Science Programme
v1.0

May 1, 2019

Motivation of Meeting

The motivation of our meeting is to make progress connecting the latest observational and theoretical research involving accretion onto massive black holes, e.g. for the "Changing Look" AGN/quasars and TDEs, with particular emphasis on physical processes that we are now observing over short timescales. The "crisis" refers to the severe problems these observations cause for accretion theory, though we welcome any other sense of crisis that attendees care to introduce!

We will keep the programme loosely packed in general, with plenty of time in the schedule for organic discussions arising during both the talks, as well as organized discussion sessions.

Scientific Organizing Committee

Chris Done (Durham University)
Suvi Gezari (University of Maryland)
Andy Lawrence (University of Edinburgh)
Chelsea MacLeod (CfA, Harvard)
Nic Ross (University of Edinburgh)
Belinda Wilkes (CfA, Harvard)

Local Organizing Committee

Philip Best
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ePosters

The disk-corona interplay in radiatively efficient broad-line AGN

Riccardo Arcodia

Through the years, AGN accretion theory has lagged behind with respect to the plethora of observational signatures driven by accretion onto supermassive black holes. For instance, the correlation observed between monochromatic logarithmic L_X and $L_{\rm UV}$, representing the smoking gun of the disk-corona interplay in radiatively-efficient AGN, still lacks a conclusive theoretical explanation, despite being used for many applications. We tested our disk-corona model (Arcodia+ in subm.) against the observed log L_X-log L_{UV}. The model can predict its key ingredient, namely a slope smaller than one, in terms of modified viscosity prescriptions in the flow inherently yielding a corona emission that increases less than the disk emission going from low- to high-accretion states. We also put forward a more quantitative observational test using a reference sample of broad-line AGN and modeling every source in the L_X-$L_{\rm UV}$ plane, to have an in-depth understanding of the physics driving the slope, normalization and scatter of one of the most used AGN X-ray to UV observables.

In the blink of a cosmic eye

Alastair Bruce

In 1998 a nova was seen in M31. Several years later, follow-up observations determined that this was no ordinary nova but rather a distant AGN which had undergone a dramatic outburst over a period of approximately two years. Of a number of possible scenarios to explain this unusual behaviour, one particularly interesting possibility is that this was a rare, high-amplitude microlensing event. I will discuss the evidence that supports this hypothesis, the serendipitous observation of a second, similar event and the future prospects for detecting more of these cosmic winks from Andromeda.

The peculiar AGN outburst Gaia16aax

Giacomo Cannizzar

Gaia16aax is a transient event discovered in January 2016. It is spatially associated with the nucleus of a known Quasar at $z = 0.25$. The source brightened by 1.5 magnitude over the course of 6 months, and decayed back into its pre-outburst state in 2 years. The historical data from the source show that this is the first time we observe the source in such an outbursting state. We present the analysis of the outburst decay of the source, with multi-wavelength photometry and spectroscopy: during its outburst state the spectra show a strong blue continuum that fades over time and broad Balmer lines

with multi-peaked line profiles, in contrast with its archival spectrum where the same lines showed a simpler morphology.

We will discuss possible scenarios that could explain the emission, such as disk instabilities or a Tidal Disruption Event, in the framework of known AGN variability.

Studying the geometry and dynamics of the inner accretion flows in AGN via FeK line variability

Deborah Costanzo

Dynamics and geometry of the innermost regions of accretion flows in AGN are still largely uncertain; a fundamental way to understand them is the study of X-ray variability properties of the Fe K line complex, a probe of the structure of the matter flows close to SMBH and of their physical state.

I analyzed XMM-Newton spectra of bright X-ray nearby Seyfert 1 galaxies, adopting the analysis technique of residual mapping: long exposures are sliced in time, and each spectrum is fitted with simple models accounting only for the continuum; the residuals are used to build-up an image in the time vs. energy domain to detect spectral features and possibly study their evolution, coupling time and spectral analysis. My focus is on the search for variations over few ks time-scales for both emission and absorption features, corresponding to phenomena located within few tens of gravitational radii from the SMBH.

Feeding and feedback in local radio galaxies

Guilherme S. Couto

This presentation resume our results using optical integral field spectroscopy of four nearby ($z < 0.07$) radio galaxies obtained with GMOS in Gemini North and South telescopes. The galaxies in our sample present extended radio jets and have in common signatures of interactions or merger events. The presence of more than one kinematic component in the galaxies of our sample indicates that feedback is disturbing the gas in the central regions, and this is usually traced by high velocity dispersion and high line ratios. Although we estimate low energetic input of the radio jet in the circumnuclear gas, jet-cloud interaction seems to be connected with extended emission-line regions. We also present resolved diagnostic diagrams for these galaxies using the optical emission-lines, and the comparison with shocks and photoionization models, which suggests more presence of shocks in regions closer to the radio jet, but also a contribution of photoionization.

Reverberation mapping and the structure of the accretion flow in AGN

Chris Done

I will show how the new intensive reverberation mapping campaigns for AGN are giving insight into the structure of the accretion flow close to the black hole. I will particularly focus on the soft X-ray excess region, and how this can be a key to understanding the (lack of) relationship between the UV and hard X-ray variability.

Reverberation Mapping of AGN on a sub-daily cadence

Juan V. Hernández Santisteban

Reverberation mapping of Active Galactic Nuclei has proven to be a fantastic technique to probe to the geometry of the accretion flow around the super massive black hole (SMBH) and its impact on the accretion due to the ever-changing inner X-ray source. This is performed by correlating the variability between energy bands, as the X-rays are reprocessed at larger radii of the accretion disc in timescales of days.

Similar studies have already raised problems with this simple picture as discrepancies between the measured size of the accretion disc differs from its theoretical expectations by factors of 3 and a puzzling disconnectedness with the X-rays. Here we present the first results of a multi-mission observational campaign using Swift and Las Cumbres Observatory (LCO) to study Fairall 9 —a Seyfert 1 AGN— in 13 photometric bands, spanning from X-rays to optical wavebands, in an unprecedented sub-daily cadence.

