2020 abstract booklet of submitted contributions

Growing Black Holes: Accretion and Mergers

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Submitted abstracts of talks and posters, including review talks (red) in alphabetic order:

Tek Prasad Adhikari
Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, India

What Shapes the Absorption Measure Distribution in AGN Outflows?

The absorption measure distribution (AMD) in the X-ray outflows of Seyfert active galactic nuclei describes the distribution of absorbing column density as a function of ionization parameter. In the literature, the AMD has been measured only for seven objects utilizing high-resolution X-ray data that contain absorption lines from ionized heavy elements. The measured AMDs display a universal broad shape containing a prominent dip, for which the absorbing column drops by around two orders of magnitude. In this work, we test a range of photoionization models computed using numerical code TITAN against the overall shape of the AMD as observed in Seyferts. We demonstrate that the shape of the AMD depends both on the spectral energy distribution (SED) of radiation that enters the outflow, and the density of the warm absorber (WA). The model that best reproduces the observed shape of the AMD is one wherein the gas density of the WA is of the order of 10^{12} cm^{-3}, irradiated by an SED whose optical/UV luminosity is 100 times higher than the X-ray luminosity. When the cloud density is higher than ~10^{11} cm^{-3} , free-free heating dominates the entire absorber, and only one instability zone occurs, in agreement with observations. Our model estimates the warm absorber location to be ~10^{15} cm.

Viola Allevato
Scuola Normale Superiore, Italy

The interplay between AGN and the large-scale structure of the Universe

The presence of a super massive BH in almost all galaxies in the Universe is an accepted paradigm in astronomy. How these BHs form and how they co-evolve with the host galaxy is one of the most intriguing unanswered problems in modern Cosmology and of extreme relevance to understand the issue of galaxy formation. Clustering measurements can powerfully test theoretical model predictions of BH triggering scenarios and put constraints on the typical

environment where AGN live in, through the connection with their host dark matter halos. In this talk, I will present some recent results on the AGN clustering dependence on host galaxy properties, such as galaxy stellar mass, star formation rate and specific BH accretion rate, based on X-ray selected Chandra COSMOS Legacy (CCL) Type 2 AGN. We find no significant dependence of the large-scale bias and typical halo mass on galaxy stellar mass and specific BHAR for CCL Type 2 AGN at mean z~ 1, while a negative dependence on SFR is observed, i.e. lower SFR AGN reside in richer environment. Mock catalogs of AGN, matched to have the same X-ray luminosity, stellar mass, BHAR, and SFR of CCL Type 2 AGN, almost reproduce the observed Mstar - Mh, BHAR - Mh and SFR-Mh relations, when assuming a fraction of satellite A of 15%. This corresponds to a ratio of the probabilities of satellite to central AGN of being active Q ~ 2. Mock matched normal galaxies follow a slightly steeper Mstar - Mh relation, in which low mass mock galaxies reside in less massive halos than mock AGN of similar mass. Moreover, matched mock normal galaxies are less biased than mock AGN with similar specific BHAR and SFR, at least for Q > 1.

Lorenzo Amati
INAF OAS Bologna
Review Talk
The THESEUS Space Mission
The Transient High-Energy Sky and Early Universe Surveyor (THESEUS) is a space mission concept currently under Phase A study by ESA as candidate M5 mission, aiming at exploiting Gamma-Ray Bursts for investigating the early Universe and at providing a substantial advancement of multi-messenger and time-domain astrophysics. Through an unprecedented combination of X-/gamma-rays monitors, an on-board IR telescope and automated fast slewing capabilities, THESEUS will be a wonderful machine for the detection, characterization and redshift measurement of any kind of GRBs and many classes of X-ray transients. In addition to the full exploitation of high-redshift GRBs for cosmology (pop-III stars, cosmic re-ionization, SFR and metallicity evolution up to the "cosmic dawn"), THESEUS will allow the identification and study of the electromagnetic counterparts to sources of gravitational waves which will be routinely detected in the late '20s / early '30s by next generation facilities like aLIGO/aVirgo, LISA, KAGRA, and Einstein Telescope (ET), as well as of most classes of transient sources, thus providing an ideal sinergy with the large e.m. facilities of the near future like LSST, ELT, TMT, SKA, CTA, ATHENA.

