 10^-5$ Msun/year or an average of $\sim 10^-7$ Msun/year per object is obtained. The result for the Solar Neighborhood will be extrapolated for the entire Milky Way, using a suitable stellar distribution function. In addition, we compare our results to those of the Magellanic Clouds and other Local Group galaxies, for which the distance determination problems do not exist. This work is a step towards more reliable determinations of the mass loss of AGB stars, and it aims to provide new insight on the discrepancy between the dust mass produced by AGB stars and that estimated to be present in the ISM.

A First Look at the Circumstellar Dust Composition of O-Type Mira Variables Observed With Spitzer

Tina Güth (New Mexico Institute of Mining and Technology (New Mexico Tech))

M. J. Creech-Eakman (New Mexico Institute of Mining and Technology)

Abstract

Our research concerns the detailed dust composition surrounding Mira variables. These regular pulsators are easily observed in the optical and infrared due to their changes in brightness. Data on 25 Miras were obtained with the Spitzer IRS instrument in 2008-09 under a GO program led by Creech-Eakman. The stars were observed once per month to track changes in their brightness and spectral features. This dataset is unique for both the number of observations of each star and the high SNR due to quick exposure times to avoid saturation of the detectors. The reduced spectra reveal a wonderful "forest" of features that provide insight into the stellar atmospheres and circumstellar dust composition. The sample of stars in this study span the range of oxygen- to carbon-rich, with each type exhibiting certain known solid state components (i.e dust). Preliminary examination of the oxygen-rich Miras shows many of the primary known features, such as broad silicate emission and aluminum oxide (Al2O3). Using the radiative transfer modeling code, DUSTY, we are attempting to identify several broad, and some sharp, dust features by implementing recently derived laboratory spectral indeces for dust opacities. Prominent features seen in oxygen-rich stars include: water ice emission, as well as amorphous and crystalline silicates, and potentially corundum. We will show preliminary results for a sub-sample of the set and discuss plans for publishing the entire sample.

The Optical Interferometry View of Convection in Nearby Red Supergiants

Miguel Montarges (IRAM, Grenoble)

Pierre Kervella (Unidad Mixta Internacional Franco-Chilena de Astronomia, Santigo, Chile), Guy Perrin (LESIA, Meudon, France), Andrea Chiavassa (Lagrange, Nice, France)

Abstract

Red supergiant (RSG) stars are the later stage of evolution of massive stars. The strong increase in size that massive stars experience when they leave the main sequence (at a mostly constant mass) causes their surface gravity to be very weak. This in principle favors the triggering of mass loss from their surface, consistently with their important observed mass loss rate. However, we do not know exactly which are the physical processes that effectively trigger the outflow. Nearby red supergiants are easy targets for optical/infrared interferometers, as they exhibit very large angular diameters. They significantly resolve the features present on their photosphere, in particular convective cells. I will present our recent observational and modeling results on the photosphere of the two nearby RSGs: Betelgeuse and Antares. I will also briefly present our ongoing project aiming at getting a better understanding of the convective activity of RSG.

WEDNESDAY

plenary session

Asteroseismic Windows Into the Hearts of Red Giants

Jim Fuller (California Institute of Technology)

Abstract

Over the last decade, precision space-based photometry has provided high signal-to-noise detections of oscillations in thousands of red giant stars. Combined with asteroseismic modeling and interpretation, this wealth of data has allowed for unprecedented characterization of red giant interiors, whose core properties can now be measured more precisely than the core of our own Sun. I will review recent progress in this field, focusing on four asteroseismic breakthroughs: 1. The ability to determine the evolutionary stage of red giants and to distinguish hydrogen and helium-burning stars. 2. Measurements of the rotation rates of the cores of red giants, which defy nearly all theoretical expectations. 3. The detection of strong magnetic fields in the cores of red giants, providing the first direct measurements of internal stellar magnetic fields. 4. New constraints on mixing in red giant cores, yielding evidence that convective overshoot and/or diffusive mixing processes are more efficient than expected.

Testing Gyrochronology With Kepler

Anomalous Braking in Old Field Stars

Jennifer van Saders (Carnegie Observatories)

Tugdual Ceillier (Laboratoire AIM, CEA/DRF), Travis S. Metcalfe (Space Science Institute), Victor Silva Aguirre(Aarhus University), Marc H. Pinsonneault (Ohio State University), Rafael A. García (Laboratoire AIM, CEA/DRF), Savita Mathur (Space Science Institute), Guy R. Davies (University of Birmingham)

Abstract

Gyrochronology utilizes the spin-down of stars as a function of time to estimate stellar ages. Thanks to Kepler, we now have rotation periods numbering in the tens of thousands, making it a particularly enticing tool to obtain chronological information for studies of the Milky Way and extrasolar planets. However, gyrochronology is in its adolescence: it has been well-tested and validated in young and intermediate age open clusters, but old-star gyrochronology remains largely unexplored due to the technical challenges of obtaining an appropriate calibration sample. We present results on a sample of old, well-characterized asteroseismic target stars from the main Kepler mission to show that standard period-age relations fail in old field stars, and furthermore that they fail under predictable conditions. This unexpected behavior suggests a new class of magnetic braking models, where braking is weaker in stars with Rossby numbers of Ro > 2.0. This discovery both weakens the diagnostic power of gyrochronology in old stars and hints at an interesting transition occurring in our own Sun. We will discuss our progress to date in understanding this braking behavior, and place it in context of larger rotation samples.

Age Dependance of Wind Properties for Solar Type Stars

A 3D Study

Victor Réville (CEA AIM Paris Saclay)

C.P. Folsom (IPAG Grenoble), A. Strugarek (Université de Montréal), A.S Brun (CEA AIM Paris Saclay)

Abstract

Young and rapidly rotating stars are known for intense, dynamo generated magnetic fields. Spectropolarimetric observations of those stars among precisely aged clusters are key tools for gyrochronology and magnetochronology. We use ZDI maps of several young K-type stars of similar mass and radius but with various ages and rotational periods, to perform 3D numerical MHD simulations of their coronae and follow the evolution of their magnetic properties with age. Those simulations yield the coronal structure as well as the instant torque exerted by the rotating wind on the star. Coronal temperatures and density are set thanks to an evolutionary model that yields very different wind speeds. The speed spatial distribution is shaped by the three dimensional structure of the magnetic fields. For some stars of the sample, compression regions appear in the equatorial plane when the fast wind encounters the slow wind, within 30 stellar radii. We also find that the angular momentum loss follows the open flux formulation we derived in our recent work and that it is proportional to Ω^3. The mass loss decreases with age, in agreement with observations of Lyman-alpha absorption at the astropause.

The Missing Morphology Term in Stellar Rotation Evolution

Cecilia Garraffo (Harvard-Smithsonian Center for Astrophysics)

Jeremy J. Drake (Harvard-Smithsonian Center for Astrophysics), Ofer Cohen (Harvard-Smithsonian Center for Astrophysics)

Abstract

Observations of young open clusters have revealed a bimodal distribution of the rotation periods of solar-like stars that has proven difficult to explain under the existing rubric of magnetic braking. Recent studies suggest that magnetic complexity can play an important role in controlling stellar spin-down rates. In this talk I will discuss the missing term representing magnetic morphology in the context of stellar spin-down models. Using state-of-the-art magnetohydrodynamical magnetized wind simulations we have derived analytical expressions representing the magnetic field morphology dependence of mass and angular momentum loss rates. Magnetic field complexity provides a natural physical basis for stellar rotation evolution models requiring a rapid transition between weak and strong spin-down modes.

The Magnetic, Coronal, and Rotational Evolution of Pre-Main-Sequence Stars

Scott Gregory (University of St Andrews)

Abstract

Pre-main-sequence (PMS) stars more massive than about 0.35 solar masses transition from hosting fully convective interiors to configurations with a radiative core and outer convective envelope during their gravitational contraction. Observational evidence has emerged that PMS stars (at least those above $\sim$0.5 solar masses) are born with simple, axisymmetric, magnetic fields, with tilted kilo-Gauss dipole and/or octupole components. As they evolve across the HR diagram, and in particular once they progress onto Henyey tracks, their large-scale magnetic fields become complex, multipolar, and non-axisymmetric, with weak ($\sim$0.1 kG) dipole components. I will demonstrate, by comparing Hayashi to Henyey track PMS stars from a sample of $\sim$1000 in 5 star forming regions, that this observed magnetic topology transition has corresponding signatures at X-ray wavelengths, and in the rotation period distributions of accreting systems. X-ray emission decays faster with age for higher mass PMS stars. The increase in magnetic complexity and the decay of coronal X-ray emission from young early K to late G-type PMS stars, the progenitors of main-sequence A-type stars, is consistent with the dearth of X-ray detections of the latter, as well as the lack of magnetic field detections in most Herbig stars.

Rotation Periods for Fully-Convective M Dwarfs in the Solar Neighborhood

Elisabeth Newton (Harvard University)

Jonathan Irwin (CfA), David Charbonneau (Harvard), Zachory K. Berta-Thompson (MIT), Jason A. Dittmann (Harvard), Andrew A. West (BU)

Abstract

Despite the prevalence of fully-convective stars, very few members of the field population have measured rotation periods. The lack of observational constraints at field ages has hampered studies of rotational evolution. We present rotation periods for 387 nearby mid-to-late M dwarfs in the Northern hemisphere, and new detections for M dwarfs in the Southern hemisphere. These measurements are derived from photometry from the MEarth North and South transit surveys, and include detections from 0.1 to 140 days. The period distribution is mass dependent: as the mass decreases, the slowest rotators at a given mass have longer periods, and the fastest rotators have shorter periods. We find a dearth of stars with intermediate rotation periods, which suggests that fully-convective stars undergo rapid angular momentum evolution. The typical detected rotator has stable, sinusoidal photometric modulations at a semi-amplitude of 0.5 to 1%. We find no correlation between period and amplitude for stars below 0.25Msun, and discuss the rotation-magnetic activity relation. We use Galactic kinematics and established age-velocity relations to estimate the M dwarf spin-down timescale. We find that stars with P<10 days are on average <2 Gyrs, and that those with P>70 days are about 5 Gyrs.

(Re)solving Mysteries of Convection and Mass Loss of AGB Stars

What New Models and Observations Tell Us About Long-Standing Problems

Susanne Höfner (Uppsala University)

Abstract

The recent progress in high spatial resolution techniques, spanning wavelengths from the visual to the radio regime, is leading to valuable insights into the complex dynamical atmospheres of AGB stars and their wind forming regions. Striking examples are detections of asymmetries and inhomogeneities in the photospheric and dust-forming layers which are probably related to large-scale convective flows predicted by 3D "star-in-a-box" models. Furthermore, high-resolution observations allow to measure dust condensation distances and they give information about the chemical composition and sizes of dust grains close to the star. These are essential constraints for understanding wind acceleration and developing a predictive theory of mass loss on the AGB, which is a crucial ingredient of stellar and galactic chemical evolution models.

ALMA Observations of the Not-So Detached Shell Around the Carbon AGB Star R Sculptoris

Matthias Maercker (Chalmers University of Technology)
W. Vlemming (Chalmers University of Technology), H. Olofsson (Chalmers University of Technology)

Abstract
I will present our ALMA observations of the CO emission around the carbon AGB star R Sculptoris. The data reveal the known detached shell and a previously unknown, binary induced, spiral shape. The observations confirm a formation of the shell during a thermal pulse about 2300 years ago. The full analysis of the ALMA data shows that the shell around R Scl in fact is entirely filled with molecular gas, and hence not as detached as previously thought. This has implications for the mass-loss rate evolution immediately after the pulse, indicating a much higher mass-loss rate than previously assumed. Comparing the ALMA images to our optical observations of polarised, dust scattered light, we further show that the distributions of the dust and gas coincide almost perfectly, implying a common evolution of the dust and gas, and constraining the wind-driving mechanism. The mass-loss process and amount of mass lost during the thermal pulse cycle affect the chemical evolution of the star, its lifetime on the AGB, and the return of heavy elements to the ISM. New high-resolution ALMA observations constrain the parameters of the binary system and the inner spiral, and will allow for a detailed hydrodynamical modelling of the gas and dust during and after the last thermal pulse. Our results present the only direct measurements of the thermal pulse evolution currently available. They greatly increase our understanding of this fundamental period of stellar evolution, and the implications it has for the chemical evolution of evolved stars, the ISM, and galaxies.

THURSDAY

plenary session

Advances in Understanding Solar and Stellar Flares

Adam Kowalski (University of Maryland & NASA/GSFC)

Abstract

Flares result from the sudden reconnection and relaxation of magnetic fields in the coronae of stellar atmospheres. The highly dynamic atmospheric response produces radiation across the electromagnetic spectrum, from the radio to X-rays, on a range of timescales, from seconds to days. New high resolution data of solar flares have revealed the intrinsic spatial properties of the flaring chromosphere, which is thought to be where the majority of the flare energy is released as radiation in the optical and near-UV continua and emission lines. New data of stellar flares have revealed the detailed properties of the broadband (white-light) continuum emission, which provides straightforward constraints for models of the transformation of stored magnetic energy in the corona into thermal energy of the lower atmosphere. In this talk, we discuss the physical processes that produce several important spectral phenomena in the near-ultraviolet and optical as revealed from new radiative-hydrodynamic models of flares on the Sun and low mass stars. We present recent progress with high-flux nonthermal electron beams in reproducing the observed optical continuum color temperature of $T \sim 10{,}000$ K and the Balmer jump properties in the near-ultraviolet. These beams produce dense, heated chromospheric condensations, which can explain the shape and strength of the continuum emission in M dwarf flares and the red-wing asymmetries in the chromospheric emission lines in recent observations of solar flares from the Interface Region Imaging Spectrograph. Current theoretical challenges and future modeling directions will be discussed, as well as observational synergies between solar and stellar flares.