On the vertical structure of an accretion disk supported by radiation pressure

Ari Laor

I will describe the vertical structure of an accretion disk supported by radiation pressure, and possible interesting implications on the observe SED, the onset of winds, and rapid variability.

Extreme spectral variability in TDSS Quasars

Chelsea MacLeod

The Time Domain Spectroscopic Survey (TDSS) is accumulating multiple spectra for over 10,000 quasars over the SDSS survey area. We present an analysis of a small fraction of these sources that were discovered by TDSS to be extremely variable. We use photometry from SDSS, Pan-STARRS, PTF, and CRTS to constrain the timescales,

and spectroscopy from TDSS to measure the continuum and Balmer line variability that may be linked to state changes in quasars.

Models of continuum of weak emission-line quasars

Marcin Marculewicz

Weak emission-line quasars (WLQ) are objects with enormous weak emission-lines. The properties of WLQs are different from those of BL Lac objects but consistent with normal AGNs (Plotkin et al. 2010). There are several explanations of weakness of emission-lines: 1) existence of a cold accretion disk (Laor & Davis 2011) or a radiatively inefficient accretion flow (Yuan & Narayan 2004), 2) presence of shielding gas, 3) the broad emission-line region (BELR) is built anemic (Shemmer et al. 2010) 4) the activity of WLQ has just started Hryniewicz et al. (2009). Any explanation of WLQ phenomena is still not given. We determined the mass of super massive black hole (SMBH) of the quasar SDSS J094533.99+100950.1 based on Novikov-Thorne equation and compared with two obtained masses (Czerny et al. 2011), (Laor & Davis 2011). For more WLQ we produced the grid of the models and obtained the mass of SMBH and accretion rate.

New Constraint on the Quenching of the Star Formation in $M*$ Galaxies from Heavily-Obscured X-ray AGNs

Thibaud Moutard

The fact that star formation is observed to stop earlier in more massive galaxies, on average, suggests the existence of mass-related quenching processes, and the stellar mass function of star-forming galaxies shows that such "mass quenching" operates in galaxies with stellar mass reaching $M^* \sim 10^{10.6} M_\odot$. However, several mechanisms able to halt the cold gas supply may be put forth to explain the slow quenching of those galaxies, e.g., from the heating of the gas via viral shocks within dark-matter halos reaching a mass of $M_h \sim 10^{12} M_\odot$ or due the feedback of a radio-loud active galactic nucleus (AGN).

I will present the results we recently obtained on the incidence of radio-loud and heavily-obscured X-ray AGNs within evolved and massive galaxies that are in the process of quenching at $0.2 < z < 0.5$, and show how they argue for a picture where M* galaxy quenching happens along cosmic filaments.

Quasars in the unlimited general relativity

Lubos Neslusan

When a model of a relativistic compact object (RCO), e.g. a neutron star, is constructed, it is postulated that the distribution of matter inside it must be qualitatively the same as in the Newtonian physics, i.e. only a normalized solution of the field equations is

acceptable. Because of this postulate (never proved; or in a circle), only a tiny fraction of all realistic solutions has been used to model the RCOs. We consider the unlimited Einstein's general relativity and show that RCO of whatever a large mass can be stable and acquires a minimum-energy configuration with the outer surface situated above its event horizon; and that the gravitational acceleration of objects in the RCO's vicinity is not linearly proportional to the RCO's mass/energy. The most massive quasars (as RCOs) could have enough energy to continuously emit the radiation of the observed luminosity during the whole age of the universe.

An atmosphere and outflow in the tidal disruption event AT2017eqx links hydrogen rich and poor TDEs

Matt Nicholl

A star passing close to a supermassive black hole is disrupted by tidal forces, with accretion of the stellar debris powering a luminous flare. Several observed flares have lacked hydrogen lines, despite hydrogen making up the bulk of most stars. We have obtained time-series spectroscopy and panchromatic imaging of a new tidal disruption event, AT2017eqx. Spectra initially show hydrogen and helium emission, but later only helium, showing that a lack of hydrogen lines does not mean a lack of hydrogen gas. The helium lines shift to shorter wavelengths, indicating an outflow. This is the first time these properties have been observed in the same TDE, but contain important clues to understanding the population at large. Combining viewing angle effects with an atmosphere and outflow can unify the spectra of previously disparate flares, with predictions for their X-ray properties.

Discovery of the new changing look case in NGC 1566

Victor Oknyansky

We present a study of optical, UV and X-ray light curves of the nearby changing look active galactic nucleus in the galaxy NGC 1566 obtained with the Neil Gehrels Swift Observatory and the MASTER Global Robotic Network over the period 2007 - 2018. We also report on our optical spectroscopy at the South African Astronomical Observatory with the 1.9m telescope on the night 2018 August 2–3. A substantial increase in X-ray flux by 1.5 orders of magnitude was observed following the brightening in the UV and optical bands during the last year. After a maximum was reached at the beginning of 2018 July the fluxes in all bands decreased with some fluctuations. The amplitude of the flux variability is strongest in the X-ray band and decreases with increasing wavelength. Low-resolution spectra reveal a dramatic strengthening of the broad emission as well as high-ionization [Fe X]6374 lines. These lines were not detected so strongly in the past published spectra. The change in the type of the optical spectrum was accompanied by

a significant change in the X-ray spectrum. All these facts confirm NGC 1566 to be a changing look Seyfert galaxy.

The energy dependence of X-ray variability in AGN

Iossif Papadakis

Power spectrum (PSD) analysis has been frequently used in the variability studies of AGN for almost 30 years now. Most studies in the past has been done using light curves in two broad energy bands, namely 0.5-2 and 2-10 keV (i.e the "soft" and "hard" bands, respectively). I will present results from a detailed PSD analysis of a few bright, highly variable nearby Seyferts in various energy bands, using archival XMM-Newton data, mainly. The main objective is to determine the PSD slope, amplitude and high frequency break dependence on energy. I will shortly discuss implications of the results on various variability mechanisms.

