IAUS 347: Early Science with ELTs (EASE)
Proceedings IAU Symposium No. xxx, 2015
A.C. Editor, B.D. Editor & C.E. Editor, eds.

DOI: 00.0000/X000000000000000X

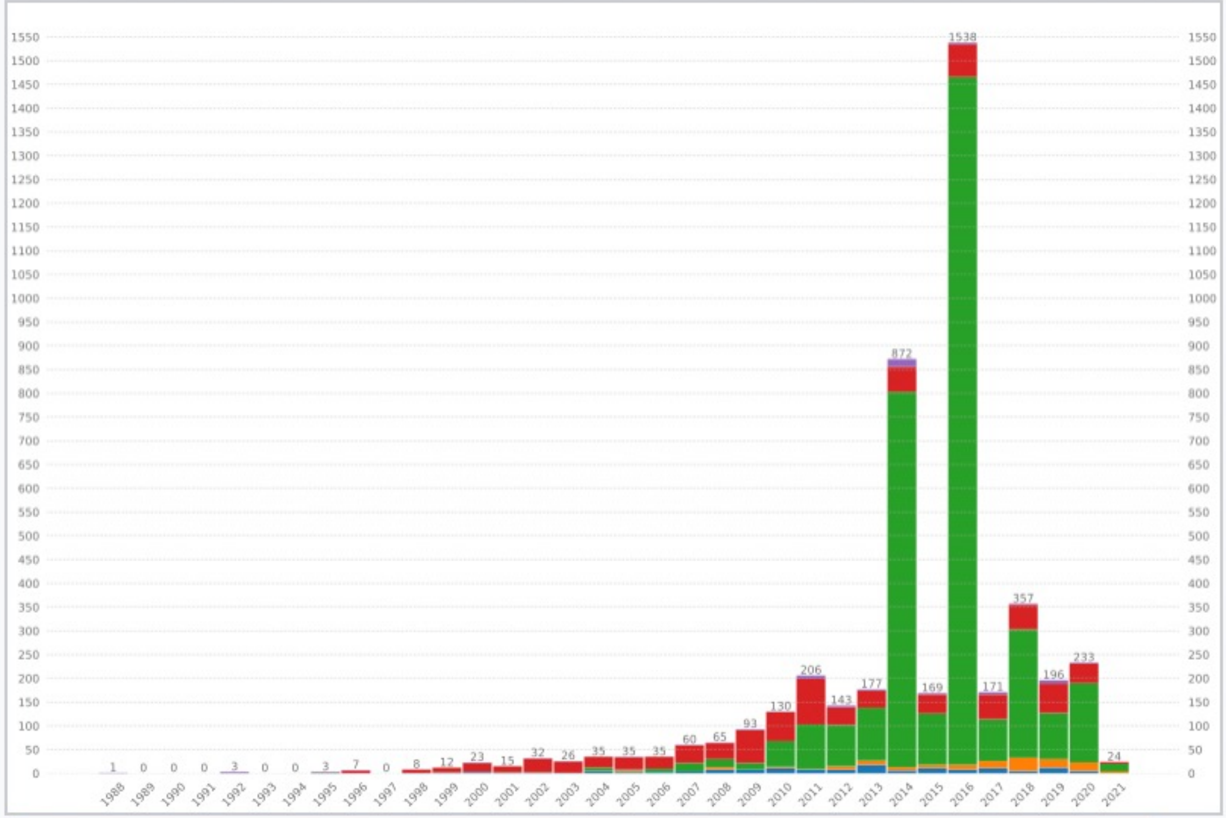
Direct Imaging of Exoplanets at the Era of the Extremely Large Telescopes

Gaël Chauvin[1,2]

[1] Unidad Mixta Internacional Franco-Chilena de Astronomía, CNRS/INSU UMI 3386 and Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile,

[2] Univ. Grenoble Alpes, CNRS, IPAG, F-38000 Grenoble, France.
email: gael.chauvin@univ-grenoble-alpes.fr

Dr Priya Hasan
Asst Professor in Physics
Maulana Azad National Urdu University
Hyderabad
priya.hasan@gmail.com



Number of extrasolar planet discoveries per year through 2020, with colors indicating method of detection:

- Direct imaging
- Microlensing
- Transit
- Radial velocity
- Timing

Problems in Exoplanet Detection

- A planet is an extremely faint light source compared to its parent star.
- For example, a star like the Sun is about a billion times as bright as the reflected light from any of the planets orbiting it. In addition to the intrinsic difficulty of detecting such a faint light source, the light from the parent star causes a glare that washes it out. For those reasons, very few of the exoplanets reported as of April 2014 have been observed directly, with even fewer being resolved from their host star.
- astronomers have generally had to resort to indirect methods to detect extrasolar planets.