Richard Anantua
Center for Astrophysics | Harvard & Smithsonian
Discovering the Compsoition of Relativsitic Jets from Polarization Maps
A self-similar, stationary semi-analytic model based on jet regions of a high accuracy relativistic magnetohydrodynamics (HARM) simulation and including electrons, protons and positrons is applied to M87 between 43 GHz and 230 GHz to constrain its particle composition. Synchrotron emission is related to the partial pressure of electrons and positrons emitting at the observed frequency, which, in turn, is related to the local magnetic pressure and plasma ion number

density in the Ion Reduced Constant Electron Beta Model. Positron-deficient jets with only slightly sub-equipartition electron betas are required to achieve observable degrees of circular polarization V/I > 0.001 for M87 in this model. Photon annihilation into electron-positron pairs is often neglected in radiative transfer routines applied to general relativistic magnetohydrodynamic (GRMHD) simulations of jet/accretion flow/black hole (JAB) systems. To help bridge this gap, the Ion Reduced Constant Electron Beta Model is incorporated into the general relativistic polarized radiative transfer postprocessor GRTRANS for simple, simulation-based jet and disk semi-analytic models.

Riccardo Arcodia
Max-Planck-Institute for Extraterrestrial Physics
Do stellar-mass and super-massive black holes have similar dietary habits?
Through the years several attempts to connect the phenomenology and physics of mass accretion around super-massive and stellar-mass black holes in a mass scale-invariant fashion have been made. We here try to improve on this connection in the radiatively-efficient end of accretion mode, testing the disk-corona energetic interplay in soft and soft-intermediate states of the X-ray binary GX 339-4 with 454 RXTE-PCA archival observations. The observed scatter in the log Ldisk - log Lcor plane of XRBs is very high (~0.5 dex) and incompatibly larger than in our radiatively-efficient AGN sample (~0.3 dex). It is notwithstanding remarkable that once similarly broad Photon index and accretion rate distributions are selected, AGN and XRBs overlap quite nicely in the mass-normalized log Ldisk - log Lcor plane with a scatter of ~0.3 dex. Nonetheless, this is still incompatibly higher than ~0.2dex, namely what is claimed to be the real physical scatter in the log Ldisk - log Lcor in AGN. We conclude that either the two systems are not entirely analogous and should not be scaled without caution, or they are indeed similar thus the physical scatter of the disk-corona emission in AGN is not as low as we think, with insightful implications for both accretion physics and quasars cosmology.

Maria Celeste Artale
Institute for Astro and Particle Physics, Austria
The most likely host galaxies of a compact binary coalescence
Understanding which are the most likely host galaxies of gravitational-wave sources would provide us with fundamental information to comprehend the nature of compact binaries in the era of gravitational-wave (GW) astronomy. In this talk, I will present a novel method to investigate the host galaxies of binary compact objects, by combining catalogs from hydrodynamical cosmological simulations together with population synthesis models. I will discuss the probability that a galaxy hosts a compact binary coalescence as a function of its stellar mass and star formation rate across cosmic time (up to redshift ~6). My results show that there is a strong correlation between the stellar mass of the host galaxy and the merger rate per galaxy. Similar correlations, but weaker, are found with the star formation rate and with the gas metallicity. Moreover, early-type galaxies host the vast majority of compact binary mergers at low redshift. These results are crucial for low-latency searches of GW sources as they provide a

way to rank galaxies inside the error box of a given GW detection, reducing the number of viable host candidates.