Low-mass and High-mass Supermassive Blackholes Are Spun-up in Different Evolution Paths

Jing Wang

How Supermassive SMBHs are spun-up is a key issue of modern astrophysics. As an extension of the study in Wang et al. (2016), we here address the issue by comparing the host galaxy properties of nearby ($z < 0.05$) radio-selected Seyfert 2 galaxies. The two-dimensional bulge+disk decompositions for the SDSS mages are compared between high-mass ($M_{\rm BH} > 10^{7-9} M_{\odot}$) and low-mass ($M_{\rm BH} > 10^{6-7} M_{\odot}$) SMBHs. We identify a dichotomy in their various host galaxy properties for the radio powerful SMBHs, in which high-mass SMBHs have a preference for being spun-up in classical bulges, and low-mass SMBHs in pseudo-bulges. The dichotomy suggests and confirms that high-mass and low-mass SMBHs are spun-up in different ways, i.e., a major "dry" merger and a secular evolution.

SDSS J141324.27+530527.0: A New "Changing-look" Quasar with a "Turn-on"Transition

Dawei Xu

We present the spectroscopic study of the "changing-look" quasar SDSS J141324+530527.0 (SBS 1411+533) at z=0.456, which shows a "turn-on" spectral type transition from Type-1.9/2 to Type-1 within a rest-frame timescale of 1-10 yr by a comparison of our new spectroscopic observation and the Sloan Digital Sky Survey archive database. The invariability of the line wing of MgII 2800 emission and timescale argument (the invariability of [OIII]5007 line blue asymmetry) suggests that a variation of obscuration (an

accelerating outflow) is not a favorable scenario. The timescale argument allows us to believe the type transition is possibly caused by either a viscous radial inflow or a disk instability.

Tuesday, Morning I

Overview of Optical/UV Spectroscopic Properties of Quasars

Mike Eracleous (Invited)

I will present an overview of the optical and UV spectroscopic properties of quasars and what they may be able to tell us about the source of the ionizing continuum and the broad emission line region. I will begin with a summary of the observed (single-epoch) optical and UV spectra and their diversity, including the shape of the continuum (and the broad-band spectral energy distributions) and the relative intensities and profiles of the broad emission lines. I will then introduce important time scales and length scales and describe how variability studies sampling different time scales can inform us about the structure of the continuum source and the broad emission line region. I will close with highlights from recent, intensive, systematic campaigns to study variability and examples of recently-recognized, dramatic spectroscopic variations.

Accretion Disk Theory

Bozena Czerny (Invited)

I will talk about accretion disk theory in the context of quasar crisis, although I am not sure that the title of the conference is fully appropriate. There are fashion trends in astronomy, and this is one of such swirls, hopefully very useful. The theory of accretion disk was fully formulated in 1972/73, a year later it was already known that accretion disk models are unstable. For some time this caused reservations about the very existence of the disks in astrophysical systems. With time, disk models appeared useful to the community as they represented (sometimes extremely well!) the broad band spectra of quasars and galactic binaries. But the problem of the model stability was not solved, despite the progress in numerical MHD simulations and 1-D time-dependent computations showing periodic outbursts (limit cycle behaviour) with direct comparison to the data. The point is, from observational point of view, that the standard disk model does not predict the hard X-ray emission (and jet), and from the theoretical point of view the problem is that some physics in the description of the disk interior and spontaneous formation of the hot plasma phase is still missing. We know that since the beginning, but the attention payed recently to some observational facts like existence of the Changing-Look AGN makes the issue of addressing these problems rather urgent.

Tuesday, Morning II

Insight into the Physics Behind Changing-State AGN from Multi-wavelength Observations

Dr. Stephanie LaMassa (Invited)

The past few years have seen an uptick in the discovery of changing-state AGN and quasars, defined by the dramatic appearance and/or disappearance of broad Balmer lines in the optical spectrum. Though the classification of these sources relies on characteristics in the optical spectra, data from across the electromagnetic spectrum are important for shedding light on the physical triggers of these transitions and for providing estimates of the time scales related to the accretion process. In my talk, I will discuss how these multi-wavelength observations overwhelmingly rule out variable obscuration as the driver of changing-state AGN and how these sources are important probes for understanding accretion onto supermassive black holes and the duty-cycle of AGN activity.

Discovery of 21 CLQs in the northern sky based on the optical and mid-IR variability

Xue-Bing Wu

We present the discovery of 21 new CLQs at $0.05 < z < 0.60$, which significantly increases the number of such objects known to date. These CLQs were discovered by several ways, from (1) repeat spectra in the SDSS, (2) repeat spectra in the LAMOST and SDSS, and (3) photometric variability and new spectroscopic observations. Their optical and mid-IR variability is not consistent with the scenario of variable obscuration in 10 CLQs at more than 3-sigma confidence level. We confirm a bluer-when-brighter trend in the optical. However, the mid-IR WISE colors W1 - W2 become redder when the objects become brighter in the W1 band, probably due to a stronger hot dust contribution in the W2 band when the AGN activity becomes stronger. The physical mechanism of type transition in CLQs is discussed.

Changing-State Quasars in CRTS and beyond

Matthew Graham

We have undertaken a systematic search for quasars in the Catalina Real-time Transient Survey exhibiting both strong photometric and spectroscopic variability over a decadal baseline. 73 sources show specific patterns of optical and mid-IR photometric behavior and a defined spectroscopic change. This forms a higher luminosity sample to compliment existing sets of changing-look quasars in the literature. Taken as a whole, this population of extreme varying quasars is characterized by low Eddington ratios and the amplitude

of the associated variability correlated with a change of Eddington ratio. Associated timescales are best matched to cooling/heating fronts propagating through the accretion disk. We also discuss the prospects for the discovery of changing quasars in new surveys such as the Zwicky Transient Facility using deep learning.