Exoplanet imaging

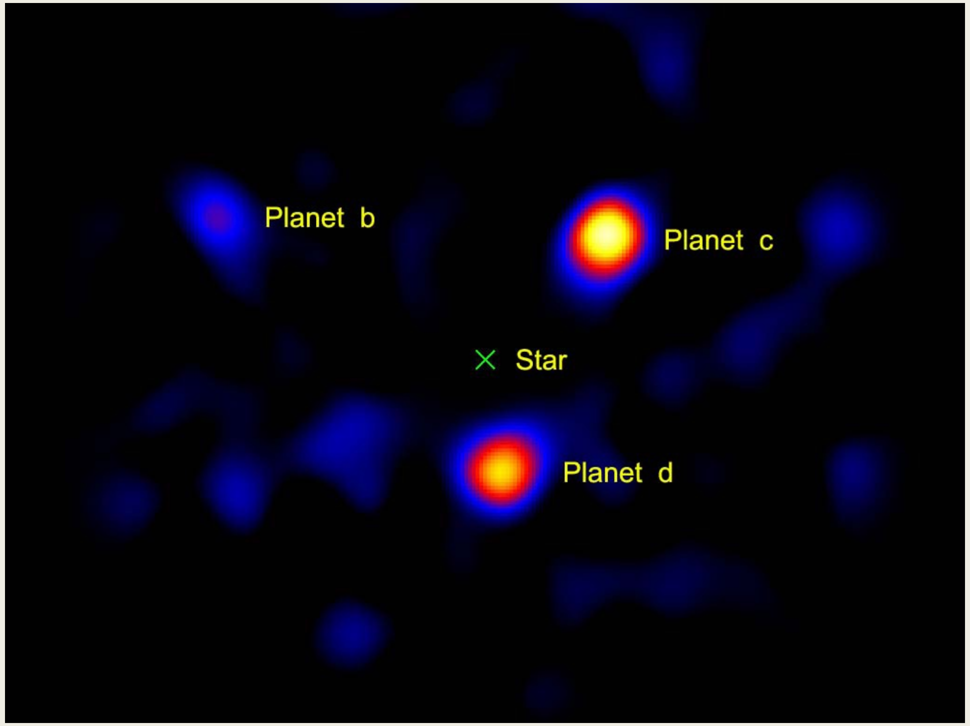
- Planets orbiting far enough from stars to be resolved reflect very little starlight, so planets are detected through their thermal emission instead.
- It is easier to obtain images when the star system is relatively near to the Sun, and when the planet is especially large (considerably larger than Jupiter), widely separated from its parent star, and hot so that it emits intense infrared radiation
- ; images have then been made in the infrared, where the planet is brighter than it is at visible wavelengths. Coronagraphs are used to block light from the star, while leaving the planet visible. Direct imaging of an Earth-like exoplanet requires extreme optothermal stability.[55] During the accretion phase of planetary formation, the star-planet contrast may be even better in H alpha than it is in infrared – an H alpha survey is currently underway.[56]

Observing modes

imaging (IMG)

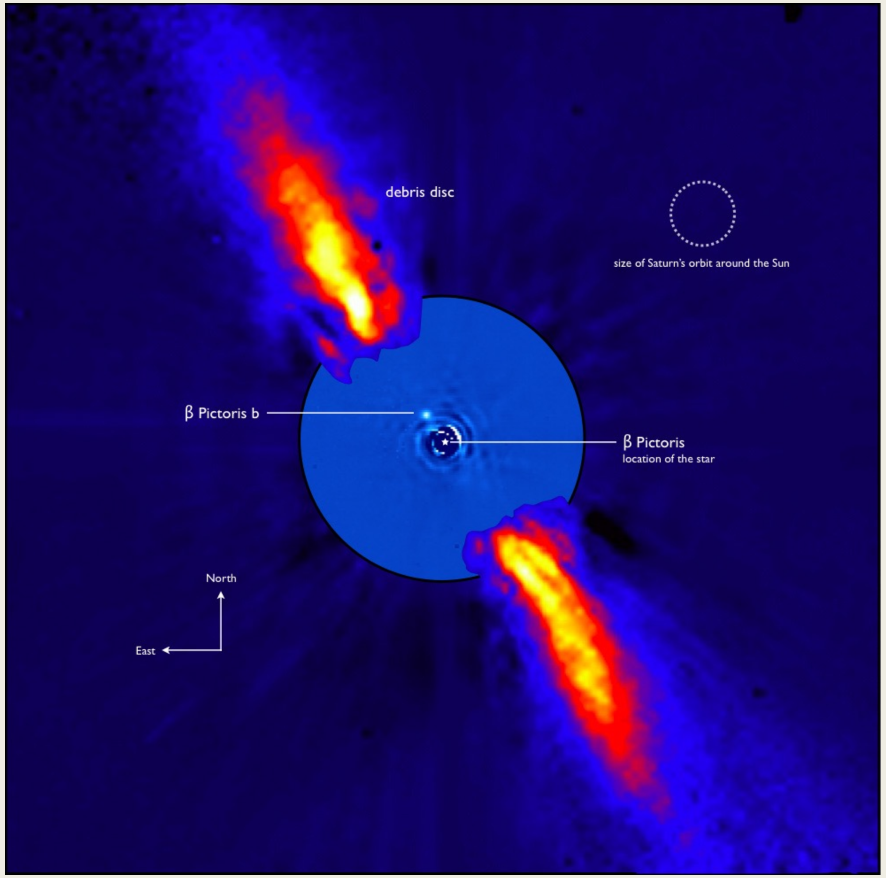
medium and high resolution spectroscopy (MRS, HRS)