Arthur Avakyan
Levonovisch, Russian Federation
The effect of thermal winds on the outbursts evolution of Low-mass X-ray binaries
Modern high-resolution optical and X-ray spectra obtained obtained by observing outbursts of X-ray transients indicate the existence of winds from accretion disks. The rate of loss of matter in winds is estimated to be at a level or greater than the rate of accretion onto the central object. Such a wind inevitably affects the dynamics of an outburst, as it is an important mechanism for the evolution of a viscous accretion disk and must be taken into account when modeling disk parameters. One of the main parameters is alpha-viscosity parameter, which characterizes the momentum transfer rate in a viscous accretion disk.. According to previous works, parameter alpha lies in the range 0.6–1.5. A model of non-stationary disk accretion onto a black hole was improved, which takes into account the influence of wind flowing from the surface of the disk. Also an aspect of the presence of wind on the disk have been studied: the dependence of the degree of irradiation of the outer parts of the disk on the matter density in the wind and, as a result, the emergence of a “feedback” mode. The wind, taking the angular momentum out of the disk, reduces the role of viscosity in the evolution of the accretion disk, reducing the estimate of the parameter alpha. Using the model, for the first time, an outburst of the X-ray nova 4U 1543-47 of 2002 was fitted, which led to a almost twofold change in the alpha parameter. It was also analyzed what effect the ablation of the angular momentum by the wind during X-ray outbursts can have on the change in the orbital period of a binary system. A comparison of the theoretical and observed rate of change of the orbital period is necessary to understand which processes make the main contribution to the evolution of the angular momentum of binary systems of this class.

Branislav Avramov
Astronomisches Rechen-Institut: Zentrum für Astronomie, University of Heidelberg, Germany
Dynamical interaction and energy exchange of stars with a Massive Black Hole binary
We use large-scale, high-precision N-body simulations to study the interaction and subsequent ejection of stars by a massive black hole binary (BHB) within a dense, triaxial galaxy merger remnant. It has already been established in previous work that stars on centrophilic orbits in a triaxial potential can provide efficient loss cone refilling, thus resolving the final parsec problem (FPP). We focus on analyzing the properties and statistics of these stars, including their energy and orbital element changes, as well as phase space distributions. The simulations used are highly efficient, fully GPU-parallelized codes which include Post-Newtonian corrections (up to order 2.5) to the BHB equations of motion, in order to account for gravitational wave emission. The simulations utilize a novel, hybrid integration approach which combines direct summation with the self-consistent field (SCF) method in order to efficiently represent the galaxy merger remnant potential, while conserving computational time.

Arash Bahramian
International Center for Radio Astronomy Research, Australia
Hunting black holes in Galactic Star Clusters
The presence of black holes (both stellar- and intermediate-mass) in globular clusters has been a central question in the study of compact objects and their evolution in these star clusters. All bright (Lx > 10^35 erg/s) X-ray binaries in Galactic GCs have been found to be accreting neutron stars. Recent evolutionary dynamical models such as N-body and Monte Carlo simulations have shown that the dynamical ejection rate of BHs in GCs is lower than what was previously assumed. And indeed, advancements in multi-wavelength studies of GCs over the past decade have led to the discovery of strong BH candidates in globular clusters. We have been conducting a deep radio survey (with VLA and ATCA) of Galactic globular clusters to search for candidate black hole X-ray binaries in Galactic globular clusters (i.e., via the established connection between accretion in the X-rays and radio jet outflow in the radio). In this talk, I will present some of the recent results from our survey, including identification of new black hole candidates in globular clusters, our follow-up multi-wavelength studies to constrain the properties of these systems, and our work on population of these systems and their link to globular cluster properties.

Vivienne Baldassare
Yale University, United States
Variability selection of active galactic nuclei in low-mass galaxies
The population of massive black holes (BHs) at the centers of nearby low-mass galaxies provides some of the best observational constraints on the masses of “black hole seeds” at high redshift. Furthermore, while BHs are ubiquitous and well-studied in Milky Way-sized and larger galaxies, relatively little is known about the population and properties of BHs in low-mass galaxies. However, BHs in these systems can be difficult to identify due to star formation dilution of the active galactic nucleus (AGN) signal and metallicity effects. In Baldassare et al. 2018, we showed that long-term optical variability can identify AGNs in low-mass galaxies that are missed by other selection techniques. I will present a new analysis of the nuclear variability of more than 50,000 nearby galaxies using data from the Palomar Transient Factory. We use difference imaging to construct high-quality light curves, and identify over 200 new low-mass, variability-selected AGN. After controlling for magnitude, we find that the fraction of variability-selected AGN is constant down to galaxy stellar masses of 1e9 solar masses. We also study the variability properties of AGNs as a function of BH mass down to BH masses of 1e5 solar masses, and find no dependence of the long-term optical variability properties on BH mass.