A New Class of Changing-Look LINERs

Sara Frederick

We report the discovery of several AGN caught "turning on" during the ZTF survey. Classified as LINERs by weak narrow forbidden line emission in their archival spectra, they were detected by ZTF as hosting nuclear transients. We found via follow-up spectroscopy that they had transformed into broad-line AGN, reminiscent of iPTF16bco. In one case, follow-up UV and optical spectra revealed the transformation into a narrow-line Seyfert 1 with strong coronal lines, and Swift monitoring revealed bright UV emission that tracked the optical flare, accompanied by a luminous soft X-ray flare that peaked $\sim$60 days later. Archival light curves of the sample revealed similar smooth, flare-like deviations from quiescence, and constrain the onset of the optical nuclear flaring. We will present the systematic selection and follow-up of this unique class of transients related to physical processes associated with the LINER accretion state, and compare their properties to previously reported changing-look Seyferts.

Tuesday, Afternoon I

State Transition in Supermassive Black Hole Accretion explaining Changing-Look AGN (Invited)

Hirofumi Noda (Invited)

It is under much debate what kind of change in a supermassive black hole (BH) accretion causes changing-look active galactic nuclei (CLAGN). Aiming to understand it, we modeled optical, UV, and X-ray continua of a typical CLAGN Mrk 1018 observed by XMM-Newton and Swift while it changed from type 1 in 2008 to type 1.9 in 2016. As a result, we found drastic spectral variation like the soft-to-hard state transition seen in Galactic binaries, especially in an UV to soft X-ray band dominated by a warm Comptonization emission. This suggests that CLAGN are caused by the state transition in a BH accretion flow triggered by a rapid mass accretion rate change (Noda & Done 2018, MNRAS, 480, 3898). In this presentation, we introduce these results by comparing the CLAGN spectral variation with the state transition in Galactic binaries.

The Analogous Structure of Accretion Flows in Supermassive and Stellar Mass Black Holes

John Ruan

Several lines of evidence now suggest possible similarities between black hole accretion flows in active galactic nuclei (AGN) and Galactic X-ray binaries, despite their factor of $\sim 10^8$ difference in black hole mass. However, it is still uncertain whether the structure and geometry of the disk-corona system in X-ray binaries directly scale up in mass to AGN, and whether this analogy still holds in different spectral states. I will present a novel approach to testing the X-ray binary/AGN analogy, based on direct comparisons of faded 'changing-look quasars' to X-ray binary outbursts. Using Chandra X-ray and ground-based rest-UV observations of faded changing-look quasars, we probe the evolving geometry of their accretion flows as a function of Eddington ratio, based on the observed spectral changes. We find that the observed spectral evolution in fading quasars displays a remarkable similarity to accretion state transitions in X-ray binary outbursts. These results show that the structures of black hole accretion flows directly scales across a factor of 10^8 in black hole mass and across different accretion states.

Changing look microquasars

Teo Muñoz-Darias

Accreting stellar-mass black holes, also known as microquasars, represent a unique window to study black hole accretion on time-scales much shorter than those typically observed in AGN/QSOs. In the last decades, X-ray and radio observations have been used

to study in great detail the coupling between accretion and ejection processes in these objects, a coupling that can be extended to super-massive black-holes. However, only recently we have started to systematically study the changes in their optical and infrared spectra.

In this talk, I will focus on the dramatic changes that we are observing in the optical spectra of several microquasars using our dedicated programs at the GTC and VLT telescopes. I will show that these changes are in most cases (but not exclusively) due to the presence of outflows from the accretion flow. Finally, I will attempt to connect (to some extent) this phenomenology with that observed in some changing look QSOs.

Tuesday, Afternoon II

Multi-wavelength observations of tidal disruption flares

Sjoert Van Velzen (Invited)

The tidal disruption of a star by a massive black hole is a rare event that results in a spectacular flare of electromagnetic radiation. Visible from radio to X-ray wavelengths, tidal disruption flares are a unique probe to study massive black holes and the nucleus of their host galaxies. The advent of optical transient surveys has accelerated this field; the increased detection rate has fueled a large number of (often unexpected) discoveries. In this talk I will present these recent discoveries, focussing on results that can constrain the emission mechanism of tidal flares.

The mm view of TDEs: New constraints on jets, outflows, and SMBH accretion

Kate D. Alexander

Tidal disruption events (TDEs) in which a star is torn apart by a supermassive black hole (SMBH) offer a unique opportunity to study the formation and growth of relativistic jets and provide new insights into SMBH accretion. Radio observations of TDEs allow us to precisely localize the emission (confirming its TDE origin), to determine the properties of outflowing material (energy, size, expansion velocity), and to trace the ambient density profile around previously-dormant SMBHs on otherwise unresolvable scales of $\sim$0.1 - 10pc. Despite increasingly intensive radio follow up of TDEs in recent years, the sample of radio-detected TDEs remains small, revealing an unexpectedly diverse population. I will present updated constraints on the weakest outflows in TDEs, including the first millimeter observations of TDEs undertaken with ALMA. The increased sample size promised by newly upgraded wide-field optical surveys will shed further light on the physical conditions required for jet formation in TDEs.

The spectroscopic follow up of an X-ray bright tidal disruption event

Thomas Wevers

We present UV/optical, X-ray and optical spectroscopic follow-up of a new X-ray bright tidal disruption event. The Swift lightcurve is atypical, showing a secondary maximum/plateau after 40-80 days of decline from peak, similar to ASASSN-15lh. In addition to broad H, He and potentially O/Fe lines, narrow emission lines emerge in the optical spectra during the plateau phase. We identify both high ionisation (He I and [O III]) and

low ionisation (Fe II) lines. These lines, in conjunction with the $L_{\rm opt}/L_X$ ratio evolution, suggest the rapid formation of a compact accretion disk. We similarly identify Fe II lines in optical spectra of ASASSN-15oi 330 d after discovery, indicating that a class of Fe-rich TDEs exists. Taken together with the plateau in X-ray and UV/optical luminosity this indicates that emission from the central source is efficiently reprocessed into UV/optical wavelengths, suggesting that we are witnessing the real-time assembly of an accretion disk around a SMBH. I'll present the observations and their implications and highlight some similarities between TDEs and NLS1 galaxies.