Latest Developments in Solar Dynamo

A Key to Stellar Magnetic Activity and Variability

Rosaria Simoniello (Geneva Observatory)

Abstract

The multitude of activity phenomena on the Sun's surface are related to magnetic fields believed to be driven by a dynamo mechanism acting in the tachocline. This global dynamo involves the generation and evolution of the largest features of the sun, such as sunspots, the overall magnetic polarity of the sun, and its short and long-term changes over the solar activity cycle. Recent findings have rapidly changed our picture of the principles driving solar dynamo and at the origin of the observed amplitude fluctuations in cycle strength. Stellar data have achieved a richness comparable to that of solar data thanks to a wealth of spectro-polarimetric information and statistical studies of unprecedentedly huge samples of stars observed by space-borne telescopes (KEPLER, COROT). It is essential, for the understanding of the effect of stellar mass on the resulting magnetic activity, to fully exploit the wealth of these observations. Solar like stars are known to show chromospheric activity similar to that on the Sun in the Ca II H and K emission. However the tachocline moves towards increasing depths with later spectral types, disappearing around M4. What is the role of the tachocline?How does its presence differentiate magnetic activity with respect to fully convective stars?How does stellar internal structure affect the principles driving stellar dynamo? I will review the latest developments in solar dynamo which need to be brought to the knowledge of the stellar community to open a new window on stellar observables holding clues on the above mentioned questions.

Carmencita, the CARMENES Input Catalogue of Bright, Nearby M Dwarfs

Jose A. Caballero (LSW Heidelberg)

M. Cortes-Contreras (UCM), F. J. Alonso-Floriano (UCM), D. Montes (UCM), J. C. Morales (ICE), V. J. S. Bejar (IAC), S. V. Jeffers (IAG), V. M. Passegger (IAG), I. Ribas (ICE), A. Reiners (IAG), A. Quirrenbach (LSW), P. J. Amado (IAA), R. Mundt (MPIA), et al.

Abstract

CARMENES, the brand-new, Spanish-German, two-channel, ultra-stabilised, high-resolution spectrograph at the 3.5 m Calar Alto telescope, started its science survey on 01 Jan 2016. In one shot, it covers from 0.52 to 1.71 μm with resolution R = 94,600 ($\lambda < 0.96$ μm) and 80,400 ($\lambda > 0.96$ μm). During guaranteed time observations, CARMENES carries out the programme for which the instrument was designed: radial-velocity monitoring of bright, nearby, low-mass dwarfs with spectral types between M0.0V and M9.5V. Carmencita is the 'CARMEN(ES) Cool dwarf Information and daTa Archive', our input catalogue, from which we select the circa 300 targets being observed during guaranteed time. Besides that, Carmencita is perhaps the most comprehensive database of bright, nearby M dwarfs ever built, as well as a useful tool for forthcoming exoplanet hunters: ESPRESSO, HPF, IRD, SPIRou, TESS or even PLATO. Carmencita contains dozens of parameters measured by us or compiled from the literature for about 2,200 M dwarfs in the solar neighbourhood brighter than $J = 11.5$ mag: accurate coordinates, spectral types, photometry from ultraviolet to mid-infrared, parallaxes and spectro-photometric distances, rotational and radial velocities, Halpha equivalent widths, X-ray count rates and hardness ratios, close and wide multiplicity data, proper motions, Galactocentric space velocities, metallicities, full references, homogeneously derived astrophysical parameters, and much more. In my talk, I will explain how we build Carmencita standing on the shoulders of giants and observing with 2-m class telescopes, and produce a dozen MSc theses and several PhD theses in the process (http://carmenes.caha.es).

Understanding Multifaceted Nature of M Dwarf Magnetism

Oleg Kochukhov (Uppsala university)

Denis Shulyak (Goettingen university), Alexis Lavail (Uppsala university), Gregg Wade (Royal Military College of Canada)

Abstract

Active M dwarf stars host powerful and distinctly non-solar magnetic dynamos, which manifest themselves by ubiquitous surface activity phenomena such as flares and X-ray emission. Direct evidence of strong magnetic fields IS detected in the intensity and polarisation line profiles, yet analyses of these observables lead to contradictory conclusions about magnetic field strengths and topologies. Here we present a set of complementary projects aimed at developing self-consistent, physically-sound empirical models of M-dwarf magnetism. On the theoretical and modelling side, we discuss improvements of the diagnosis of field strengths using Zeeman broadening of atomic and molecular lines. We also present results of an in-depth study of polarised radiative transfer in M-dwarf atmospheres, taking into account both global and local magnetic field components, and assess the resulting impact on interpretation of the Zeeman Doppler maps of M dwarfs. On the observational side, we report the first ever spectropolarimetric observations of M dwarfs in all four Stokes parameters and present the serendipitous discovery of a sudden evolution of the magnetic field topology in one of the brightest active M dwarfs.

Stellar Magnetism, Winds and Their Effects on Planetary Environments

Aline Vidotto (Trinity College Dublin)

Abstract
In this talk I will review the recent works on magnetism of cool, main-sequence stars, their winds and potential impact on surrounding exoplanets. The winds of these stars are very tenuous and persist during their lifetime. Although carrying just a small fraction of the stellar mass, these magnetic winds regulate the rotation of the star. Since cool stars are likely to be surrounded by planets, understanding the host star winds and magnetism is a key step towards characterisation of exoplanetary environments. Although these environments may be potentially dangerous for a planet's atmosphere, the interaction between exoplanets and the host star winds can provide other avenues for planet detection and maybe even assess planetary properties, which would otherwise remain unknown.

HARPS-N Observes the Sun as a Star

Xavier Dumusque (Observatory of Geneva)

D. F. Phillips (Harvard-Smithsonian Center for Astrophysics), A. Glenday (Harvard-Smithsonian Center for Astrophysics), A. Collier Cameron (SUPA, School of Physics, University of St. Andrews), D. Charbonneau (Harvard-Smithsonian Center for Astrophysics), D. W. Latham (Harvard-Smithsonian Center for Astrophysics), C. Lovis (University of Geneva), G. Micela (INAF, Palermo), E. Molinari (INAF, Foundation Galileo Galilei), J. Maldonado (INAF, Palermo), F. Pepe (University of Geneva), R. Haywood (Harvard-Smithsonian Center for Astrophysics), S. Udry (University of Geneva)

Abstract

Radial velocity perturbations induced by stellar surface inhomogeneities including spots, plages and granules currently limit the detection of Earth-twins using Doppler spectroscopy. Indeed, the effects of stellar surface inhomogeneities on observed stellar radial velocities are extremely difficult to characterize because except for the Sun, stellar surfaces cannot be resolved, and thus developing optimal correction techniques to extract true stellar radial velocities is extremely challenging. To learn more about possible ways to correct for radial velocity stellar signals we have built a solar telescope to feed full-disk sunlight into the HARPS-N spectrograph. This setup enables long-term observation of the Sun as a star with state-of-the-art sensitivity to radial velocity changes. We can then use Solar Dynamic Observatory (SDO) images to link any radial velocity perturbation with physical changes on the solar surface. During this talk, I will present the first year of data. With observations of the Sun every possible day for a few hours, this data set represents our best chance of understanding deeply stellar signals, to test the best observational strategies to look for exoplanets, and to find correction techniques to mitigate the impact of stellar signals. I will show the first detection of Jupiter as an exoplanet, and first attempts to model stellar signals using SDO images, Gaussian-process regression, and spectroscopic observables. If successful, these new methods to mitigate stellar signals should be directly applicable to others stars, as the same spectrograph is used, and should enable the detection of Venus over the next two years, thus demonstrating the possibility of detecting Earth-twins around other solar-type stars using the radial velocity technique.

A Path Towards Understanding the Rotation-Activity-Age Relation of M Dwarfs With K2 Mission, X-Ray and UV Data

Beate Stelzer (INAF - Osservatorio Astronomico di Palermo, Italy)

Mario Damasso (INAF - Osservatorio Astrofisico di Torino, Italy), Aleks Scholz (SUPA, University of St.Andrews, United Kingdom), Sean P. Matt (University of Exeter, United Kingdom), Ignasi Ribas (CSIC - IEEC, Spain)

Abstract

We present an updated view of the rotation-activity-age relation for (old) field M dwarfs based on K2 rotation periods and flares, archival X-ray and UV data, and dedicated Chandra and XMM-Newton observations. The rotation-activity-age relation can be used as a proxy for magnetic fields – which are difficult to measure in M dwarfs – and is, therefore, key to studies of (i) the predicted dynamo transition at the fully convective boundary (SpT$\sim$M3), (ii) differences in angular momentum loss through magnetized winds with respect to solar-type stars, and (iii) the evaporation of planet atmospheres, especially relevant for M dwarfs because of the small separation of their planets' habitable zones where they are strongly exposed to the stellar high-energy emission. We use a two-fold approach to obtain tight observational constraints: (1) In our study of the activity-rotation relation of nearby, proper-motion selected M dwarfs using photometric time-series from the K2 mission combined with X-ray and UV data we find strong evidence for an abrupt change of optical photometric activity (flares, rotation cycle amplitude and residual variability) at $P_{\rm rot} \sim 10$ d, and an unexpectedly steep decline of X-ray activity in the unsaturated regime of slow rotators. (2) The age-activity relation is investigated through deep X-ray observations of a sample of M dwarfs in wide binaries with white dwarfs. Here the white dwarf serves as a chronometer for the age of the M dwarf. Our results provide important input for accurate angular momentum evolution models and planet atmosphere escape calculations for M dwarfs.

Tracking Magnetic Variability From High-Resolution Unpolarised Spectra

Annelies Mortier (University of St Andrews)

Abstract

Discovering Earth-like exoplanets using the radial velocity (RV) technique is mainly being challenged by stellar activity. Only by understanding the variable signals imposed by the star itself will we be able to find the underlying planetary signals. Activity indicators, such as the FWHM of the spectral lines and the Ca II H&K emission, are already being used to understand the stellar variations. However, the high-resolution spectra that we have from the RV searches contain much more information. In this talk I will explain about a new technique of extracting information on the stellar magnetic field directly from the intensity spectrum. By combining thousands of lines, we can extract the Zeeman broadening effect. We apply this to the high-resolution spectra time series taken with HARPS and HARPS-N in order to disentangle the stellar magnetic signal from the signals from Earth-like planets.

THURSDAY

Variability of Solar/Stellar Magnetic Activity

Session 3
Age/Rotation/Activity Relation from Stellar Surveys and Theory

Chairs: H. Korhonen, S. Criscuoli

Variability of the Sun and Sun-Like Stars on Different Time Scales

Sami K. Solanki (Max Planck Institute for Solar System Research)

Abstract
Although many features can be seen moving across the sun at various wavelengths, the Sun is an almost constant star with regard to its radiative output and its radiative variability has generally only been discovered after the beginning of the space age. For Sun-like stars it is easier to measure their small levels of variability from the ground, leading to some unexpected discoveries that seemed to suggest a behavior rather different from that displayed by the Sun. Revisions of the measurements and advances in modelling have, however, in recent years shown that some of the main differences between the Sun and stars can be reconciled. A much richer data set of short and medium-term variability has been provided by the COROT and Kepler missions. Although a number of exciting results have already been obtained from these data, many more are expected in the coming years as the data are more thoroughly analyzed and models developed to describe solar variability are extended to describe stars similar to the Sun, but not exact solar analogs.

Age-Rotation-Activity Relations

Observations and Theory

Gibor Basri (UC Berkeley)

Abstract
The fact that stellar rotation and chromospheric emission are correlated with age was explicitly noted by Wilson (1963) and reinforced by Kraft (1967). Wilson knew that CaII emission was correlated with surface magnetic field in the Sun. Skumanich (1972) suggested a simple functional for the age-activity relation, and suggested that magnetic braking was the likely reason for the decline in activity. A theory for the rotation-activity connection was elucidated by Noyes et al. (1984), who invoked the Rossby number as important to the stellar dynamo. This calibrated the relation by convection zone depth and turnover time, although it was noted early and recently confirmed that it is not clear whether Rossby number is empirically superior to the rotation period itself in producing a clear rotation-activity relation. In fact, turnover times are hard to properly define, and the Rossby number is itself calibrated to tighten the relations. The number of stars in samples used to study this has increased dramatically, as have the diagnostics available to assess magnetic activity. It remains clear is that there is a strong relationship between magnetic activity and stellar rotation, and that magnetic braking forces both activity and rotation to decrease with age. These relations are also subject to modification as a function of stellar mass. There has recently been a great increase in the number of measured stellar rotation periods, and in the calibration of these relations using star clusters (whose ages can be independently assessed). I will summarize some of the ongoing progress on this topic.