Ankush Banerjee
KJSCSC, India
MAGICal GRB 190114C: Cutoff in the spectrum at sub-GeV energies
GRB 190114C is a famous Gamma-Ray Burst (GRB) due to its detection at sub-TeV energies by MAGIC, seen at redshift z = 0.42. This burst is one of the brightest GRB detected by \fermi.

We present a detailed analysis of GRB 190114C prompt emission, using the two \fermi detectors: GBM and LAT. The *LAT low energy events* (LLE) data is also considered. A joint GBM-LAT analysis reveals a sub-GeV spectral cutoff. A similar high energy cutoff was reported in GRB 160509A and GRB 100724B earlier, and a handful of other sources. The cutoff can be explained by the intrinsic opacity due to pair production within the emitting region. Such morphology in these GRBs suggests that they belong to one specific class having a similar source of the radiation mechanism. GRB 190114C shows a transition from non-thermal to a quasi-thermal-like spectrum along with radiation due to external shock. From spectrum analysis and Lorentz factor evolution from the trigger time to late emission, considering the fact that sub-TeV photons are detected in MAGIC, we are able to draw an emission mechanism picture, where the prompt emission spectrum is more consistent with spectrum via photospheric dissipation with the presence of external shock emission simultaneously.

Srimanta Banerjee
Tata Institute of Fundamental Research, Mumbai

Observing the imprints of event horizon on X-ray spectra

A fundamental difference between a neutron star (NS) and a black hole (BH) is the absence of a physical surface in case of black holes. The soft X-ray emission from the surface or the boundary layer, formed between the innermost part of the accretion disc and the surface of the NS, provides additional seed photons for Comptonization and affects the properties of the Comptonizing component in the hard state. Thus, the strength of Comptonization can serve as an important tool for distinguishing BHs from NSs. In this paper, we systematically analyse heretofore the largest sample of spectra from black hole and neutron star X-ray binaries in the hard state for this purpose, using archival RXTE observations. We find that the black holes and neutron stars in our sample occupy different regions in the Compton y- parameter and the amplification factor (A), the corona temperature (kTe) and A, and the y-kTe planes. We thus show that one can separate out the black holes from the neutron stars, using the probability distributions of the y-parameter, the amplification factor A and the corona temperature kTe with a high confidence level. Our method can also be used as a tool to identify an unknown compact object with a high statistical significance.

Geoff Beck
University of the Witwatersrand, South Africa

Multi-messenger probes of dark matter annihilation

We present compelling anomalies in both particle physics data from the LHC and astrophysical anomalies from PAMELA, DAMPE, and AMS that could be explained by the addition of heavy neutrino-like particle to the Standard Model. In this context we explore multi-messenger methods of probing such a particle as a constituent of dark matter. In particular we look gamma-rays, radio observations, and at both neutrino observations with KM3NeT and exploiting neutrino-gamma-ray correlations with HESS telescope data on the galactic centre. We show that this multi-messenger approach provides a particularly powerful probe of leptophilic dark matter particles, capable of exploring below the thermal relic cross-section for masses up to a few TeV.

Ehud Behar
Technion, Israel
Radio Emission from Radio Quiet Supermassive Black Holes
X-ray and radio observations have the potential of revealing the physics of gas just before it falls into black holes. However, the details of black hole accretion remain obscured, and in particular the origin of the radio emission is contentious. Stellar coronae, like that of our Sun, are also known to be X-ray and radio sources, and are much better understood. Despite the vast disparity in mass, there is evidence that micro-physical processes are similar in both sources. The talk will thus explain how we can learn about black hole accretion by analogy with stellar coronae. We will also describe the many difficulties in this analogy, and how those are confronted with new observations. Especially observations in the mm band (~100 GHz) are shedding new light on the nature of the black-hole accretion-disk coronae.