Wednesday, Morning I

AGN and quasars, accretion processes, relativistic jets

Aneta Siemiginowska (Invited)

Relativistic jets, extending to hundreds kiloparsec distances from the origin, display the black hole accretion history. In binaries, the formation of a jet depends on the black hole accretion state, and the jet radiation fades away relatively quickly. In AGN and quasars, the link to the accretion state is not quite clear as the timescales involved in the jet formation and radiation processes are much longer. However, these timescale allow us to study some details of the accretion process, jet formation and jet-ISM interactions. I will review the observed properties of quasar jets, their morphology, radiation and variability, and draw potential connections to the accretion process. I will also argue that the relativistic jets provide an important piece to the 'Quasars in Crisis' puzzle.

New investigations in CL AGNs using the 'old' UV data archives

Martin Ward

Variability is a valuable tool for studying AGN inner regions, and the physical processes operating therein. A number of multi-wavelength campaigns of selected AGN have provided observational input to fuel the so-called "Quasar Viscosity Crisis"; However, despite "big data" studies of AGN variability using Pan-STARRS, the Catalina survey and archival X-rays, the ultra-violet (UV) region remains relatively under exploited. We have therefore started an investigation of AGN UV photometry, using the XMM-OM, the SWIFT-UVOT, GALEX and the SDSS u-band, data archives. We require multiple UV observations of the same AGN, and also an SDSS spectrum to classify the object. We identify several 1000 AGN with multiple (albeit poorly sampled) UV observations taken over many years. We extract information on UV variability correlations with their black hole mass, Eddington ratio, and put constraints on the duty cycle of activity. We have identified some cases of new candidates for "changing look" AGN.

Directly probing the quasar accretion disc with multi-epoch photometry

John R. Weaver

With the ever-increasing size of mutli-epoch photometric and spectroscopy surveys, we are now able to pursue detailed time-domain studies over a wide range of astrophysical phenomena. Of great interest is establishing standard candles. It has been suggested that if quasar variability is driven by local accretion disc processes, then this may provide a

characteristic luminosity and hence a distance modulus. However, local intervening dust and poorly understood accretion disc behaviour complicate observational constraints.

We present a study of 9258 quasars observed with multi-epoch ugriz photometry with spectroscopic redshifts as part of the SDSS Southern Survey. By developing a linear model for the accretion disc variability, we demonstrate the power of long-baseline photometric lightcurves to isolate the accretion disc spectrum, and then de-redden using several well-known extinction laws. The result is a clarified picture of the evolution of quasar properties since $z = 5$, and valuable constraints on the accretion light.

Main Trends of the Main Sequence – the crucial effect of Virial Factor

Swayamtrupta Panda

We address the effect of orientation of the accretion disk plane and the geometry of the broad line region (BLR) in the context of understanding the broad distribution of quasars. We utilize photoionization code CLOUDY to model the BLR in the context of Quasar Main Sequence, incorporating the grossly underestimated virial factor (f). Treating the aspect of viewing angle appropriately, we re-discover the dependence of the RFe sequence on L/LEdd ratio and the related observational trends - as a function of the SED shape, cloud density and composition, verified from prior observations. Sources with RFe in the range $1 - 2$ (about 10% of all quasars, the so-called extreme Population $\mathcal{A}$ [xA] quasars) are explained as sources of high, and possibly extreme Eddington ratio along the $R_{\rm Fe}$ sequence. This result has important implication for the exploitation of xA sources as distance indicators for Cosmology. FeII emitters with $R_{\rm Fe} > 2$ are very rare ($< 1\%$ of all type 1 quasars). Our approach also explains the rarity of these highest Fe II emitters as extreme xA sources.

Wednesday, Morning II

The Impact of Radiation Pressure in Quasar Accretion Flows

Omer Blaes (Invited)

Classical accretion disk models do a good job of explaining thermal states of black hole X-ray binaries. In contrast, they completely fail to explain many observational aspects of the big blue bump in active galactic nuclei and quasars. The reasons for this are almost certainly that these models fail to adequately account for the effects of radiation pressure and ultraviolet opacities. In this talk I will focus on the complexities of radiation pressure on the dynamics and thermodynamics of the accretion flow, and discuss simulations that suggest that the inner regions of quasar accretion disk may have radically different structures from those of classical models.

The Impact of Opacity in Quasar Accretion Flows

Shane Davis (Invited)

Observational constraints on the spectral shape and the sizes of quasar emission regions are in conflict with standard accretion disk models. This contrasts with disk dominated states of X-ray binaries, which seem to be reasonably consistent with theoretical predictions. This suggests focusing on aspects of the problem that differ between these two systems and one possibility is the ultraviolet opacities present in quasars. I will present results from numerical models and simulations that suggest the enhanced opacity due to atomic transitions can have significant impact on the structure of quasar accretion flows and offer some speculation on how such effects may resolve conflicts between observation and theory.

Thursday, Morning I

The QUEST-La Silla AGN variability survey

Paula Sanchez

In this talk I will present the current status of our QUEST-La Silla AGN variability survey. We used the QUEST camera on the ESO-Schmidt telescope to obtain well sampled optical light curves of AGN in well-studied extragalactic fields. I will present our results on the study of the link between variability properties (e.g., characteristic timescales and amplitudes of variation) and physical parameters of the system (e.g., black-hole mass, luminosity, and Eddington ratio). In addition, I will present our variability-based AGN selection technique. We implemented a Random Forest algorithm to classify our objects as either AGN or non–AGN according to their variability features and optical colors. Unlike for many literature studies, we do not cut our sample to point–like objects, thus we can select AGN that have a significant contribution from redshifted starlight in their host galaxies.

Long-term NIR variability in the UKIDSS Ultra-Deep Survey: a new probe of AGN physics at high redshift

Elizabeth Elmer

Near-infrared (NIR) observations of variability offer a key diagnostic to help resolve the current contradictions in our understanding of AGN properties because they probe the regions around the accretion disk and dusty torus. However, such observations are challenging to obtain as the variations are only seen on timescales of months to years. The UKIDSS Ultra Deep Survey provides a unique opportunity to investigate the light curves of 300,000 galaxies over an unprecedented baseline of $\sim$10 years. Using the K-band light curves of all the galaxies in the field, we isolate a sample of 339 AGN that vary in the NIR. Interestingly, only about half of these sources are detected in deep Chandra X-ray imaging of the field, and there are preliminary indications that the non-X-ray sources are a systematically different class of AGN. I will present initial results from the analysis, including a comparison of the X-ray and non-X-ray populations.