An Improved Stellar Age-Activity Relationship for Ages Beyond a Gigayear

Rachel Booth (Queen's University Belfast)

Katja Poppenhaeger (QUB)

Abstract

When the first bio-marker in an exoplanetary atmosphere is found, it will most likely be found in a planet orbiting an inactive, old nearby star. In order to assess this exoplanet's evolution, we will need to reliably estimate the age of the star, which is notoriously difficult for old field stars. Since Skumanich first presented evidence of a relationship between the rotation and the age of a star there has been much interest in developing a calibrated relationship which can be used to provide an estimate of a star's age. Currently these age-activity relationships are only reliable for ages under a gigayear. My research uses the advancement in asteroseismology which has allowed large samples of solar and late-type stars' ages to be determined and combines these with X-ray data from which I measure the stellar activity in order to derive a new and improved age-activity relationship for stars with ages greater than a gigayear.

Rotation and Spot Activity of Young Solar-Type Stars

Jyri Lehtinen (University of Helsinki, Aalto University)

Lauri Jetsu (University of Helsinki), Thomas Hackman (University of Helsinki), Gregory W. Henry (Tennessee State University)

Abstract

We present results from a recent multidecade study of the spot activity of young solar-like stars, based on photometry gathered at the Fairborn observatory since 1987. Our period analysis of this photometry reveals systematic tendencies in the stellar rotation and activity behaviour with respect to stellar mass. Period variations seen in the light curves point to a flat rotation dependence of the absolute equator to pole differential rotation. Activity cycles are commonly seen in the light curve mean levels and amplitudes and their lengths fall on distinct branches when compared to the Rossby number and chromospheric activity levels. Our results indicate that there are systematic simultaneously excitable cycle modes present in the active stars in the form of a previously undescribed split into two parallel cycle branches. Several of the studied stars have superimposed cycles belonging to both of the parallel branches. Active longitudes are also frequently seen on the more active stars and range from short lived structures lasting for a few years into highly stable longitudinal confinement of the observed activity over decades. We find, however, that there is a sharp transition between weakly and strongly active stars so that only stars with a sufficiently high activity level have clearly developed active longitudes. When active longitudes do appear, they commonly have a markedly shorter rotation period than the photospheric mean rotation period, recovered from direct light curve period analysis. This may be a signature of radial differential rotation or that the active longitudes follow an azimuthal dynamo wave.

What Can We Learn About Stellar Activity Cycles From ZDI?

Victor See (University of St Andrews)

M. Jardine (St Andrews), A. Vidotto (Trinity College Dublin), J.F. Donati (Toulouse), C. Folsom (Toulouse), S. Boro Saikia (Goettingen), R. Fares (Catania), S. Gregory (St Andrews), G. Hussain (ESO), S. Jeffers (Goettingen), S. Marsden (Southern Queensland), J. Morin (Montpellier), C. Moutou (Marseille), J.D. do Nascimento (CfA), P. Petit (Toulouse), L. Rosen (Uppsala), I. Waite (Southern Queensland)

Abstract

It is known that activity cycles, similar to the 11 year cycle of the Sun, can exist on other stars. Previous work suggests that stars may lie on two branches in a cycle period vs rotation period diagram though there is no definitive explanation for why this should be the case. Fundamentally, activity cycles occur as a result of the underlying dynamo. Indeed, a great deal has been learnt about the Sun's activity cycle by studying how its magnetic field evolves over each activity cycle. In the same way, we should be able to learn about the activity cycles of others stars by studying their magnetic field properties. In this talk, I will present new insights into stellar activity cycles by analysing the magnetic maps of stars that are known to present activity cycles. I will show that stars along each of the branches appear to have different magnetic field topologies.

Session 4
Constraining Solar/Stellar Dynamo Theory

Chairs: R. Collet, R. Simoniello

Numerical Simulations of Solar/Stellar Dynamos

Laurene Jouve (IRAP Toulouse / France)

Abstract

In this talk, we will review some aspects of the stellar magnetism and in particular what numerical simulations tell us about the physical processes underlying the observations. In cool stars, a convective dynamo is thought to be responsible for the presence and evolution of magnetic fields. The question of the impact of the internal stellar structure on the magnetic field topology will be addressed. We will focus in particular on the role of differential rotation and of a tachocline. Another important aspect of stellar dynamos is the possible presence of magnetic cycles and how its period depends on the stellar parameters. Numerical simulations addressing this issue will be presented. Finally, one step of the dynamo process is the emergence of magnetic flux from the interior where it is created and organised to the exterior where it emerges as starspots. We will also show results of global 3D MHD numerical simulations of such a process.

The Stellar Context for Solar Magnetism

Travis Metcalfe (Space Science Institute)

Jennifer van Saders (Carnegie Observatories), Ricky Egeland (High Altitude Observatory), Marc Pinsonneault (Ohio State University), Orlagh Creevey (Observatiore de la Cote d'Azur), Rafael Garcia (CEA Saclay France)

Abstract

Precise photometry from the Kepler space telescope allows not only the measurement of rotation in solar-type field stars, but also the determination of reliable masses and ages from asteroseismology. These critical data have recently provided the first opportunity to calibrate rotation-age relations for stars older than the Sun. The evolutionary picture that emerges is surprising: beyond middle-age the efficiency of magnetic braking is dramatically reduced, implying a fundamental change in angular momentum loss beyond a critical Rossby number (Ro$\sim$2). I will review detailed evolutionary modeling of the Kepler observations and discuss recent efforts to expand the sample and minimize systematic uncertainties. This will provide the context for multiple lines of evidence that the Sun is in a transitional evolutionary phase, and that its magnetic cycle may represent a special case of stellar dynamo theory.

Magnetic Furnaces

Examining Fully Convective Dynamos and the Influence of Rotation.

Kyle Augustson (CEA Service d'Astrophysique)

Allan Sacha Brun (CEA Service d'Astrophysique), Juri Toomre (University of Colorado)

Abstract

The dynamo action likely present within fully convective regions are explored through global-scale 3-D simulations. These simulations provide a contextual analog for the convective dynamos that are likely operating deep within the interiors of fully convective low mass stars. A logarithmic range of rotation rates are considered, thereby capturing both convection barely sensing the effects of rotation to others in which the Coriolis forces are prominent. The vigorous dynamo action realized within all of these turbulent convective cores builds magnetic fields with peak strengths exceeding a megagauss, with the overall magnetic energy (ME) in the faster rotators reaching super-equipartition levels compared to the convective kinetic energy (KE). Such strong fields are able to coexist with the flows without quenching them through Lorentz forces. This state is achieved due to the velocity and magnetic fields being nearly co-aligned, and with peak magnetic islands being somewhat displaced from the fastest flows as the intricate evolution of these MHD structures proceeds. As the rotation rate is increased, the primary force balance shifts from nonlinear advection balancing Lorentz forces to a magnetostrophic balance between Coriolis and Lorentz forces.

Activity-Rotation-Age Relationships for M dwarfs and the Ages of Extrasolar Planets

Scott Engle (Villanova University)

Abstract

Red Dwarfs (M dwarfs or dM stars) make up ∼75% of the local stellar inventory, and a recent statistical analysis data from the Kepler Mission indicates that ∼15% of red dwarfs host Earth-size planets orbiting within their liquid water Habitable Zones (HZ). This is among the reasons they have been targeted by an increasing number of planet-hunting programs. As such, developing a method to accurately estimate the age of a field M dwarf is of critical importance to a number of fields. However, due to their long lifetimes and very slow nuclear evolution, the best method for determining ages is likely through "magnetic tracers" such as X-UV activity levels and stellar rotation rates. The Living with a Red Dwarf program?s database of M dwarfs with photometrically determined rotation periods (via starspot modulations) is becoming substantial, and a full range of "calibrators" is being realized. We report on our current results and continuing efforts to build reliable Activity-Rotation-Age relationships for M dwarfs, utilizing X-UV measures obtained with HST, IUE Chandra and XMM (both proposed by us, and archival). Such relationships permit the assessment of the habitability of planets hosted by red dwarfs, by delineating the X-UV radiation environments these planets are exposed to, and have been exposed to in the past. After proper calibration, the relationships can also permit the age of a field red dwarf (and any hosted planets) to be determined through measures of either the stellar rotation period or X-UV activity level.

THURSDAY

Sun-like Stars Unlike the Sun

Chair: Natalie Hinkel

High-Precision Parameters and Chemical Abundances of Solar-Like Stars

Poul Erik Nissen (Aarhus University)

Abstract
In this introductory review, I will discuss the accuracy/precision of fundamental parameters and chemical abundances of solar-like stars determined from high resolution spectra with very high signal- to-noise. Can we really obtain 1-sigma errors of 10 K in Teff, 0.015 dex in logg, 0.01 dex in abundances, and 1 Gyr in age for solar twins as claimed by several authors? Assuming that the answer is yes, I will review recent findings of trends between abundance ratios, elemental condensation temperature, and stellar age, and discuss how these results may provide new information on extrasolar planets and nucleosynthesis of elements. If time allows, I will also discuss the C/O and Mg/Si ratios in solar-like stars as constraints on the composition of terrestrial planets.

Planet Signatures in the Chemical Composition of Sun-Like Stars

Jorge Melendez (IAG / USP)

Abstract
There are two possible mechanisms to imprint planet signatures in the chemical composition of Sun- like stars: i) dust condensation at the early stages of planet formation, causing a depletion of refractory elements in the gas accreted by the star in the late stages of its formation; ii) planet engulfment, altering the chemical composition of the host star. I will discuss both planet signatures and the influence of galactic chemical evolution.

Possible Explanations for the Abundance Trends With Condensation Temperature

Elisa Delgado Mena (IA - Universidade do Porto)

Abstract
After the first planets discovered, astronomers have been trying to search for chemical signatures of planet formation on the planet-host stars. Several studies suggested that the chemical abundance trend with the condensation temperature, Tc, is a signature of terrestrial planet formation. However, rocky material accretion is by far not the only explanation for the Tc-trend and the real astrophysical nature of this correlation is still up to debate. I will discuss the effects of Galactic chemical evolution on the Tc trends and its dependence on the stellar age and Galactic birth place.

The Nucleosynthetic History of Elements in the Galactic Disk

[X/Fe]–Age Relations From High-Precision Spectroscopy

Lorenzo Spina (Universidade de São Paulo - IAG)

Abstract

The chemical composition of stars is intimately linked to the Galaxy formation and evolution. In particular, knowledge of the [X/Fe]-age relations is a gold mine from which we can achieve a great understanding about the processes that governed the formation and evolution of the Milky Way. We used accurate age and chemical abundance determinations for a sample of 42 solar twins to outline the [X/Fe]-age relations of 24 species from carbon to europium. This data set revealed that each different class of elements shows a distinct evolution with time that relies on the various characteristics, rates and timescales of the nucleosynthesis' sites from which they are produced. Namely, the alpha-elements are characterized by a [X/Fe] decrement as time goes on. Strikingly, an opposite behaviour is observed for Ca. The iron-peak elements show an early [X/Fe] increase followed by a decrease towards the youngest stars. The [X/Fe] for the n-capture elements decrease with age. We also found that both [Mg/Y] and [Al/Y] are precise stellar clocks, with [Al/Y] showing the steepest dependence from age.

The 16 Cygni System

A Laboratory for Studying the Influence of a Planetary System on Its Host Star

Morgan Deal (LUPM / IRAP)

Abstract

The accretion of heavy planetary matter onto main-sequence stars leads to fingering instabilities induced by the inverse mu-gradient. This leads to an extra convection zone which rapidly mixes the accreted matter inside the star. A first consequence of this mixing is that no signature of the accreted heavy elements remains at the surface. A second consequence is that, due to the extra mixing, an important quantity of lithium may be rapidly destroyed. Such an effect can explain the abundance differences observed in the two main stars of the 16 Cygni system.

Possible Reasons for Solar Oddity

Bengt Gustafsson (Uppsala University)

Abstract

I shall comment on various possible explanations for the departure of the solar elemental composition from that of the majority of solar-type stars: (1) dust cleansing of primordial solar nebula, (2) cleansing of the protoplanetary disk by planet formation in combination with a long-lived disk or early retraction of the deep solar convection zone, e.g. due to episodic accretion (3) galactic chemical evolution in combination with migration. Some suggestions for further clarifying studies will be given.

Do We Need NLTE in the Abundance Analysis of Solar-Type Stars?

Maria Bergemann (Max-Planck Institute for Astronomy, Heidelberg)

Abstract

Over the past decade, enormous progress has been made in our understanding of physical processes in the atmospheres of solar-like stars. One of the most critical additions to the state-of-the-art models is non-local thermodynamic equilibrium (in short, NLTE). I will describe the ongoing efforts to analyze chemical composition of Sun-like stars with NLTE radiation transport models and outline the key results, as well as the major successes and challenges on the way to a more realistic abundance analysis of Sun-like stars.

3D-Based Solar/Stellar Abundance Analyses

Martin Asplund (Australian National University)

Abstract

I will discuss current and future possibilities in terms of using realistic 3D radiative-hydrodynamical stellar atmosphere models for solar and stellar abundance analyses, including detailed non-LTE radiative transfer. Such modelling removes the free parameters (mixing length, micro- and macroturbulence) that have hampered stellar spectroscopy for many decades, which together with a more realistic atmosphere structure should lead to more reliable results in terms of inferred chemical compositions of stars. Recent work on 3D non-LTE modelling for the Sun and other stars have demonstrated the feasibility of this approach, which will be briefly discussed. The major challenge now is how to incorporate this much more computationally demanding stellar modelling for large-scale spectroscopic surveys involving thousands or even millions of stars.