Krzysztof Belczynski
Copernicus Center, Polish Academy of Sciences
Review Talk
Gravitational-wave Astrophysics: LIGO/Virgo BH-BH/BH-NS/NS-NS mergers
I will discuss the astrophysical importance of the recent LIGO/Virgo direct detections of gravitational-waves. Despite the fact that massive BH-BH dominance in gravitational-wave signal was predicted prior the detections, it is not at all clear which one of the several formation scenarios produces these massive mergers. This inhibits astrophysical information inference from LIGO/Virgo observations, as conclusions are different within each formation scenario. I will comment on LIGO/Virgo recent reports of detection of BH-NS mergers and objects within the first and the second mass gap. Additionally, all of the ten O1/O2 LIGO/Virgo BH-BH merger detections have low values for their effective spins. I will demonstrate how this can be naturally explained within framework of classical binary evolution scenario of the formation of BH-BH mergers. It appears that magnetic fields (Tayler-Spruit dynamo) play an important role in efficient transport of angular momentum and spin-down of massive stars that produce low-spinning black holes.

Jillian Bellovary
CUNY - Queensborough Community College, US
Review Talk
Multimessenger Signatures of IMBHs
Recent discoveries of dwarf galaxies hosting active galactic nuclei suggest that intermediate-mass black holes (IMBHs) may be a common occurrence in such low-mass systems. Electromagnetic signatures such as emission lines and variability combined with observations in all wavelengths from radio to X-rays give us clues to the presence of IMBHs. Quantities such as the occupation fraction of IMBHs in dwarf galaxies in the local universe can lead us to determining the formation mechanism of IMBHs (and possibly SMBHs) in the early universe. I

will give a review of our progress in searching for and discovering such systems locally, as well as future discovery prospects with gravitational wave detectors such as LISA.

Marco Berton
Finnish Centre for Astronomy with ESO - University of Turku
Review Talk
NLS1 galaxies and their rapidly growing black holes
Narrow-line Seyfert 1 galaxies (NLS1s) are a subclass of active galactic nuclei (AGN) identified more than 30 years ago, but still not entirely understood. Their most distinctive feature is the narrowness of their permitted lines, which is not intrepreted as a sign of obscuration as in other AGN, but is instead attributed to low rotational velocity around a relatively low mass black hole (10^6 - 10^8 solar masses). Since their luminosity is comparable to that of typical broad-line Seyfert 1 galaxies (BLS1s), their Eddington ratio is high, suggesting that these objects are characterized by fast-accreting black holes. Interestingly enough, some of them have been detected in gamma-rays, a sign that they can harbor powerful relativistic jets. In this talk I will outline their main properties, and discuss how the presence of relativistic jets in them affects our understanding of jet physics. I will also show how many of their properties indicate that their true nature is that of young AGN in a recently triggered activity phase, and how they are connected with high-redshift quasars. Finally, I will report some recent results I obtained regarding their host galaxy properties and their emission line profiles, which not only seem to confirm their young age, but may also suggest that signs of evolution are present even within the NLS1 class.

Dipanweeta Bhattacharyya
Indian Institute of Astrophysics, India
Cosmic spin and mass evolution of black holes and its impact
The evolution of the central black hole is mainly dependent on the processes of gas accretion, the capture of stars, mergers as well as electromagnetic torque. In the case of gas accretion in the presence of cooling sources, the flow is momentum-driven, after which the black hole reaches a saturated mass and subsequently, it grows only by stellar capture and mergers. We model the evolution of the black hole mass and spin with the initial seed mass and spin as a function of redshift in a ΛCDM cosmology. For the stellar capture, we have assumed a power-law density profile for the stellar cusp in a framework of relativistic loss cone theory that includes the effect of the black hole spin, Carter's constant, loss cone angular momentum, and capture radius. We discuss the dependence of the capture rate on these parameters and the predicted capture rates of $10^{-5} - 10^{-6}$ yr^{-1} are closer to the observed range. We have considered the merger activity to be effective for $z \lesssim 4$, while we include the effect of Blandford - Znajek torque for spin evolution,thus obtaining the joint black hole mass and spin evolution. We predict the impact of the evolution on the $M_{\bullet} - \sigma$ relation and compare our results with available observations. We also apply our evolution model to the specific cases of the quasars ULASJ134208.10+092838.61 (z=7.54), ULASJ112001.48+064124.3 (z=7.08) and DELSJ003836.10-152723.6 (z=7.02) and retrodict their formation parameters.