Thursday, Morning I

Temporally Resolving Changing Look AGN and New Types of Flares from Accreting SMBHs

Benny Trakhtenbrot

A growing number of transient phenomena in galaxy nuclei have recently begun to shed new light on SMBH demographics and the physics of gas accretion onto these objects, tracing events where this accretion has drastically intensified, diminished, or otherwise changed its nature. I will present some recent results concerning these new classes of highly variable phenomena, focusing on new results obtained with fast, multi-wavelength follow-up observations. I will discuss a "switch on" changing look AGN where we were able to temporally resolve the appearance of the AGN-like blue continuum and of the broad Balmer emission lines, with a lag that is broadly consistent with the predicted travel time to the broad line region. I will also discuss a newly identified, yet poorly understood class of UV-bright flares from accreting SMBHs, with broad Bowen fluorescence features. While all these events observationally differ from the tidal disruption events known to date, the physics behind them may be interlinked.

10,000 solar mass black hole in NGC 4395 - primordial or no AGN feedback?

Jong-Hak Woo

We present the reverberation study of the lowest-luminosity Seyfert 1 galaxy NGC 4395, based on the monitoring campaign in 2017 and 2018. The time delay of the Hα emission with respect to the V-band continuum is measured as 83$\pm$14 min., which is shortest among the light echo measurements based on the Balmer emission lines. Combining with the Hα velocity dispersion 426$\pm$1 km/s, we obtain $\sim$10,000 $M_{\odot}$. This mass is the smallest reverberation mass, and comparable to the low mass end of heavy seed primordial black holes. NGC 4395 is consistent with the M-σ relation, when σ is constrained from the central region, indicating that the relation requires no hierarchical galaxy assembly or AGN feedback. Moreover, the BLR size - luminosity relation extends down to L_{5100} = 10^{40} erg/s by 2 orders of magnitude. However, the clear offset of NGC 4395 indicates a large intrinsic scatter, suggesting that indirect black hole mass estimates based on the size-luminosity relation are much more uncertain than previously considered.

Multi-wavelength monitoring of the extraordinary changing-look AGN Mrk 1018

Bernd Husemann

Mrk 1018 was one of the first changing-look AGN reported in 1985 and a proto-type for this class of AGN variability. We serendipitously discovered that Mrk 1018 had recently another changing-look event based on MUSE observation as part of the Close AGN Reference Survey (CARS). We immediately started a multi-wavelengths (X-ray, FUV, optical, and radio) follow-up monitoring which reveals that the changing-look event can neither be explained by a cloud obscuration event nor a TDE, but is consistent with a drastic change in accretion flow. Surprisingly, the AGN is not dimming further and currently varies on a low accretion level with the possibility to re-brighten again in the next years. I will discuss possible scenarios for triggering the rapid accretion rate changes including tests on the proposed recoiling SMBH scenario.

Outliers in Changing-Look AGN

Marzena Sniegowska

We present the detailed analysis of SDSS J123359.12+084211.5 source, which was classified by MacLeod et al. (2018) as a CL AGN. However, this object is an exception in CL AGN population, because of the large Eddington ratio and strong changes in Fe II emission. We model the optical spectra in the bright-state and the dim-state. The changes in the Fe II strength affects the position of the object in the plot of the optical FWHM Hβ vs. $R_{\rm Fe}$ plane, where $R_{\rm Fe}$ is the ratio of EW Fe II and EW Hβ. A broad component of Hβ line changes dramatically as well, which affects the position of the source at a Quasar Main Sequence, and may cause the significant dispersion in the known parameter correlations. Moreover, we have found a few more objects with similar behaviour.

The X-ray view of the repeat changing-look AGN NGC 1566

Michael Parker

NGC 1566 is one of only a handful of AGN that have undergone more than one changing-look event, having changed from Sy 1.9 to Seyfert 1.2 and at least five times. The most recent event was in 2018, where the source increased in X-ray flux by a factor of 70 and nearly three magnitudes in the UV in under 9 months, coinciding with the reappearance of strong broad lines in the optical spectra.

For the first time, high quality X-ray spectra were taken at the peak of the outburst. The spectra show a classic Seyfert 1 X-ray spectrum, with a soft excess, compton hump, and iron line, as well as outflowing absorption in the high-resolution RGS spectrum. The remarkable speed with which this 'standard' AGN develops, and the repeating nature, offers a unique insight into the changing look phenomenon.

Thursday, Morning I

Cold discs and Extreme Reprocessing

Andy Lawrence

An appealing way out of the AGN timescale problem is the idea that energy is generated only very close to the black hole, but reprocessed by an otherwise passive disc and/or surrounding clouds. This idea has some interesting observational consequences. I explore this idea by looking at evidence for extreme EUV variability in MKN110, a lukewarm disc in the nuclear transient AT2018hyz, and cold discs in TDE hosts.

Quasar Viscosity Crisis: I'll see it when I believe it

Ski Antonucci

I and a few others have written many critiques of our joint efforts over the decades, pointing out many seemingly obvious disproofs of our models such as the quasistatic accretion disk model for the Big Blue Bump. These have been roundly ignored, but the facts will catch up with us eventually. Variability properties of AGN completely negate the quasistatic assumption ($M(r)$ indep of r for example), and this was known since before the model was proposed. I was appalled to see that there is NOW a perceived viscosity crisis, when this has been discussed explicitly for over 30 years (e.g. Alloin et al 1985 on variations of NGC1566). Equally devastating critiques of spin measurements from the X-ray Kα line have also appeared in abundance, and also to no apparent effect.