Lithium Abundance of the Solar-Type Superflare Stars

Satoshi Honda (University of Hyogo, Nishi-Harima Astronomical Observatory)

Abstract

We will present the Lithium abundances in the solar-type superflare stars to investigate the nature of such stars and the differences of the Sun. Young stars, close binary stars, and dMe stars sometimes produce "superflares", flares whose total energy is $10 - 10^6$ times larger than the largest flares on the Sun. It has been recognized that the superflares will not occur on the slowly rotating, single solar-type stars (Sun-like stars). However, Maehara et al. (2012) and Shibayama et al. (2013) found the superflare events on Sun-like stars from the photometric data of Kepler spacecraft. We performed the high dispersion spectroscopy of solar-type superflare stars by Subaru/HDS, and estimate the stellar parameters and lithium abundance of the stars to compare with the Sun. Our spectroscopic analysis of superflare stars show more than half of targets have no evidence of binary system and the stellar parameters are in the range of solar-type stars (Notsu et al. 2015a&b). We also investigate the correlations of Lithium abundance with stellar atmospheric parameters, rotational velocity, and superflare activities to understand the nature of superflare stars and the possibility of the nucleosynthesis of lithium by superflares. The derived lithium abundance in superflare stars do not show the correlation with stellar parameters. As compared with the lithium abundance in Hyades cluster which is younger than the sun, it is suggested that half of observed stars are young. However, there are some objects which show the low lithium and slowly rotate from the estimated vsini and period of brightness variation. This results indicates that the superflare stars are not only young stars but also old stars like our sun. In our observations, we could not find the any evidence of lithium productions by superflare.

Observational Inputs on the Solar/Stellar Connection

Probing Solar Analogues With Asteroseismology and High-Resolution Spectroscopy

Paul Beck (Service d'Astrophysique, CEA Paris-Saclay)

Abstract

Unless located in eclipsing binary systems or clusters, the mass or the radius of a star are challenging parameters to determine. In this talk we discuss what the analysis of space photometry, in particular using asteroseismology, activity and rotation, can do to characterize solar analogues beyond offering the possibility to derive precise mass, radius and surface gravity and how the combined analysis with high-resolution ground-based spectroscopy can contribute to provide a comprehensive picture. The continuous four years of photometric observations of stars collected by the NASA Kepler space telescope have provided data with unparalleled quality and quantity. We selected a set of 20 solar analogues according to their mass, effective temperature, and surface gravity. High-quality Kepler observations provide unique datasets for detailed seismic analysis and further enable the extraction of surface rotation periods and proxies of photospheric magnetic activity. Furthermore, in an extensive, on-going spectroscopic campaign, we collected high-resolution, high-signal-to-noise-ratio spectra with the Hermes spectrograph. Combining these two techniques enables us to explore the solar/stellar connection from a wealth of observational information. Having stellar ages constrained from seismic modeling and gyrochronology allows us to confront it with the stars' lithium abundance. We also studied the chromospheric and photospheric magnetic activity against the stellar parameters from seismology and rotation rate. In this talk, we present the latest results from our series of recent accepted and submitted papers by Beck et al. (2016a,b) and Salabert et al. (2016a,b) comparing our set of solar analogues to the Sun.

THURSDAY

Cool Dwarf Multiplicity Throughout the Ages

The Implications of Cool Star Multiplicity Statistics for Star Formation Theories

Cathie Clark (University of Cambridge)

Abstract
It has long been recognised that the assembly of multiplicity statistics for a large dynamic range of primary masses provides a tool for distinguishing various star formation scenarios. I will review the extent to which we currently have the statistical information to conduct this analysis and highlight future observational needs. I will also discuss the long-standing problem of creating extreme mass ratio binaries and describe scenarios explored in the recent theoretical literature. Finally, I will review the extent to which data on circumstellar discs in young brown dwarfs can constrain the dynamical environment in which they formed.

Accretion Dynamics in Pre-Main Sequence Binary Stars

Observationally Testing the Accretion Stream Theory

Ben Tofflemire (University of Wisconsin, Madison)

Abstract
Protostellar disks are integral to the formation of low-mass stars and planets. A paradigm for the star-disk interaction has been extensively developed through theory and observation in the case of single stars. Most stars, however, form in binaries or higher order systems where the distribution of disk material and mass flows are more complex. Pre-main sequence (pre-MS) binary stars can have up to three accretion disks: two circumstellar disks and a circumbinary disk separated by a dynamically cleared gap. Theory suggests that orbital motion may drive periodic accretion streams that flow from a circumbinary disk across the gap onto the circumstellar disks or stellar surfaces. Thus, accretion in pre-MS binaries is controlled not only by radiation, disk viscosity, and magnetic fields, but also by orbital dynamics. As part of a larger, ongoing effort to characterize mass accretion in young binary systems, we test the predictions of the binary accretion stream theory through continuous, multi-orbit, multi-color optical and near-infrared time-series photometry. Our observations from LCOGT, SMARTS, WIYN 0.9m, and ARCSAT provide detailed mass accretion rates and a measurement of the warm circumstellar material, all as a function of orbital phase. The predicted phase and magnitude of enhanced accretion are highly dependent on the binary orbital parameters and as such, our campaign focuses on 9 pre-MS binaries of varying periods and eccentricities. We present results highlighting the detection of consistent enhanced accretion events near periastron passages in eccentric binaries and strong sensitivity to the binary orbital parameters.

Constraining the Early Stages of Binary Star Evolution

Ed Gillen (University of Cambridge)

Suzanne Aigrain, Lynne Hillenbrand, Caroline Terquem, Jerome Bouvier, Silvia Alencar, John Stauffer, Ann Marie Cody, Amy McQuillan, John Southworth, Simon Hodgkin, Monika Lendl, Davide Gandolfi, Pedro Viana Almeida, Fabio Favata, Guisi Micela

Abstract

There are only a dozen known low-mass, pre-main sequence eclipsing binaries (PMS EBs) with well-determined masses and radii. Detecting and characterising a sample of low mass EBs sharing the same age and composition, yet spanning a wide range of masses, was one of the key motivations for CoRoT to observe the 3 Myr old NGC 2264 star forming region for 23 days in 2008. We identified 37 EBs among the possible cluster members and have performed an intensive program of ground-based follow-up observations to confirm their membership and determine their parameters. Furthermore, CoRoT observed the cluster again for 40 days in Dec 2011 – Jan 2012, as part of a coordinated campaign with Spitzer, Chandra, and a number of ground-based facilities including VLT/FLAMES, providing a unique simultaneous multi-band photometric and spectroscopic dataset. I will present the sample of confirmed and candidate cluster members, detailing our innovative methods to determine their fundamental parameters using Gaussian process regression, before comparing our results to different models of stellar evolution. Of particular note, this sample includes: the first low-mass PMS EB with evidence of a circumbinary disk; two of the most extreme mass-ratio PMS EBs known; and a potential visual multiple containing three eclipsing signals. Taken together, this work offers an intriguing window onto the formation and early evolution of multiple star systems.

Fundamental Calibrators for Stellar Evolution Models

New Eclipsing Binaries in Young Clusters Identified by K2

Trevor David (California Institute of Technology)

Abstract

Double-lined eclipsing binaries serve as fundamental calibrators for stellar evolution models. Benchmark grade calibrators (with mass and radius uncertainties of $\sim$3%) having component masses below 1 solar mass are rare, particularly at pre-main sequence stages. We present the discovery and characterization of new eclipsing binaries in young stellar clusters, all identified by K2. In the 5 – 10 Myr old Upper Scorpius region, the nearest OB association, we present the lowest mass stellar eclipsing binary to date, with both components close to the hydrogen burning limit. Also in Upper Scorpius, we present evidence for a hierarchical triple with an eclipsing pair of brown dwarfs, only the second eclipsing brown dwarf pair known to date. In the 110 – 125 Myr old Pleiades cluster, only one eclipsing binary was known prior to the K2 mission. We present three new Pleiades eclipsing binaries, all with system masses less than 1 solar mass. We use these systems to critically assess stellar evolution models at low masses and young ages. K2 data in hand has also revealed new eclipsing and transiting systems in the moderately older (600 – 800 Myr) Hyades and Praesepe clusters.

The Role of Dynamics in Multiplicity

Richard Parker (Liverpool John Moores University)

Abstract
Binaries in the field are often used as a benchmark with which to compare binary populations in young star-forming regions. However, several studies have argued that dynamical interactions in star-forming regions can drastically alter the initial fraction, and orbital parameters of binary and multiple systems. In this talk I will show that basic information (i.e. position and membership probability) can be used to place constraints on the amount of dynamical evolution that a population of binaries has experienced in a given natal star-forming region. Based on observed properties of nearby star-forming regions, I will argue that the field binary population is likely to be indicative of the initial binary population as set by star formation. I will conclude by showing that the semimajor axis regime that observations are currently able to probe is, however, very sensitive to stochastic dynamical processes and that more observations are desperately required.

Towards the True Binary Fraction of Very Low Mass Stars and Brown Dwarfs

Daniella Bardalez Gagliuffi (UC San Diego)
Adam Burgasser, Christopher Gelino, Jonathan Gagné, Enrique Solano, Miriam Aberasturi, Sarah Schmidt, Kelle Cruz

Abstract
Brown dwarf formation and how it differs from star formation is not well understood. Multiplicity is a key statistic for constraining theories on the formation and evolution of very low mass (VLM) stars and brown dwarfs. Most binary systems have been found through high resolution imaging, with a peak in the projected separation distribution at 1-4 AU coincident with the angular resolution limits of HST/ground-based adaptive optics. This suggests an observational bias and potentially significant underestimation of the VLM binary fraction, in conflict with formation theories. We have devised a separation-independent method to find potential binary systems using low-resolution, near-infrared spectra, which has uncovered over 60 VLM binary candidates to date. In order to find the true low mass star binary fraction, we are applying this method on an unbiased, volume-limited, spectroscopic sample of M7 – L5 dwarfs, and following up candidates with high resolution imaging and spectroscopy to confirm their binary nature. Uncovering a large binary population would signify a different formation mechanism between stars and brown dwarfs.

Properties of Stellar and Substellar Companions From the M-dwarfs in Multiples (MinMs) Survey

Kimberly Ward-Duong (Arizona State University)

Abstract

We present new findings from the M-dwarfs in Multiples (MinMs) Survey, a large-scale M-dwarf companion study of a complete volume-limited sample of 245 early M-dwarfs within 15 pc, as based on Hipparcos parallaxes. Through the addition of new high-resolution adaptive optics (AO) images to archival AO and digitized wide-field archival plate imaging, the entire sample is sensitive to companions at and beyond the bottom of the main sequence at projected separations of $\sim$3 - 10,000 AU. The full sample is sensitive to 50 M_{Jup} companions beyond $\sim$100 AU, and with 75% of the sample sensitive to 50 M_{Jup} between $\sim$3 - 100 AU, we present a comprehensive survey searching for brown dwarf companions to M-dwarfs over the widest separation range to date. Our results include a new $\sim$60 M_{Jup} companion at 7700 AU from its host star—one of the widest M-dwarf+brown dwarf systems discovered—and new close (< 50 AU) stellar and substellar candidate companions resolved with AO imaging. Multiple epochs of imaging with both high resolution and wide-field techniques for each target allows us to confirm or reject common proper motion candidates over the full separation range. Orbital fits are calculated for a subset of bound systems with multi-epoch astrometric measurements. By combining our measurements with reported detections from previous radial velocity searches, we present statistics over the broadest separation range for the companion frequency, separation distribution, mass ratio distribution, and frequency of hierarchical systems for M-dwarfs and M-dwarf+brown dwarf companions. These measurements extend our knowledge of companion properties for the lowest-mass stars, showing them to be distinct from their higher mass counterparts.

Fundamental Stellar Parameters With HST/STIS Spectroscopy of M Dwarf Binaries

Sergio B. Dieterich (Carnegie Institution of Washington - Department of Terrestrial Magnetism)

Abstract

Mass is the most fundamental stellar parameter, and yet model independent dynamical masses can only be obtained for a small subset of closely separated binaries. The high angular resolution needed to characterize individual components of those systems means that little is known about the details of their atmospheric properties. We discuss the results of HST/STIS observations yielding spatially resolved intermediate resolution red optical stellar spectra for six closely separated M dwarf systems, all of which have precision dynamical masses for the individual components ranging from 0.4 to 0.076 MSol. We assume coevality and equal metallicity for the components of each system and use those constraints to perform stringent tests of the leading atmospheric and evolutionary model families throughout the M dwarf mass range. We find the latest models to be in reasonably good agreement with observations. We also discuss specific spectral diagnostic features such as the well-known gravity sensitive alkali lines and address ways to break the temperature-metallicity-gravity degeneracy that often hinders the interpretation of these features. This work is funded by NASA grant HST-GO-12938.