Gopal Bhatta
Astronomical Observatory of Jagiellonian University, Poland

Properties of gamma-ray variability of blazars

I present an in-depth and systematic analysis of a sample of 20 powerful blazars, including 12 BL Lacs and 8 flat spectrum radio quasars, utilizing Fermi/LAT observations from the period 2008–2018 using various analysis tools such as flux distribution, symmetry analysis, and time series analysis. The results show that blazars with steeper γ-ray spectral indexes are found to be more variable; and the γ-ray flux distribution closely resemble both normal and lognormal probability distribution functions. The statistical variability properties of the sources as studied by power spectral density analysis are consistent with flicker noise ($P(\nu) \propto 1/\nu$) – an indication of long-memory processes at work. Statistical analysis of the distribution of flux rise and decay rates in the light curves of the sources, aimed at distinguishing between particle acceleration and energy dissipation timescales, counter-intuitively suggests that both kinds of rates follow a similar distribution and the derived mean variability timescales are in the order of a few weeks. The corresponding emission region size is used to constrain location of γ-ray production sites in the sources to be a few parsecs. Additionally, using Lomb-Scargle periodogram aided with extensive Monte Carlo simulations, we detected year timescale quasi-periodic oscillations in the sources S5 0716+714, Mrk 421, ON +325, PKS 1424-418 and PKS 2155-304; and the detection significance was computed taking proper account of the red-noise and other artifacts inherent in the observations. The results can be explained in the light of current blazar models with relativistic shocks propagating down the jet viewed close to the line of sight.

Manuela Bischetti
INAF OATs, Italy

Hyper-luminous quasars as probes of AGN feedback and galaxy assembly in the z~2-6 Universe

I will present evidence of QSO-driven outflows in the 1 Gyr old Universe, resulting from the stacking analysis of ALMA observations for a sample of 48 QSOs at z~6. The high sensitivity reached by our analysis has allowed us to assess presence of high-velocity [CII]-emitting gas with velocities beyond 1000 km/s, tracing outflows with associated mass outflow rates of 100-200 Msun/yr. For the first time, we have proven that cold, quasar-driven outflows are common at z~6 and we have quantified their average prevalence, energetics and morphology. I will discuss how these outflows may affect the host-galaxies of the first QSOs and relate their properties to those observed in lower-z AGNs.

I will then report on the first systematic study of molecular gas properties in the host-galaxies of the most luminous quasars in the z~2-5 Universe, where the impact of AGN feedback is expected to be maximised. I will show that these sources show extreme (AGN-corrected) star formation rates of 500-1000 Msun/yr, able to exhaust molecular fuel in only few Myr. Moreover, the combination of NOEMA + ALMA + JVLA observations of CO and mm continuum emission has revealed to be a unique tool in probing the assembly of quasars host galaxies. Indeed we

have found that a huge (>75%) fraction of hyper-luminous quasars “is in good company” of massive, nearby (< 30 kpc) companions.

Marvin Blank
NYUAD, United Arab Emirates

The NIHAO Project: How Black Hole Accretion and Feedback affects Galaxy Scaling Relations

The NIHAO project (Numerical Investigation of a Hundred Astrophysical Objects) is a set of 100 cosmological high resolution zoom-in simulations of galaxies, whose halos range from dwarf to elliptical masses. I will present our current work to include black hole formation, accretion and feedback into our simulations.
I will furthermore show how NIHAO compares with various scaling relations known from observations, and how AGN feedback and different black hole accretion models affect these scaling relations.