Among the most salient and seemingly robust information about the BBB: 1) we know the central engine SED from spectropolarimetry and it shows the Ba continuum in absorption, indicative of an optically thick thermal emitter; 2) microlensing constrains the surface brightness to be $\lesssim$1/10 the disk value in many cases. Together these imply an optically thick but patchy disk, in the spirit of the toy model of Dexter and Agol 2012.

The Simple Quasar Continuum and Limits on Large Amplitude Variability

Martin Elvis

All the intrinsic emission components of the quasar continuum arising within the sphere of influence of the black hole are tightly related to one another with small scatter. The apparently large scatter is due to the confusing effects of obscuration and host galaxy starlight. Estimates of the residual scatter are becoming tighter and, as the observations were gathered for hundreds to thousands of objects over one to two decades, this residual scatter places limits on how often and/or how many quasars undergo the rapid state changes evident in changing look quasars.

Anomalous AGN Disc Temperature Profiles

Keith Horne

I summarise recent evidence for anomalous temperature-radius profiles of AGN accretion discs. Analysis of X-ray, UV, and optical lightcurves from Swift, HST, and LCO reveal time delays increasing with wavelength that test the $T \sim R^{-3/4}$ prediction for the temperature profile of steady blackbody accretion discs. Significant anomalies in some cases indicate a need to revise the standard disc model predictions. Several potential remedies are considered.

Thursday, Morning I

Two-phase AGN clumpy torus model and SED library (Invited)

Ralf Siebenmorgen

I will present our two-phase AGN clumpy torus model and SED library (Siebenmorgen, et al., 2014). On the technical site I show updates of our radiative transfer dust code for considering temporal variations, as well as scattering light and di-chroic polarisation.

We assume that dust near active galactic nuclei (AGNs) is distributed in a torus-like geometry, which can be described as a clumpy medium or a homogeneous disk, or as a combination of the two (i.e. a two-phase medium). The dust particles considered are fluffy and have higher submillimeter emissivities than grains in the diffuse interstellar medium. The dust-photon interaction is treated in a fully self-consistent three-dimensional radiative transfer code.

We provide an AGN library of spectral energy distributions (SEDs). Its purpose is to quickly obtain estimates of the basic parameters of the AGNs, such as the intrinsic luminosity of the central source, the viewing angle, the inner radius, the volume filling factor and optical depth of the clouds, and the optical depth of the disk midplane, and to predict the flux at yet unobserved wavelengths. The procedure is simple and consists of finding an element in the library that matches the observations. The AGN library accounts well for the observed scatter of the 10mic. silicate feature strengths and wavelengths of the peak emission. AGN extinction curves are discussed and we find that there is no direct one-to-one link between the observed extinction and the wavelength dependence of the dust cross sections. The validity of the approach is demonstrated by matching the SEDs of a number of representative objects. Strikingly, for the five luminous objects we find that pure AGN models fit the SED without needing to postulate starburst activity. Further details see: http://www.eso.org/ rsiebenm/agn_models/index.html.

Chandra Imaging of the Circumnuclear Regions of Nearby AGNs

Giuseppina Fabbiano

Chandra has the unique capability to image at a few 10-100 pc resolution the circumnuclear environment of nearby AGNs. These observations have presented complex and intriguing emission, including the kpc-scale hot bubble of NGC 4151 (Wang et al 2010) and the knotty Fe Kα emission of ESO 428-G014. I will present a few examples and discuss the possibility that some of these features may be connected with past quasar outbursts.

The Red Quasar Crisis: Where do they fit into the QSO population?

Lizelke Klindt

A key focus of many red quasar studies is to understand whether they fit into the AGN unified scheme, are a transitional phase in quasar-galaxy co-evolution or represent an intrinsically peculiar quasar population. We report on a systematic, controlled comparison between the FIRST radio properties of red and blue SDSS quasars. We find a factor of 3 enhancement of compact radio sources among red quasars, which is evidence that they occupy an early evolutionary phase. We confront accretion disc and dust-extinction models with a comprehensive VLT/X-shooter spectroscopic dataset for 21 red quasars matched to 37 blue quasars, designed to better understand the nature of red quasars. These data have allowed us to differentiate whether the dust reddening occurs on nuclear or host galaxy scales, as well as explore emission line kinematics, ionisation properties of the BLR/NLR and the frequency of outflows.

Friday Morning II

Spectroscopic searches for sub-parsec separation supermassive black hole binaries

Jessie Runnoe (Invited)

Supermassive black hole binaries are thought to be an inevitable product of hierarchical galaxy evolution scenarios where all massive galaxies host a central black hole and grow via a process of mergers and accretion. The early stages of this process have been observed in the form of interacting galaxy pairs and kilo-parsec separation dual active galactic nuclei, but the sub-parsec separation, gravitationally bound binaries that are expected to follow have so far eluded observation. The detection of this population is important because at the smallest separations they become bright sources of low-frequency gravitational waves. I and collaborators are conducting a systematic search for close supermassive black hole binaries among quasars based on the hypothesis that the secondary black hole in the system is active and the resulting broad emission lines will be doppler shifted due to its orbital motion (analogous to a single-line spectroscopic binary star). The binary candidates are therefore selected from nearby quasars via substantial (>1000 km/s) shifts of the broad Hβ lines relative to the systemic redshift. The keystone of this search is an ongoing spectroscopic monitoring campaign to look for signs of bulk motion of the quasar indicative of orbital motion. I will present an update on the observational research program that I have been leading to evaluate the credentials of these candidates.

Supermassive black hole binaries in the era of multi-messenger astrophysics

Tamara Bogdanovic (Invited)

Supermassive black hole binaries (SMBHBs) are a product of galaxy mergers and progenitors of coalescing binaries, considered to be the prime sources for future gravitational wave (GW) detectors. Expectations for detection of gravitational radiation from SMBHBs have recently been raised by the success of the Laser Interferometer Gravitational-Wave Observatory, by the increasing sensitivity of the Pulsar Timing Arrays, and by selection of the Laser Interferometer Space Antenna for a large-class mission in the European Space Agency science program. In light of these developments, the rates at which SMBHBs form and evolve to coalescence remain important open questions in black hole astrophysics. Presently, the best avenue to address them is through electromagnetic observations and theoretical modeling. I will discuss how recent and anticipated advances in multi-messenger observational searches and modeling can help us to piece together the evolution of SMBHBs from galactic mergers all the way to the GW regime.