Doubling Down

Individual Dynamical Masses for Ultracool Binaries

Trent Dupuy (University of Texas at Austin)

Abstract

Evolutionary models of stars at the bottom of the main sequence and into the substellar regime are widely used, but some of their basic predictions have remained essentially untested by direct measurement. The past several years have seen progress in testing models thanks to a growing number of dynamical (total) masses for brown dwarf binaries determined via (relative) orbit monitoring from ground-based adaptive optics (AO). However, the strongest tests of models require individual masses, particularly for calibrating the fundamental mass-luminosity relation. We present a new sample of individual dynamical masses for 17 binary systems, including objects down to $\sim$30 $M_{\rm Jup}$. These new results were only made possible by long-term orbit monitoring that combines resolved astrometry from Keck AO and HST with unresolved photocenter motion from our infrared astrometry program at the Canada-France-Hawaii Telescope over the past decade. We find that the mass-luminosity relation in the L/T transition is quite shallow, implying that the bulk substellar cooling decelerates as clouds disappear, perhaps even caused by this change at the surface. We also test whether models can reproduce the observed properties of each coeval, co-composition binary along a single isochrone. The ages derived from models using mass and luminosity are consistent with the age of the field population (>$\sim$1 Gyr) for most of our sample, as expected. Two of our sample binaries with spectral signatures of low surface gravity have model-derived ages of $\sim$80 Myr and $\sim$300 Myr, enabling the first tests of models using low-gravity ultracool dwarf dynamical masses.

THURSDAY

The Solar-Stellar Connection in the ALMA Era

Atacama Large Millimeter/sub-millimeter Array (ALMA)

Introducing the Status and Capabilities of ALMA

Wouter Vlemmings (Nordic ALMA Regional Center / Chalmers University of Technology, Onsala Space Observatory)

Abstract

ALMA, the Atacama Large Millimeter/submillimeter Array, is soon entering its fifth year of operations. This transformational facility, located at 5 km altitude in the Atacama desert in Chile, has already produced groundbreaking results across many astonomical research areas. Soon Solar observations will also be possible. In this talk, I will present a basic overview of the ALMA project, the user interaction through the regional centers, and the ALMA capabilities that are offered and expected in the future.

Stellar Observations With ALMA

Sofia Ramstedt (Uppsala University)

Abstract

The Atacama Large Millimeter/submillimeter Array (ALMA) has, in its few years of operation at limited capabilities, already revolutionized our view on cool stars. For young and evolved stars, the early observations have mainly focused on circumstellar molecular gas and dust. With the capabilities improving, for example with long baselines offering extreme resolution capable of resolving the surfaces of nearby giant stars, and with polarization measurements, both in continuum and lines being offered in the latest cycle, the first attempts at exploring magnetic activity have recently been published. In this talk I will review stellar observations with ALMA by selecting some highlights, and with focus on observational techniques interesting also for solar observations when available.

Mapping the “Radio Surface” of an Evolved Star With ALMA

Eamon O’Gorman (Dublin Institute for Advanced Studies)

Pierre Kervella (Observatoire de Paris; Universidad de Chile), Leen Decin (Leuven), Anita Richards (Manchester), Iain McDonald (Manchester), Andrea Chiavassa (Observatoire de la Côte d’Azur), Xavier Haubois (ESO), Guy Perrin (Observatoire de la Côte d’Azur), Graham Harper (Colorado), Miguel Montarges (IRAM), Keiichi Ohnaka (UCN Chile), Jan Martin Winters (IRAM), Arancha Castro-Carrizo (IRAM)

Abstract

ALMA has the potential to spatially resolve a limited sample of stars at multiple frequencies. Such observations would allow the temperature structure to be probed at varies depths in the star’s extended atmosphere. An even smaller sample of stars can not only be spatially resolved with ALMA, but can be mapped with good detail (i.e., a few beams across the ’radio surface’). Here we present our initial ALMA long baseline Band 7 mapping of the radio surface of one such star, Betelgeuse, a red supergiant with one of the largest angular diameters at ALMA frequencies.

Solar Observations in Cycle 4 of ALMA

Masumi Shimojo (National Astronomical Observatory of Japan)

ALMA Solar Development Team

Abstract

The Sun is one of scientific targets of the Atacama Large Millimeter/sub-millimeter Array (ALMA). However, solar observations had not been offered until Cycle 3, because of a lot of difficulties for observing the Sun with the radio interferometer for night astronomy. We have been developing observing schemes for the Sun since 2010, and the joint ALMA observatory started to offer solar observations from Cycle 4 at last. Since the special treatments are needed for solar observations, there are some limitations for observing the Sun in comparison with the observations of other celestial targets. We held the commissioning campaign in December 2015 for verifying the observing modes, and the images synthesized from the commissioning data show us new sights of solar physics. The data obtained with the ALMA will bring about great scientific achievements.

The Cold Heart of the Solar Chromosphere

Tom Ayres (Center for Astrophysics & Space Astronomy, University of Colorado at Boulder)

Abstract

There is no doubt that the solar chromosphere is a complicated place. It is pervaded by strong tangled interacting magnetic fields, threaded by thin plasma jets arcing into the corona, and constantly bombarded by shock waves from below. Less appreciated, the ostensibly hot chromosphere harbors pockets of surprisingly cool gas, source of the curious off-limb emissions of strong CO lines in the thermal IR. An early notion linked the cold gas to a "molecular cooling catastrophe" confined to quiescent areas of the low chromosphere, surrounding the more disturbed small-scale magnetic flux concentrations. Modern 3D time-dependent models have suggested, alternatively, that transient cool plumes could be a natural consequence of adiabatically expanding convective bubbles overshooting into the low chromosphere. Up to this point there has been no way to dynamically map the cold patches on the solar disk, and test the alternative ideas. This is about to change, however, thanks to ALMA: the sub-mm continuum becomes optically thick in the right altitude range, is a reliable thermometer, and the imaging resolution and cadence are terrific.

Prospects for ALMA Studies of the Solar-Stellar Connection

Jeffrey L. Linsky (JILA / University of Colorado and NIST, Boulder)

Abstract

ALMA provides a splendid opportunity to observe a wide range of star types at millimeter wavelengths to investigate the solar-stellar connection. I will compare the sensitivities and wavelength coverages of ALMA and the JVLA to highlight the discovery space that ALMA has for stellar astronomy. At millimeter wavelengths, ALMA will be able to detect thermal and gyroresonance emission from nearby stellar chromospheres and transition regions. Comparison of millimeter fluxes from ALMA with centimeter fluxes from JVLA may be able to separate thermal from gyrosynchrotron emission from stellar coronae and thereby measure magnetic field strengths in stellar coronae. Measurements of stellar wind mass-loss rates are feasible with ALMA for giants but will be difficult for main sequence stars. The study of stellar flares should be an active area of research with ALMA.

FRIDAY

plenary session

The Role of Cool Evolved Stars in Galactic Chemical Evolution.

Amanda Karakas (Monash University)

Abstract

The chemical evolution of the Universe is governed by the nucleosynthesis contribution from stars, which in turn is determined primarily by the initial stellar mass. I will review the status of theoretical stellar evolutionary models and yields of single stars between about 1 to 10 solar mass. Stars in this mass range evolve to become cool red giants after the main sequence. It is during the giant branches that these stars experience mixing events that can significantly change the surface composition of the envelope. Observed enrichments include carbon, lithium, nitrogen, fluorine, and heavy elements synthesized by the slow neutron capture process (the s-process). Cool evolved stars release their stellar yields through strong outflows or winds, in contrast to massive stars that explode as core-collapse supernovae. I will discuss the main uncertainties affecting theoretical calculations and highlight areas of recent progress. Finally, I will discuss the role that cool evolved stars play in the broader picture of Galactic chemical evolution.

Miras Found in KWFC Intensive Survey of the Galactic Plane

Noriyuki Matsunaga (The University of Tokyo)
KISOGP project team

Abstract
Miras are useful tracers of stellar populations in the Milky Way because their distances can be determined accurately based on period-luminoisty relation. We have been conducting a large-scale survey of the northern disk using Kiso Wide-Field Camera attached to Schmidt telescope at Kiso observatory. The KISOGP (KWFC Intensive Survey of the Galactic Plane) project have made 40-70 epoch observations in I-band of about 320 sq. degrees for over 3 years starting in 2012. In the data analysis so far, we detected more than 700 Miras with periods between 100 and 600 days, approximately 90% of which were not previously reported as variable stars. Preliminary estimates of distance locate these Miras in heavily-reddened regions in the disk with few Miras previously known in the distance range of 2 to 8 kpc but some being further than 10 kpc. We are also carrying out follow-up observations: (1) low-resolution optical/IR spectroscopy for classification of carbon-rich and oxygen-rich Miras, and (2) search for SiO maser emissions to study their mass-loss features and radial velocities. In this presentation, we'll present some characteristics of these Miras based on the various data mentioned above and discuss what they tell us about the structure and evolution of the Galactic disk.

Resolving the Extended Atmosphere and the Inner Wind of Mira (Omicron Ceti) With Long ALMA Baselines

Ka Tat Wong (Max Planck Institute for Radio Astronomy)

Tomasz Kamiński (ESO/Chile), Karl M. Menten (MPIfR), Friedrich Wyrowski (MPIfR)

Abstract

We present the recent ALMA data of Mira (omi Cet) which show its radio photosphere, extended atmosphere, and inner wind at an unprecedented detail. Mira was observed in the 2014 ALMA Long Baseline Campaign with baselines up to 15 km. The data produce images of SiO and H2O emission/absorption at an angular resolution of $\sim$30 mas at 220 GHz, which clearly resolve the wind of this prototypical Mira variable within the dust condensation radius. Very unique in the dataset is that molecular transition lines are seen in *absorption* towards the continuum source, even in lines which are dominated by maser emission, allowing detailed studies of physical conditions and chemistry along the line of sight. We have modelled the 28SiO J=5-4 v=0, 2 and H2O ν_2=1 J(Ka,Kc)=5(5,0)-6(4,3) emission and absorption with the aim to understand the spatial structures of Mira's extended atmosphere, dust condensation process, shock dissipation, and the kinematics. The results challenge previous hydrodynamic and dust-formation models of Mira and Mira variables.

The Milky Way as a galaxy – impact of large spectroscopic surveys in the era of Gaia

Sofia Feltzing (Lund Observatory)

Abstract

The Milky Way is the one spiral galaxy that we can study in great detail. The advent of Gaia has over the past decades created a lot of activity to produce the necessary ground-based spectroscopic surveys that will complete Gaia. The role of cool stars in this context is of particular interest as they give the map of the properties of the Galaxy in terms of stellar ages and elemental abundances. I will discuss some of the past surveys, give example results from the on-going surveys and explore the potential of the future surveys such as those conducted by WEAVE, DESI, and 4MOST.

The Oldest Stars in the Milky Way

Louise Howes (Lund Observatory)

Martin Asplund (Australian National University)

Abstract

Over the past five years, the old assumption that metal-poor stars exist only in the Galactic halo has been shown to be false. Several observational campaigns have succeeded in finding very metal-poor giant stars within the confines of the Galactic bulge, and following the principle that the Milky Way formed "inside-out", there is significant theoretical weight behind the idea that these stars are the oldest in the Galaxy. By studying the chemistry of these stars, we can gain insight into the earliest stages of the Milky Way's formation, including what the very first stars of the Galaxy would have looked like. In this talk I will present the latest findings of the EMBLA survey, which has successfully identified more than 500 RGB stars in the bulge with [Fe/H]<-2. The survey has observed 50 with high-resolution spectrographs, and have found some peculiar chemical differences in them compared to the younger metal-poor stars found in the halo. This includes a lack of stars with the large carbon enhancement that is characteristic of the lowest metallicity objects in the halo. We have also been able to confirm – for a small subsample of our stars – that the majority are indeed on tightly-bound orbits, rather than passing through the bulge region on typical eccentric halo star orbits. This discovery confirms that these stars live permanently in the bulge, and that the bulge we see today has grown around them. We are following up some 200 of these stars with Kepler K2 Campaign 9, from which we will get highly accurate stellar parameters, and be able to derive ages. We hope the statistical age of all 200 stars will then confirm that we have truly found the remnants of the first stars of the Milky Way.