Lumen Boco
SISSA, Italia

Merger rates of compact binaries in galaxies

In this talk I will investigate the merging rates of compact binaries and the related detection rates of gravitational waves with current (AdvLIGO/Virgo) and future detectors (Einstein Telescope). I will rely on three main ingredients:
1) a redshift dependent galaxy statistics observationally determined,
2) a star formation and chemical enrichment history for individual galaxies
3) a compact remnant mass distribution taken from stellar evolution simulations
The detailed treatment of the individual chemical history of each single galaxy allows to relate the properties of the gravitational wave signal to the properties of the host galaxy. A differentiation based on the morphological type of the galaxy is also performed. Finally, I will present the predicted detection rate, also for lensed GW events.

Akos Bogdan
Smithsonian Astrophysical Observatory

Establishing a correlation between the total mass of galaxy clusters and the black hole mass of brightest cluster galaxies

Supermassive black holes (BHs) residing in the brightest cluster galaxies (BCGs) are over-massive relative to the stellar bulge mass or central stellar velocity dispersion of their host galaxies. The preferential location of these BHs at the bottom of a deep potential well suggests that they may undergo a different evolutionary path than BHs in satellite galaxies. Using a sample of galaxy clusters, we demonstrate that the total gravitating mass of galaxy clusters exhibits a tight correlation with the BH mass of the BCGs. We establish that this correlation is tighter than that between the stellar bulge mass and the BH mass of the BCGs. Our results suggest that the BH mass of BCGs may be set by physical processes that are governed by the

properties of the host galaxy cluster, such as the inflow of cold gas onto the cluster center or a series of low angular momentum mergers.

Ananda Deepika Bollimpalli
Nicolaus Copernicus Astronomical Center, Warsaw

Variability in tilted, truncated discs around black holes

Black hole X-ray binaries exhibit rapid variability in their X-ray light curves termed as quasi-periodic oscillations (QPOs). Low-frequency (< 10 Hz), type-C QPOs are observed especially during the low/hard state, while the high-frequency QPOs (>100 Hz) often appear in pairs in 3:2 ratio. The observed characteristics of the low-frequency QPOs are best explained by a phenomenological model based on the Lense-Thirring precession of a hot, geometrically thick accretion flow which is misaligned with respect to the black hole spin axis. Recent studies have extended this model to explain the corresponding high-frequency QPOs as the global oscillation modes of the same hot, thick flow. A key assumption of these models is that the inner hot, geometrically thick flow precesses as a rigid body, independent of the outer cold, geometrically thin disc. However, the coupling between the outer disc and the inner hot flow may influence the precession, which has not been accounted for in any of the currently existing models. To test these models, we have performed GRMHD simulations of a truncated disc with inner hot flow misaligned with the spin axis of the black hole. In this talk, I will focus on the findings of our simulations, in relation to the high-frequency and low-frequency QPOs. In particular, we study the coupling between the outer geometrically thin disc and the inner tilted hot flow to understand its influence on the precession on the flow, thereby the QPOs.

Floor Broekgaarden
Center for Astrophysics | Harvard & Smithsonian, United States of America

The role of BH-NS mergers in gravitational-wave sources, short-GRBs, r-process enrichment and TDEs

Mergers of black hole-neutron star (BH-NS) binaries are expected to be observed by gravitational-wave observatories in the coming year(s). Such observations will not only provide confirmation that these systems exist in our Universe, they will also give unique insights into the death of massive stars, the evolution of binary systems and their possible association with gamma-ray bursts, r-process enrichment and kilonovae (TDEs).
In this talk I will present binary population synthesis of field-born BH-NS systems in order to predict their merger rate and merger characteristics for ground-based gravitational-wave observatories. I will discuss how the characteristics of the BH-NS population and their massive star progenitors changes across cosmic time and how this affects the number of mergers and their accompanying electromagnetic counterparts in our Universe. I will focus on key uncertainties arising from the relevant physical processes in massive binary-star evolution, as well as discussing the impact of not knowing the metallicity-specific star formation history over cosmic time. Considering these uncertainties I will address the question: “what is the contribution of BH-NS mergers to the population of gravitational-wave sources, short-GRBs, kilonovae and to the r-process enrichment of our Universe?” To further address this question I will compare the

BH-NS merger rate with the NS-NS and BH-BH rates and also discuss other important (future) observations of BH-NS systems such as radio-loud pulsar-BH binaries.