Looking for dwarf black holes in the nearby Universe

Paulina Lira

I will present results from our search for dwarf Black Holes (BHs) in the nearby Universe. Two independent methods have been used: the spectroscopic follow up of candidate small BHs selected from the SDSS, which hints a paucity of (active) BHs below galaxy absolute magnitudes of Mg = -18; the search of (active) dwarf BHs by variability signatures detected in the HiTS survey, which explored 120-150 square degrees of sky during a week in 2013, 2014 and 2015 each, and is sensitive to time scales of a few hours (Forster et al., 2016, Martinez et al., submitted).

Friday Morning II

Electromagnetic and gravitational radiation from Dual Supermassive Black Holes

Sarah Burke-Spolaor (Invited)

During a major galaxy merger, two SMBHs will interact with a common environment as they sink to the center of the merging system. The black hole pair will eventually form a binary, emitting the most intense gravitational radiation in the Universe until they coalesce. Up to 10% of galaxies could contain black hole pairs at various stages of evolution, however the discovery of sub-kpc supermassive pairs has been difficult. I will detail several efforts to detect both electromagnetic and gravitational radiation from dual supermassive black holes.

Revealing the Hidden Universe with Supercomputer Simulations of Black Hole Merin MHD simulations

Manuela Campanelli (Invited)

Supermassive black holes at the centers of galaxies power some of the most energetic phenomena in the Universe. Their observations have numerous exciting consequences for our understanding of galactic evolution, black hole demographics, plasma dynamics in strong-field gravity, and general relativity. When they collide, they produce intense bursts of gravitational and electromagnetic energy and launch powerful relativistic jets. Understanding these systems requires solving the highly-nonlinear and highly-coupled field equations of General Relativity and Relativistic Magnethodrodynamics. It is only with the use of sophisticated numerical techniques for simulations, data extraction and visualization, and running on petascale supercomputers of ten to hundreds of thousands of CPUs simultaneously that this problem is tractable. This talk will review some of the new developments in the field of computational relativistic magnetohydrodynamics that allow us to successfully simulate and visualize the innermost workings of these violent astrophysical phenomena.

Quasar disk aspect ratio and viscosity from CSQs and LIGO

K. E. Saavik Ford

We will discuss our recent work using the timescales of dramatic variability of Changing Look Quasars/Changing State Quasars (CLQs/CSQs) to constrain fundamental aspects of quasar disk models, including aspect ratio (H/r) and viscosity parameter (α). This theoretical work will be placed in the context of current observations (e.g. Ross et al., Stern et al., Graham et al.). In addition, we will discuss the current and future expected

constraints on quasar disk models from LIGO (McKernan et al., Ford et al.), notably aspect ratio and disk lifetime.

Friday Morning II

Understanding the properties of the obscuring material around active galactic nuclei with ALMA

Almudena Alonso-Herrero (Invited)

The properties of the dusty molecular torus of active galaxies drive the geometrical covering factors, i.e., the fraction of obscured AGN. Understanding the dependence of the covering factor with AGN type, AGN luminosity, Eddington ratio and redshift has important implications for both AGN and galaxy evolution. It is becoming clear that the evolution of the covering factors of X-ray selected AGN shows a transition for luminous AGN and Quasars and/or high Eddington ratios. The likely interpretation for these observations is that AGN-driven outflows play a dominant role in clearing some or even all the obscuring material around the accreting supermassive black hole. ALMA offers us the best opportunity to investigate the geometry and properties of the obscuring material as well as the nuclear molecular outflows in nearby active galaxies. In this talk I will present recent ALMA results from the Galaxy Activity, Torus, and Outflows Survey (GATOS). We are obtaining ALMA observations of the molecular gas and (sub)-millimeter continuum with physical resolutions 7-15pc of a sample of X-ray selected Seyfert galaxies. I will show that massive ($10^5 - 10^7 M_\odot$) and large (diameters of up to 20-50pc) nuclear disks/tori are detected in the GATOS Seyferts. We are also finding some tantalizing results. The molecular column densities at the AGN location appear to be correlated with the X-ray absorptions. This clearly shows that the physical resolutions achieved with ALMA are reaching the relevant scales responsible for AGN obscuration. We also find that the molecular mass surface density of the nuclear disks/tori, which could be a proxy for the AGN covering factor, appear to decrease at higher Eddington ratios and AGN luminosities. All these results are relevant for understanding the obscuring material in more distant AGN and Quasars where dusty molecular tori cannot be resolved even with the highest ALMA angular resolutions.

The physical properties of the host galaxies of radio loud quasars and galaxies at $z \sim 1 - 2$

Dr. Mojegan Azadi (Invited)

AGN release a tremendous amount of energy over a wide range of wavelengths. To study the emission mechanisms operating in the AGN and in the host galaxy, it is critical to disentangle the contributions from each as a function of wavelength. We present results of spectral energy distribution analysis for radio loud quasars and galaxies from the 3CRR sample at $1 < z < 2$. We consider a multi-component model to fit the photometry over a wide range of wavelengths from X-ray to radio. The components at the highest energies account for the X-ray, UV and optical emission from the accretion

disk. At near-infrared to far-infrared wavelengths a combination of a clumpy medium and a homogeneous disk accounts for the radiation from the dust grains in a torus-like geometry. At radio wavelengths, a power-law/parabola component is included to account for the emission from the radio jets and lobes. In addition, an underlying component from UV to radio wavelengths is considered which accounts for the emission from the host galaxy. Using this multi-component analysis, we investigate the physical properties of the obscuring torus in quasars and narrow line radio galaxies as well as the host galaxy of each class to test AGN Unification schemes. Also, we investigate the connection between AGN activity and the SF activity of the host galaxies as well as the relation between the level of obscuration of AGN and their host galaxies physical properties.