Gemini Planet Imager Exoplanet Survey

Overview and Highlights

Jenny Patience (ASU)

Macintosh, B. (Stanford University), Graham, J. R. (UC Berkeley), Barman, T. (University of Arizona), De Rosa, R. J. (UC Berkeley), Konopacky, Q. (UC San Diego), Marley, M. S. (NASA Ames Research Center), Marois, C. (Herzberg Institute of Astrophysics; University of Victoria), Nielsen, E. L. (SETI; Stanford University), Pueyo, L. (Space Telescope Science Institute), Rajan, A. (Arizona State University), Rameau, J. (University de Montreal), Wang, J. J. (UC Berkeley), Arriaga, P. (UC Los Angeles), Artigau, E. (University de Montreal), Beckwith, S. (UC Berkeley), Brewster, J. (SETI), Bruzzone, S. (University of Western Ontario), Bulger, J. (Arizona State University; Subaru Telescope), Burningham, B. (NASA Ames Research Center; University of Hertfordshire), Burrows, A. S. (Princeton University), Chen, C. (Space Telescope Science Institute), Chiang, E. (UC Berkeley), Chilcote, J. K. (University of Toronto), Dawson, R. I. (UC Berkeley), Dong, R. (UC Berkeley), Doyon, R. (University de Montreal), Draper, Z. H. (University of Victoria; Herzberg Institute of Astrophysics), Duchene, G. (UC Berkeley; Grenoble), Esposito, T. M. (UC Los Angeles), Fabrycky, D. (University of Chicago), Fitzgerald, M. P. (UC Los Angeles), Follette, K. B. (Stanford University), Fortney, J. J. (UC Santa Cruz), Gerard, B. (University of Victoria; Herzberg Institute of Astrophysics), Goodsell, S. (Durham University; Gemini Observatory), Greenbaum, A. Z. (Johns Hopkins University; Space Telescope Science Institute), Hibon, P. (Gemini Observatory), Hinkley, S. (University of Exeter), Cotten, T. H. (University of Georgia), Hung, L.-W. (UC Los Angeles), Ingraham, P. (Large Synoptic Survey Telescope), Johnson-Groh, M. (University of Victoria; Herzberg Institute of Astrophysics), Kalas, P. (UC Berkeley; SETI), Lafreniere, D. (University de Montreal), Larkin, J. E. (UC Los Angeles), Lee, J. (University of Georgia), Line, M. (UC Santa Cruz), Long, D. (Space Telescope Science Institute), Maire, J. (University of Toronto,), Marchis, F. (SETI), Matthews, B. C. (Herzberg Institute of Astrophysics; University of Victoria), Max, C. E. (UC Santa Cruz), Metchev, S. (University of Western Ontario; Stony Brook University), Millar-Blanchaer, M. A. (University of Toronto), Mittal, T. (UC Berkeley), Morley, C. V. (UC Santa Cruz), Morzinski, K. M. (University of Arizona), Murray-Clay, R. (UC Santa Barbara), Oppenheimer, R. (American Museum of Natural History), Patel, R. (Stony Brook University), Perrin, M. D. (Space Telescope Science Institute), Rafikov, R. R. (Princeton University), Rantakyro, F. T. (Gemini Observatory), Rice, E. L. (City University of New York; American Museum of Natural History), Rojo, P. (Universidad de Chile), Rudy, A. R. (UC Santa Cruz), Ruffio, J.-B. (Stanford University; SETI) , Ruiz, M. T. (Universidad de Chile), Sadakuni, N. (Stratospheric Observatory for Infrared Astronomy; Gemini Observatory), Saddlemyer, L. (Herzberg Institute of Astrophysics), Salama, M. (UC Berkeley), Savransky, D. (Cornell University), Schneider, A. C. (University of Toledo), Sivaramakrishnan, A. (Space Telescope Science Institute), Song, I. (University of Georgia), Soummer, R. (Space Telescope Science Institute), Thomas, S. (Large Synoptic Survey Telescope), Vasisht, G. (Jet Propulsion Laboratory), Wallace, J. K. (Jet Propulsion Laboratory), Ward-Duong, K. (Arizona State University), Wiktorowicz, S. J. (UC Santa Cruz), Wolff, S. G. (Johns Hopkins University; Space Telescope Science Institute), Zuckerman, B. (UC Los Angeles), S. Blunt (SETI Institute), D. Vega (SETI Institute)

Abstract

The Gemini Planet Imager (GPI) is a next-generation coronagraphic integral field unit with the sensitivity and resolution to detect planetary companions with separations of 0".2 to 1".0 around a large set of stars. An 890-hour GPI survey of 600 young, nearby stars commenced in late-2014, and approximately 200 stars have been observed thus far. The central aims of the program are: (1) the discovery of a population of giant planets with orbital radii of 5-50 AU comparable to Solar System gas giant orbits, (2) the characterization of the atmospheric properties of young planetary companions, and (3) spatially resolved imaging of debris disks. Initial results from GPI exoplanet observations include the discoveries of new cool companions including a planet and brown dwarf, and a number of resolved debris disks exhibiting a range of structures. An overview of the survey scope, current detection limits, and initial results will be presented.

Deep Near-IR Observations of the Globular Cluster M4

The First Brown Dwarf Candidates in a Globular Cluster

Andrea Dieball (University of Bonn, Germany)

L. R. Bedin (INAF - Osservatorio Astronomico di Padova, Italy), C. Knigge (University of Southampton, UK), R. M. Rich (UCLA, USA), F. Allard (CRAL, France), A. Dotter (ANU, Australia), H. Richer (UBC, Canada), D. Zurek (AMNH, USA)

Abstract

Brown Dwarfs (BDs) present a link between stars and planets, and thus are important for our understanding of both star and planet formation and evolution. The formation of BDs is a matter of considerable dispute. They might have formed just like stars, which would imply a continuous extension of the IMF into the sub-stellar regime. Or they might form via other channels like disk fragmentation and photo-evaporation, which might imply an increase of BDs in denser star clusters like globular clusters. Although large surveys undertaken in the past decade have detected large numbers of BDs, we still do not know much about old, metal-poor BDs. This is where globular clusters come in: they are massive, and thus might have produced BDs in large numbers, and they are also the oldest and most metal-poor stellar aggregates in our Galaxy. In this talk, we present an analysis of deep HST/WFC3 near-IR (NIR) imaging data of the globular cluster M4. The best-photometry NIR colour-magnitude diagram (CMD) clearly shows the main sequence extending towards the expected end of the Hydrogen-burning limit and going beyond this point towards fainter sources. As such, this is the deepest NIR CMD of a globular cluster to date. Archival HST optical data were used for proper-motion cleaning of the CMD and for distinguishing the white dwarfs (WDs) from BD candidates. Comparing our observed CMDs with theoretical models, we conclude that we have reached beyond the H-burning limit in our NIR CMD and are probably just above or around this limit in our optical-NIR CMDs. We visually inspected the positions of all NIR sources which are fainter than the (NIR) H-burning limit and conclude that we found in total four good BD candidates.

POSTERS

001 | Spectral Disentangling With Spectangular
Daniel Sablowski (Leibniz-Institut for Astrophysics Potsdam)

002 | Effect of Viscosity on Propagation of MHD Waves in Astrophysical Plasma
Alemayehu Cherkos (Addis Ababa University)

003 | Formation and Compositions of Planet Interiors and Atmospheres: Discoveries From Kepler, K2, and Beyond.
Erik Petigura (California Institute of Technology)

004 | The MUSCLES Treasury Survey: Predicting the X-Ray and UV Emission of K and M Dwarfs From the Optical Spectrum
Allison Youngblood (University of Colorado at Boulder)

005 | An Observational Test of Hot Dust Nucleation Around Oxygen-Rich Mira, O Ceti
Tomasz Kaminski (ESO Chile)

006 | The Space Environment of Close-In Exoplanets and Its Implications for Planet Habitability
Ofer Cohen (Harvard-Smithsonian CfA)

007 | Semi-Empirical Modeling of the Chromosphere and Transition Region of the M-Dwarf Host Star GJ 832
Jeffrey L. Linsky (JILA, University of Colorado)

008 | Investigating Magnetic Activity in Very Stable Stellar Magnetic Fields: a Study of the Fully Convective M4 Dwarf V374 Peg
Krisztián Vida (Konkoly Observatory (MTA CSFK))

009 | Exoplanet Transits Enable Spectroscopy Across Spatially Resolved Stellar Surfaces
Dainis Dravins (Lund Observatory, Sweden)

010 | Observational Analysis of Convection Related Phenomena in Cool Main Sequence Stars (K-G-F).
Eliana Maritza Amazo-Gomez (Universität Sternwarte München at Ludwig Maximilians Universität)

011 | Mining the Brightest Stars in the Southern Sky With FunnelWeb
Chris Tinney (UNSW Australia)

012 | The Red Giant Branch Bump: a Sensitive Probe of Mixing in Lower Mass Stellar Models
Meridith Joyce (Dartmouth College)

013 | Asteroseismology, an Independent Method of Deriving Stellar Parameters of Red Giants in Binary Systems
Nathalie Themessl (Max Planck Institute for Solar System Research)

014 | Impact of Wind on Circumstellar Dust in Classical T Tauri Star RY Tau
Svetlana Artemenko (Crimean Astrophysical Observatory)

015 | Angular Momentum Transport Efficiency in Post-Main Sequence Low-Mass Stars
Federico Spada (Leibniz-Institut fuer Astrophysik Potsdam (AIP))

016 | Time-Dependent Diameters of Mira Variable Stars
Alma Ruiz-Velasco (Lowell Observatory)

017 | The Temperature and Chronology of Heavy-Element Nucleosynthesis in Low-Mass Stars
Van Eck Sophie (Université Libre de Bruxelles)

018 | Measuring Binary Parameters for Stellar Model Calibration.
Jessica Kirkby-Kent (Keele University)

019 | Dynamic Mineral Clouds on HD 189733b
Graham Lee (University of St Andrews)

020 | Luminosities and Mass-Loss Rates of Local Group AGB Stars and Red Supergiants
Martin Groenewegen (Koninklijke Sterrenwacht van Belgie)

021 | Li-Rich Giants With Substellar Companions, a Hint of Planet Engulfment?
Elisa Delgado Mena (Instituto de Astrofisica e Ciencias do Espaço, Universidade do Porto)

022 | Stellar Multiplicity and Large Spectroscopic Surveys
Edita Sonkute (Lund Observatory)

023 | Gaussian Processes for Disentangling Stellar Activity and Planetary Signals
Vinesh Rajpaul (University of Oxford)

024 | A Catalog of Stellar Evolution Profiles and the Effects of Variable Composition on Habitable Planetary Systems
Amanda Truitt (Arizona State University, School of Earth and Space Exploration)

025 | Investigation of the Environment Around Close-In Transiting Exoplanets Using CLOUDY
Jake Turner (University of Virginia)

026 | The Crowded Magnetosphere of the Post-Common-Envelope Binary QS Virginis
Colin Hill (IRAP / OMP / University of Toulouse)

027 | MHD Simulations of Protostellar Jets: Formation and Stability of Shock Diamonds
Sabina Ustamujic (Complutense University of Madrid)

028 | Gyrochronology at the Solar Age: Rotation Periods for Cool Stars in the Open Cluster M67
Jörg Weingrill (AIP)

029 | The Contribution of Large Star Spots to the Optical-to-IR Spectral Type Mismatches in Pre-Main-Sequence Stars
Jeff Bary (Colgate University)

030 | ExoMol Project: Molecular Line Lists for Exoplanet and Other Hot Atmospheres
Sergey Yurchenko (University College London)

031 | The Dynamo Clinical Trial
Thomas Ayres (University of Colorado)

032 | Emission Lines From the Coronae of Capella
Vinay Kashyap (Harvard-Smithsonian Center for Astrophysics)

033 | Sneak Peeking at Stellar Surfaces
Panos Ioannidis (Hamburger Sternwarte)

034 | The Magnetic Field Geometry of Cool Stars
Victor See (University of St Andrews)

035 | Modeling the Rise of Fibril Magnetic Fields in Fully Convective Stars: Toward Linking Dynamo-Generated Magnetic Fields With Starspots
Maria Weber (University of Exeter)

036 | 2D Dynamics of Radiative Zone of Low-Mass Stars
Delphine Hypolite (CEA)

037 | Withdrawn

038 | The Nearest Isolated Member of the TW Hydrae Association Is a Giant Planet Analog
Kendra Kellogg (The University of Western Ontario)

039 | Lithium Depletion as a Strong Test of Core-Envelope Re-Coupling Timescales
Garrett Somers (The Ohio State University)

040 | Lightning on Exoplanets and Brown Dwarfs?
Gabriella Hodosán (University of St Andrews, UK)

041 | Rotation Periods in the Pleiaes With K2
Luisa Rebull (IRSA/SSC/IPAC/Caltech)

042 | Weather on Other Worlds: Discovery of an Extremely Fast Rotating Brown Dwarf
Megan Tannock (University of Western Ontario)

043 | Rotational Evolution of Slow Rotator Sequence Stars and the Kepler Data.
Alessandro Lanzafame (University of Catania)

044 | A Comparison of Stellar Abundance Techniques
Natalie Hinkel (Arizona State University)

045 | A First Look at the Circumstellar Dust Composition of O-Type Mira Variables Observed With Spitzer
Tina Güth (New Mexico Institute of Mining and Technology (New Mexico Tech))

046 | Helicity Inversion in Spherical Convection as a Means for Equatorward Dynamo Wave Propagation
Lucia Duarte (University of Exeter)

047 | Searching for Extrasolar Coronal Mass Ejections With Radio Spectroscopy
Jackie Villadsen (Caltech)

048 | Messages From the Reversing Layer: Clues to Planet Formation in Stellar Abundances
John Michael Brewer (Yale University)

049 | A New Generation of Stellar Isochrones Including the TP-AGB Phase
Paola Marigo (University of Padova, Italy)

050 | The Connection Between Stellar Rotation and X-Ray Activity in the Kepler Stars
Daniele Pizzocaro (INAF-Istituto di Astrofisica Spaziale e Fisica Cosmica Milano, via E. Bassini 15, 20133 Milano, Italy , Università degli Studi dell'Insubria, Via Ravasi 2, 21100 Varese, Italy)

051 | Analytically Constraining Angular Momentum Transport and Magnetic Field Topology in Stellar Radiative Zones.
Kyle Augustson (CEA Service d'Astrophysique)

052 | Finding the Largest Flares on Ultracool Dwarfs With ASAS-SN
Sarah J. Schmidt (Leibniz Institute for Astrophysics Potsdam (AIP))

053 | Search of Variable Stars in Some Open Star Clusters and Associations
Alisher S. Hojaev (National university of Uzbekistan and Ulugh Beg Astronomical institute of Uzbek Academy of Sciences)

054 | Massive Star Clusters and Comlexes to Giant Molecular Clouds Connection
Alisher S. Hojaev (National university of Uzbekistan and Ulugh Beg Astronomical institute of Uzbek Academy of Sciences)

055 | Rotation Periods of Cool Cluster and Field Stars, and Connections Between Rotational and Other Ages
Sydney Barnes (Leibniz Institute for Astrophysics (AIP))