integral field spectrograph (IFS) + combined with coronography (corono) or polarimetry (polar).



Direct image of exoplanets around the star HR8799 using a Vortex coronagraph on a 1.5m portion of the Hale telescope

Beta Pictoris



- This composite image represents the close environment of Beta Pictoris as seen in near infrared light. This very faint environment is revealed after a very careful subtraction of the much brighter stellar halo. The outer part of the image shows the reflected light on the dust disc, as observed in 1996 with the ADONIS instrument on ESO's 3.6 m telescope; the inner part is the innermost part of the system, as seen at 3.6 microns with NACO on the Very Large Telescope.

TMT

THIRTY METER TELESCOPE

An ELT Instrumentation "Equivalence Table"

Type of Instrument	GMT	TMT	E-ELT
Near-IR, AO-assisted Imager + IFU	GMTIFS	IRIS	HARMONI
Wide-Field, Optical Multi-Object Spectrometer	GMACS	MOBIE	OPTIMOS
Near-IR Multislit Spectrometer	NIRMOS	IRMS	
Deployable, Multi-IFU Imaging Spectrometer		IRMOS	EAGLE
Mid-IR, AO-assisted Echelle Spectrometer		MIRES	METIS
High-Contrast Exoplanet Imager	TIGER	PFI	EPICS
Near-IR, AO-assisted Echelle Spectrometer	GMTNIRS	NIRES	SIMPLE
High-Resolution Optical Spectrometer	G-CLEF	HROS	CODEX
"Wide"-Field AO Imager		WIRC	MICADO