056 | Anelastic Models of Fully-Convective Stars: Differential Rotation, Meridional Circulation and Residual Entropy
Felix Sainsbury-Martinez (University of Exeter)

057 | Testing the Limits of 1D LTE Spectroscopy of Solar-Like Stars
Amanda Doyle (University of Warwick)

058 | Pulsating AGB Stars: From Models to Abundances
Bernhard Aringer (University of Padova)

059 | The Magnetic Field and Planetary Environment of the Young Sun Iota Horologii
Julián David Alvarado-Gómez (European Southern Observatory (ESO))

060 | Bayesian Mass and Age Estimates for Planet Host Stars: Implications for Models of Cool Stars.
Pierre Maxted (Keele University)

061 | X-Ray Superflares on CC Eri
Subhajeet Karmakar (Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, India)

062 | Hunting for Massive Late-Type Stars in the Inner Disk of the Milky Way.
Maria Messineo (University of science and Technlogy of China)

063 | Flux-Flux and Activity-Rotation Relationships in Early-M Dwarfs
Jesus Maldonado (INAF - Osservatorio Astronomico di Palermo)

064 | Temporal Variability of the Wind From Tau Boötis
Belinda Nicholson (European Southern Observatory)

065 | Plasma Processes in Brown Dwarf Atmospheres
Christiane Helling (University of St Andrews)

066 | The Impact of Stellar Activity on High Energy Exoplanet Transits
Joe Llama (University of St Andrews)

067 | The Physical Mechanism Behind M Dwarf Metallicity Indicators and the Role of C and O Abundances
Mark Veyette (Boston University)

068 | What Does It Take to Make Giant Stars Lose Mass?
Iain McDonald (University of Manchester)

069 | Does the Stellar Signal Cause the Planets Look Like Misaligned?
Mahmoudreza Oshagh (Institute for Astrophysics, Georg-August-University of Göttingen)

070 | APOKASC 2.0: Asteroseismology and Spectroscopy for Cool Stars
Marc Pinsonneault (Ohio State University)

071 | The First CRIRES-POP Atlas: A High Resolution Near-IR Reference Spectrum of K Giant 10 Leo
Christine Nicholls (University of Vienna)

072 | Withdrawn

073 | Discovery of Temperate Earth-Sized Planets Transiting a Nearby Ultracool Dwarf Star
Valerie Van Grootel (Université de Liège (Belgium))

074 | Eccentric or Double – Alone or a Couple? Disentangling Two-Planet Resonant Radial Velocity Orbits From One-Planet Eccentric Ones.
Martin Kürster (Max-Planck-Institut für Astronomie Heidelberg)

075 | More on the Metastable Dynamo Model
Timothy Brown (Las Cumbres Observatory Global Telescope)

076 | Angular Momentum Evolution of Young Low-Mass Stars
Amard Louis (Montpellier/Geneva Universities)

077 | Using Infrared High-Resolution Spectroscopy to Explore M Dwarfs
Sara Lindgren (1. Uppsala University and 2. IPAC Caltech)

078 | The Panchromatic View of Auroral Phenomena in Brown Dwarf Atmospheres
J. Sebastian Pineda (Caltech)

079 | Using Open Cluster Red Giants to Test Atypical Li Enrichment
Joleen Carlberg (NASA/GSFC)

080 | Calibrating Young Stellar Models With Dynamical Masses in the Gaia Era
Aaron Rizzuto (University of Texas at Austin)

081 | Variability in Young, Planetary Mass Objects
Beth Biller (University of Edinburgh)

082 | A Speculative Look at Rotation in the Pleiades Based on the K2 Field 4 Campaign
John Stauffer (IPAC/Caltech)

083 | Metallicity Scales of M-L-T Subdwarfs and the Discovery of Extreme Metal-Poor Very Low Mass Stars
ZengHua Zhang (Instituto de Astrofisica de Canarias)

084 | Magnetic Activity Cycles of Planet Hosting Stars
Adriana Valio (CRAAM - Mackenzie University)

085 | From Stellar Evolution to Tidal Interaction: Impact on Planetary Habitability
Gallet Gallet (Geneva University)

086 | Asteroseismic Tests of Stellar Isochrones
Jamie Tayar (Ohio State University)

087 | The Kepler View of Stellar Flares
James Davenport (Western Washington University)

088 | Observed Effects of Star-Planet Interaction
Scott Wolk (Harvard-Smithsonian Center for Astrophysics)

089 | Atmospheric Properties of T Dwarfs Inferred From Model Fits at Low Spectral Resolution
Paige Godfrey (CUNY Graduate Center, CUNY College of Staten Island, American Museum of Natural History)

090 | Young Methane Brown Dwarfs From the BASS-Ultracool Survey
Jonathan Gagné (Carnegie DTM)

091 | Hot Jets From Young, Cool Stars
Christian Schneider (ESA / ESTEC)

092 | Cool Stars With Extreme Infrared Excesses: Potential Tracers of Planetary Collisions
Christopher Theissen (Boston University)

093 | The Gemini Planet Imager Exoplanet Survey II: Implications for Giant Planet Populations Based on the First 200 Stars
Eric L. Nielsen (SETI/Stanford)

094 | Constraining Substellar Magnetic Dynamos Using Auroral Radio Emission
Melodie Kao (California Institute of Technology)

095 | Searching for Substellar Companions With ExAO Coronagraphic Hyperspectral Imaging at Palomar
Ricky Nilsson (AMNH/Caltech/SU)

096 | Measuring the Ultraviolet Variability of M Dwarfs With GALEX
Brittany Miles (UCLA)

097 | Discovery of Young L Dwarfs in Taurus and Scorpius-Centaurus
William M. J. Best (Institute for Astronomy, University of Hawaii)

098 | A Visual Multiple Containing Three Eclipsing Binaries Spanning B–M Spectral Types
Edward Gillen (University of Cambridge)

099 | The Magnetic Coupling of Photospheres to Winds in Late Type Evolved Stars
Vladimir Airapetian (NASA GSFC)

100 | Effects of Space Weather From Active Stars on the Chemisty of Earth Twins: Atmospheric Biosignatures
Vladimir S. Airapetian (NASA Goddard Space Flight Center, Greenbelt, MD, USA)

101 | Imaging All the Sky, All the Time, in the Search for Radio Emission From Extrasolar Planets
Marin M Anderson (Caltech)

102 | Mapping the Mass-Luminosity Relation From the End of the Main Sequence Through the L/T Transition
Trent Dupuy (University of Texas at Austin)

103 | Polarized Millimeter Emission of Solar Flares
Adriana Valio (CRAAM - Mackenzie University)

104 | Identification of Young Substellar Candidates in L1495 With the CFHT W-Band Survey
Poshih Chiang (National Central University)

105 | Li-Rich AGB/RGB Stars: Lithium Abundances and Mass Loss
Walter Maciel (Universitiy of Sao Paulo)

106 | Measuring Rotation Periods of Solar-Age Stars in the M67 Open Cluster Using K2 Data
Rebecca Esselstein (University of Oxford)

107 | Parameter and Abundance Estimation With SME and the Cannon for Galactic Archaeology With HERMES (GALAH)
Sven Buder (MPIA Heidelberg)

108 | A Self-Consistent Dynamo Model for Low-Mass Fully Convective Stars
Rakesh Yadav (Harvard-Smithsonian CfA)

109 | Studies of the Coldest Brown Dwarfs With the James Webb Space Telescope
Thomas Roellig (NASA - Ames Research Center)

110 | Distribution of the Nearest Brown Dwarfs on the Galactic Plane
Gabriel Bihain (Leibniz-Institut für Astrophysik Potsdam (AIP)

111 | Probing the Abundance of SiO and HCN Throughout the Stellar Wind of R Dor
Marie Van de Sande (KU Leuven)

112 | Carmenes: Performance and Science Program
Andreas Quirrenbach (Landessternwarte Heidelberg)

113 | The Activity Cycles of Tau Bootis
Matthew Mengel (University of Southern Queensland)

114 | An Updated MHD EOS, and Some Early Results for Cool Stars
Regner Trampedach (Space Science Inst., Boulder, CO, USA.)

115 | Testing Coronal Heating Models With Dielectronic Recombination Satellites
Nancy Brickhouse (Harvard-Smithsonian CfA)

116 | The Phase-Dependent Ca II K Emission of Zeta Aur K-Type Supergiants: Chromospheric Heating Versus Irradiation Induced Emission
Violeta Gamez Rosas (Universidad de Guanajuato, Mexico)

117 | Statistical Properties of Superflares on Solar-Type Stars With Kepler Data
Yuta Notsu (Kyoto University, Japan)

118 | High Dispersion Spectroscopy of Solar-Type Superflare Stars With Subaru/Hds
Yuta Notsu (Kyoto University, Japan)

119 | Spectroscopic Characterisation of CARMENES Target Candidates From FEROS, CAFE and HRS High-Resolution Spectra
Vera Maria Passegger (Institut für Astrophysik Göttingen)

120 | The HADES RV Programme With HARPS-N@TNG - GJ3998: an Early M-Dwarf Hosting a System of Super-Earths
Laura Affer (INAF - Osservatorio astronomico di Palermo)

121 | UV and X-Ray Emission From Impacts of Fragmented Accretion Streams on Classical T Tauri Stars
Salvatore Colombo (INAF- Osservatorio Astronomico di Palermo)

122 | The Line Bisectors of G Type Giant Star HD199719
Mesut Yilmaz (Ankara University)

123 | Does the Relation Between Hα and Ca II H+K Fluxes Changes Over the Stellar Cycle?
Andrea Buccino (IAFE)

124 | An Optical Megaflare on EV Lac
B. R. Pettersen (University of Oslo)

125 | Detecting Structural Transformations and Flares Activity in Binary Stars With a Cool Companion
Daniela Boneva (Space Research and Technology Institute, Sofia, Bulgaria)

126 | A Catalog of GALEX Ultraviolet Emission from Asymptotic Giant Branch Stars
Rodolfo Montez (Smithsonian Astrophysical Observatory)

127 | X-Rays, Coronae and Activity Cycles of Solar-Like Stars
Jan Robrade (Hamburger Sternwarte)

128 | The Nucleosynthetic History of Elements in the Galactic Disk: [X/Fe] - Age Relations From High-Precision Spectroscopy
Lorenzo Spina (Universidade de Sao Paulo)

129 | Abundance Analysis of the CP Star HR 465 Using HST Advanced Spectral Library (ASTRAL) Data
Kenneth Carpenter (NASA's GSFC)

130 | Atomic Data of Neutral Magnesium, Mg I, for Astrophysical Applications
Asli Pehlivan (Lund Observatory)

131 | The Gaia-Eso Survey: A Lithium-Rotation Connection at 5 Myr?
Jerome Bouvier (IPAG)

132 | The Solar Dynamo Zoo
Ricky Egeland (High Altitude Observatory/Montana State University)

133 | Lithium Abundance of the Solar-Type Superflare Stars
Satoshi Honda (University of Hyogo)

134 | Spatially Resolved Spectroscopy Across HD189733 (K1V) Using Exoplanet Transits
Martin Gustavsson (Lund Observatory)

135 | On the Bimodal Distribution of Stellar Rotation in Young Open Clusters
Philippe Gondoin (ESA)

136 | Implications of the Mid-IR for ALMA Flare Observations
Hugh Hudson (UC Berkeley/U. of Glasgow)

137 | The First Search for Exoplanet Weather
Johanna Vos (University of Edinburgh)

138 | Calculations of S-Type and P-Type Habitable Zones in Binary Systems: a Combined Approach
Zhaopeng Wang (University of Texas at Arlington)

139 | Chandra and Kepler Monitoring of Ultracool Dwarfs
Rishi R. Paudel (University of Delaware)

140 | Age Constraints on the Scorpius-Centaurus OB Association From Supernova Ejecta in Ocean Cores
Megan Hyde (Rockhurst University)

141 | Distances, Metallicities, and Calibrated Griz Photometry of the Nearby Mid-To-Late M Dwarfs
Jason Dittmann (Harvard University)

142 | Hunting for Strong Magnetic Fields in Rapidly Rotating Sun-Like Stars
Denis Shulyak (Goettingen University)

143 | Want a PEPSI? First Spectra With the Potsdam Echelle Polarimetric and Spectroscopic Instrument
Strassmeier Klaus (AIP)

144 | Identifying the Ejected Population From Disintegrating Multiple Systems
Alexandra Ka Po Yip (Universidad de Valparaiso)

145 | Weird: Wide Orbit Exoplanet Search With InfraRed Direct Imaging
Frédérique Baron (Université de Montréal)

146 | PHOENIX Meets CO5BOLD: 3D Radiative Transfer Calculations for M-Dwarfs Chromospheres
Ivan De Gennaro Aquino (Hamburger Sternwarte)

147 | The Sun Like Stars: HT Vir
Mehmet Tanriver (Erciyes University)

148 | Spot Properties of Cool Stars From Spot Crossing Events in Planetary Transit Light Curves
John Southworth (Keele University, UK)

149 | Relation Between Brown Dwarfs and Exoplanets
Lauren Melissa Flor Torres (Universidad de Guanajuato, México)

150 | A Stellar Census of the 32 Ori Moving Group
Cameron Bell (ETH Zürich)

151 | Activity and Period Evolution in Ar Lac Observed by TIGRE
Stefan Czesla (Hamburger Sternwarte)