Luc Simard AO 4 ELT 3 Conference Firenze, May 27 - 31, 2013

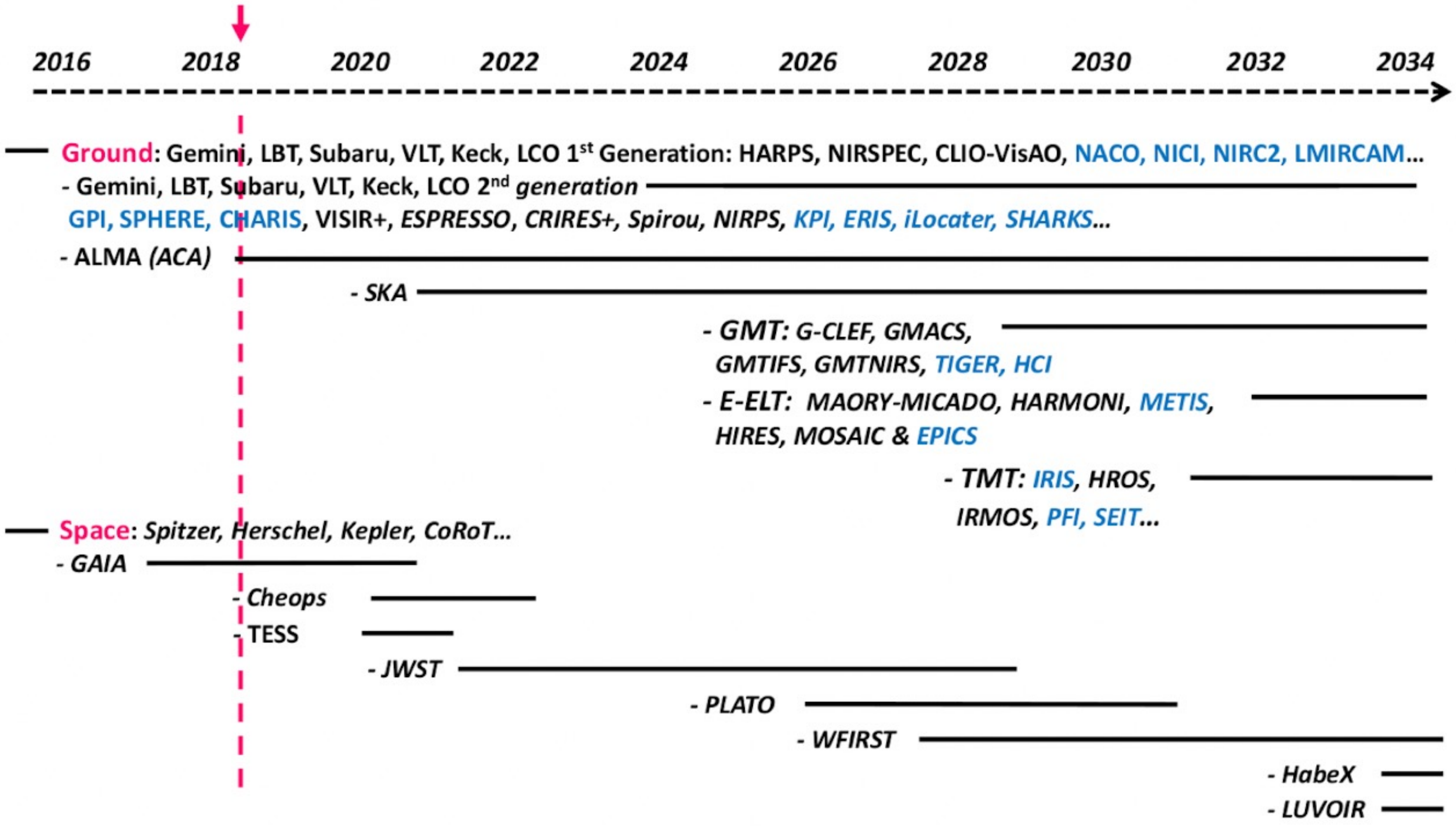


Figure 1. Timeline of current & future missions and instruments dedicated to exoplanets.

Table 1. Instrumentation roadmap of the ELTs summarizing instruments and modes adapted for high contrast imaging and spectroscopy of exoplanets and disks. For AO flavors: seeing-limited (SL), single-conjugated AO with moderate-Strehl (SCAO) and extreme-AO with high-Strehl performances (XAO). Various observing modes are proposed: imaging (IMG), medium and high resolution spectroscopy (MRS, HRS), integral field spectrograph (IFS), combined with coronography (corono) or polarimetry (polar).

Telescope (*1st Light*)	Instrument	AO	Mode	λ (μm)	Spectral resolution	FoV ($''$)	Add.
E-ELT	MICADO	SCAO	IMG	$0.8-2.4$	BB, NB	53	corono
(*2024*)		SCAO	MRS	$0.8-2.4$	< 15000	$3-$ *slit*	
	HARMONI	SCAO	IFS	$0.5-2.5$	3500-20000	0.6	corono
	METIS	SCAO	IMG	$3-19$	BB, NB	18	corono
		SCAO	MRS	$3-19$	5000	18	
		SCAO	IFS	$3-13$	100000	0.4	corono
	HIRES	SCAO	IFS	0.33-2.4	< 150000	0.09	
	EPICS	XAO	IFS	0.95-1.65	125-20000	0.8	corono
		XAO	IMG	0.6-0.9	BB, NB, DBI	2	polar
GMT	G-CLEF	SCAO	HRS	$0.4-1.0$	20000-100000	7×0.23	corono
(*2024*)	GMTIFS	SCAO	IMG	$1.0-2.5$	BB, NB	20	
		SCAO	IFU	$1.0-2.5$	5000-10000	0.5×0.25	
	GMTNIRS	SCAO	HRS	$1.1-2.5$	65000	$1.2-$ *slit*	
		SCAO	HRS	$3.0-5.0$	85000	$1.2-$ *slit*	
	TIGER	SCAO	IMG	$1.5-14.0$	300	30	corono
		SCAO	LRS	$1.5-14.0$	300	30	corono
TMT	IRIS	SCAO	IMG	$0.85-2.4$	BB, NB	33	
(*2028*)		SCAO	IFS	$0.85-2.4$	4000-8000	0.06×0.5	
	MICHI	SCAO	IMG	$3-14$	BB, NB	28	corono
		SCAO	LRS	$3-14$	600	$28-$ *slit*	corono
		SCAO	HRS	$3-14$	< 120000	$2-$ *slit*	corono
		SCAO	IFS	$7-14$	1000	0.18×0.07	corono
	NIRES	SCAO	HRS	$1.0-2.4$	20000-120000	$2-$ *slit*	
	PFI	XAO	IMG	$1-2.5$	BB, NB, DBI	1	corono
		XAO	IFS	$1-2.5$	100	1	corono