152 | Rotation and Spot Activity of Young Solar-Type Stars From Long-Term Photometric Monitoring
Jyri Lehtinen (University of Helsinki, Aalto University)

153 | Substellar Binaries From Pan-Starrs1 Image Shape Measurement
Niall Deacon (University of Hertfordshire)

154 | Searching for Giant Planets in Wide Orbits
Niall Deacon (University of Hertfordshire)

155 | The K2 Survey of Ruprecht 147
Jason Curtis (Penn State / SAO)

156 | Surface Brightness Calibration for AKARI/FIS Pointed-Observation Images of Compact Extended Sources: Application to Evolved Star Circumstellar Shells
Toshiya Ueta (Univ. of Denver)

157 | Surface Brightness Calibration for AKARI/FIS All-Sky Survey Scan Maps of Compact Extended Sources: Application to Planetary Nebulae
Toshiya Ueta (Univ. of Denver)

158 | Stellar Properties for 138,600 Targets Observed by the K2 Mission
Daniel Huber (University of Sydney)

159 | A Candidate Young Massive Planet in Orbit Around the Classical T Tauri Star CI Tau
Christopher Johns-Krull (Rice University)

160 | Simulation of the Small-Scale Magnetism in Main Sequence Stellar Atmospheres
René Georg Salhab (Kiepenheuer-Institut für Sonnenphysik)

161 | Fundamental Stellar Parameters for Weak-Line T Tauri Stars From NGC 2264
Ana Rei (Instituto de Astrofísica e Ciências do Espaço)

162 | Mean-Flow Hydrodynamics for Outflows in Stellar Evolution Models
Lars Mattsson (Nordita, KTH Royal Institute of Technology & Stockholm University)

163 | The Dust Storm in RW Aurigae
Gösta F. Gahm (Stockholm university, Sweden)

164 | An Analytical Test Case for Dust Dynamics During a Shock-Wave Passage
Lars Mattsson (Nordita, KTH Royal Institute of Technology & Stockholm University)

165 | A Survey of Long-Term X-Ray Variability in Cool Stars
John Pye (University of Leicester)

166 | Theoretical K-logP Relations for O-Rich and C-Rich Miras
Michele Trabucchi (Department of Physics and Astronomy G. Galilei, University of Padova)

167 | Probing the Effect of UV Chemistry in the Circumstellar Envelope of R Scl.
Maryam Saberi (Chalmers University of technology & Onsala Sapace Observatory)

168 | Flares of Nearby, Mid-To-Late M-Dwarfs Characterized by the MEarth Project
Nicholas Mondrik (Harvard University)

169 | Magnetic Models of Pre-Main Sequence, Low-Mass Stars With Starspots
Luiz Themystokliz Mendes (Universidade Federal de Minas Gerais)

170 | Preliminary Outcomes for 3D Facular Modelling
Charlotte Norris (Imperial College London)

171 | Blinded by the Lines: Mid-IR Spectra of Mira Variables Observed With Spitzer
Dana Baylis (New Mexico Institute of Mining and Technology)

172 | Using High Resolution X-Ray Spectra to Probe Accretion, Abundances, and Coronal Activity in the Young Cluster IC 348
David Huenemoerder (MIT)

173 | Zodiacal Exoplanets in Time: Watching Planets and Their Host Stars Evolve From Infancy to Maturity
Andrew Mann (University of Texas at Austin)

174 | Resolving M-Dwarf Binaries in Young Moving Groups (YMGs) With MagAO
Yutong Shan (Harvard University)

175 | The X-Ray Luminosity Function of M37 and the Evolution of Coronal Activity in Low-Mass Stars
Alejandro Nunez (Columbia University)

176 | Time Resolved Spectroscopic Observations of an M-Dwarf Flare Star EV Lac During a Flare
Satoshi Honda (University of Hyogo)

177 | Discoveries From the NEOWISE-Reactivation Proper Motion Survey
Jennifer Greco (University of Toledo)

178 | Magnetic Fields of Weak-Line T Tauri Stars
Belinda Nicholson (European Southern Observatory)

179 | STELLA Meets RAVE: Calibrating Low-Resolution Ca II IRT Fluxes
Silva Järvinen (Leibniz Institute for Astrophysics Potsdam (AIP))

180 | Cool Red Giants at the Edge of the Milky Way
John Bochanski (Rider University)

181 | The Double Open Cluster NGC 2451
Elena Franciosini (INAF - Osservatorio Astrofisico di Arcetri)

182 | Scaling Laws in Rotating Convection
Laura Currie (University of Exeter)

183 | CRIRES+: a Plus for the Cool Stars Community
Alexis Lavail (Uppsala University, ESO)

184 | Parallel Numerical Algorithms for Radiative Transfer
Viktoria Wichert (Hamburg Observatory)

185 | Parallelisation of Critical Code Passages in PHOENIX/3D Radiative Transfer
Mario Arkenberg (Hamburg Observatory)

186 | Map Comparison Between Quadruple Masers of the Red Supergiant S Per Using VLBI Source/Frequency Phase Transfer Technique
Yoshiharu Asaki (National Astronomical Observatory of Japan/Joint ALMA Observatory)

187 | Flare and Starspot-Induced Variabilities of Red Dwarf Stars in the Open Cluster M37: Photometric Study on Stellar Magnetic Activity
Seo-Won Chang (Yonsei University Observatory)

188 | Activity Cycle of Tau Boo Observed With TIGRE
Marco Mittag (Hamburger Sternwarte)

189 | Calibrating the TP-AGB Phase Through Resolved Stellar Populations in the Small Magellanic Cloud
Giada Pastorelli (Department of Physics and Astronomy G. Galilei - University of Padova)

190 | Determination of Activity and Rotation Periods From TIGRE Observations of the Calcium Infrared Triplet.
Johannes Martin (Universität Hamburg, Hamburger Sternwarte)

191 | M-Dwarf Chromospheres Observed With CARMENES
Stefan Czesla (Hamburger Sternwarte)

192 | An Improved Yet Enigmatic Near-Infrared Spectrum of the Archetype Y Dwarf WISE 1828+2650
Michael Cushing (University of Toledo)

193 | Magnetism: Placing the Sun in a Stellar Context
Aline Vidotto (Trinity College Dublin)

194 | Magnetic Braking of Cool Stars: Dependence on Coronal Temperature.
George Pantolmos (University of Exeter)

195 | TiO Band Analysis of Cool Stars Using Model Atmospheres
Hakan Volkan Senavci (Ankara University, Faculty of Science, Astronomy and Space Sciences Department, TR06100 Tandoğan, Ankara Turkey)

196 | The Dustiest AGB Stars in the Magellanic Clouds
Olivia Jones (STScI)

197 | Wind Models for M-Type AGB Stars in LMC
Sara Bladh (University of Padova)

198 | Calibrating the Metallicity of M-Dwarfs With Wide Physical Binaries Containing an F, G, or K Primary
David Montes (UCM, Universidad Complutense de Madrid, Spain)

199 | Panchromatic Integral-Field Approach to Probe Both the Gas and Dust Components in Planetary Nebulae
Toshiya Ueta (Univ. of Denver)

200 | Long-Term Starspot Activity of Some RS CVn and BY Dra Stars
Alla Kozhevnikova (Astronomical Observatory of Ural Federal University)

201 | M-Dwarf Astrophysics (And Planets) From the MEarth Transiting Planet Survey
Jonathan Irwin (Harvard-Smithsonian Center for Astrophysics)

202 | Properties of Disks Around Young Stars: Comparison Between Observations and MHD Models of Accretion Shocks
Rosaria Bonito (Unipa INAF Osservatori Astronomico di Palermo)

203 | CNO Abundances in Late-Type Stars in the Light of 3D Model Stellar Atmospheres
Remo Collet (Stellar Astrophysics Centre, Aarhus University)

204 | Laboratory Astrophysics for Near-Infrared Spectroscopy'
Henrik Hartman (Malmö University and Lund Observatory)

205 | Atmospheric Retrievals in the Cloudy Regime of Free-Floating Planetary Mass Objects and Directly Imaged Exoplanets
Ben Burningham (NASA Ames Research Center & University of Hertfordshire)

206 | The Mass-Radius Relation of Young Stars
Adam Kraus (UT-Austin)

207 | Mg II Chromospheric Emission Line Bisectors of HD39801 and Its Relation With the Activity Cycle.
Leonardo Enrique García García (Universidad Autónoma de Zacatecas, México)

208 | Testing Pre–Main-Sequence Models at the Lithium Depletion Boundary With Dynamical Masses
Trent Dupuy (University of Texas)

209 | Abundance Diagnostics From Optical Oxygen Lines
Andrea Dupree (Harvard-Smithsonian Center for Astrophysics)

210 | Solar Activity in Sun-As-A-Star Chromospheric and Photospheric Measurements
Serena Criscuoli (National Solar Observatory)

211 | Too Cool for Stellar Rules: a Bayesian Exploration of Trends in Ultracool Magnetism
Ellie Schwab (CUNY-The City College of New York)

212 | Taking the Next Step: Measuring Temperatures and Metallicities of M Dwarfs in Eclipsing Binaries
Yilen Gomez Maqueo Chew (Instituto de Astronomia UNAM)

213 | The [Y/Mg] Clock: Estimating Stellar Ages of Solar-Type Stars
Marcelo Tucci Maia (LNA/MCTI)

214 | Cool Young Stars in the Time Domain: the View With K2
Ann Marie Cody (NASA Ames)

215 | Why Are Rapidly Rotating M Dwarfs in the Pleiades So (Infra)red? New Period Measurements Confirm Rotation-Dependent Color Offsets From the Cluster Sequence
Kevin Covey (Western Washington University)

216 | Variations of Mass-Loss Rates in AGB Stars During Pulsations
Hyun-Il Sung (Korea Astronomy and Space Science Institute)

217 | On the Origins of Sub-Subgiants: Mass Transfer, Dynamical Encounters, and Magnetic Fields
Emily Leiner (University of Wisconsin– Madison)

218 | Chromospheric Line Bisector of Mg II and Its Relation With Chromospheric Activity.
Maria Isabel Perez Martinez (Universidad Autonoma de Zacatecas, Mexico)

219 | Determining the Stellar Initial Mass by Means of the 17o/18o Ratio on the AGB
Rutger De Nutte (Institute of Astronomy - KU Leuven)

220 | Magnetoconvection With Helical Background Fields
Manfred Küker (Leibniz-Institut für Astrophysik Potsdam)

221 | Non-Radial Oscillations in AGB Stars
Josefina Montalban (University of Padua)

222 | The Origin and Chemical Evolution of Iron-Peak and Neutron-Capture Elements in the Milky Way Disk
Chiara Battistini (ZAH - LSW Heidelberg)

223 | Ssalmon: The Solar Simulations for the Atacama Large Millimeter Observatory Network
Sven Wedemeyer (University of Oslo)

224 | (Near-)Simultaneous X-Ray and Radio Observations of Ultracool Dwarfs
Beate Stelzer (INAF - Osservatorio Astronomico di Palermo, Italy)

225 | A History of Highly Variable Mass Loss – A Far-IR View on AGB Stars
Marko Mecina (University of Vienna)

226 | Results From DROXO. IV. EXTraS Discovery of an X-Ray Flare From the Class I Protostar Candidate ISO-Oph 85
Daniele Pizzocaro (INAF-Istituto di Astrofisica Spaziale e Fisica Cosmica Milano, via E. Bassini 15, 20133 Milano, Italy , Università degli Studi dell'Insubria, Via Ravasi 2, 21100 Varese, Italy)

227 | Evidence for a Double Coronal Cycle in the Young Solar Analog Iota Hor
Jorge Sanz-Forcada (Centro de Astrobiologia (CAB, INTA-CSIC))

228 | Dynamical Masses in the Young Triple System TWA5
Rainer Koehler (University of Innsbruck)

229 | A Multi-Wavelength View of Magnetic Flaring From PMS Stars
Ettore Flaccomio (INAF - Osservatorio Astronomico di Palermo)

230 | Measurement of Starspot Properties by Forward Modeling IGRINS Spectra of LkCa4
Michael Gully-Santiago (Kavli Institute for Astronomy and Astrophysics)

231 | Properties of Disks Around Young Stars: Comparison Between Observations and MHD Models of Accretion Shocks
Rosaria Bonito (Unipa INAF Osservatori Astronomico di Palermo)

232 | Hot Super-Earths Stripped by Their Host Stars
Mia Sloth Lundkvist (ZAH, Landessternwarte)

233 | The Influence of Differential Rotation and Flux Emergence Rate on the Surface Magnetic Field Topology
Lisa Theres Lehmann (University of St Andrews)

234 | A Calibration of the Mixing-Length Parameter Based on 3D Convection Simulations for Rotating Stars With Magnetic Fields
Lewis Ireland (University of Exeter)

235 | Mass Segregation, but No Equipartition: Gaia-Eso Observations of Open Cluster NGC 2516
Rob Jeffries (Keele University)

236 | The Origin and Chemical Evolution of Iron-Peak and Neutron-Capture Elements in the Milky Way Disk
Chiara Battistini (ZAH - LSW Heidelberg)

237 | The UBVRI and Infrared Colour Indices of the Sun and Sun-Like Stars
Mehmet Tanriver (Erciyes University)

238 | The Sun on Steroids: Radio Emission From Young Suns
Joe Llama (University of St Andrews)

239 | Azimuthal Dynamo Waves in Theory and Observation
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