Tomasz Bulik
Astronomical Observatory University of Warsaw, Poland

On the effective spin distribution in binary black holes

I will discuss the binary evolution paths leading to formation of merging binary black holes. I will concentrate on the black holes spin evolution. As the best measurable quantity spin related quantity is the effective spin I will discuss what affects its value. I will present the model implied distributions of effective spins of merging black holes and compare them with observations.

Luciano Burderi
Dipartimento di Fisica - Università di Cagliari, Italy

HERMES & GrailQuest: Hunting for Gravitational Wave Electromagnetic Counterparts and Probing Space-Time Quantum Foam

HERMES (High Energy Rapid Modular Ensemble of Satellites)and GrailQuest (Gamma-ray Astronomy International Laboratory for Quantum Exploration of Space-Time are the pathfinder and the final scientific mission of a new astrophysical mission concept using a fleet of distributed detectors, whose ambitious scientific objectives I illustrate. I discuss how several of the proposed models for space-time quantisation predict an energy dependent speed for photons. Although the predicted discrepancies with the general speed of light are minuscule, I discuss how it is possible to detect this intriguing signature of space-time granularity with a new concept of modular observatory for photons in the energy band from few keV to few MeV. This observatory may consist of a swarm of small/micro/nano-satellites on low orbits. Sub-microsecond time resolution and wide energy band allows to probe tiny energy dependent delays, expected to be the signature of the granular structure of space-time in several of the proposed theories of Quantum Gravity. Moreover this kind of experiment allows to perform temporal triangulation of high signal to noise impulsive events with positional accuracies of few arc-seconds, making an observatory like that a promising hunter for the elusive electromagnetic counterparts of Gravitational Waves.

Onur Çatmabacak
University of Zurich, Switzerland

SMBH-Galaxy Scaling Relations Without Self-regulating AGN Feedback in MassiveFIRE Simulations

The growth of supermassive black holes (SMBHs) and the co-evolution with their host galaxies remains elusive, especially at high redshift. We use 37 cosmological zoom-in simulations from the MassiveFIRE suite, which is part of the Feedback in Realistic Environ-ments (FIRE) project, to investigate how birth environment and SMBHs mergers affect theSMBH−galaxy co-evolution. The growth of SMBHs is modeled in post-processing with different black hole accretion models, different choices for SMBH placements, and both with and without accounting for SMBH merging. Placing SMBHs in the densest, most gas rich environments of galaxies and accounting

for SMBH merging results in scaling relations in line with observations at low redshift. On the other hand, early growth is significantly hampered if SMBHs are positioned at the centre-of-mass of a halo and if mergers are neglected. In agreement with previous work, we find that SMBHs start to grow efficiently when their host galaxies reach M∗∼1e10 Msun, likely as a result of stellar feedback being less efficient in reducing the gas reservoirs close to the centres of massive galaxies. Moreover, we find a transition of BH accretion rate from near-Eddington to sub-Eddington rates when SMBHs surpasses ∼ 1e6 Msun. While our sample includes galaxies with dynamical masses similar to the hosts of the most luminous detected quasars beyond z∼6, none of our SMBHs has a mass larger than 1e8 Msun at those epochs according to our model.
Optional Notes

VIKAS CHAND
School of Astronomy and Space Sciences, Nanjing University, China
Shock-breakout and central engine activities in H.E.S.S. detected GRB 190829A
We have studied the H.E.S.S. detected GRB 190829A. \swift and \fermi observations of the prompt phase of this GRB reveal two isolated sub-bursts, separated by a quiescent phase. The energetic and the spectral properties of the first episode are in stark contrast to the second. The first sub-burst, which has a higher spectral peak $\sim 120 \keV$ and a low isotropic energy $\sim 10^{50}\erg$ is an outlier to the Amati correlation and marginally satisfies the Yonetoku correlation. However, the energetically dominant second sub-burst has lower peak energy and is comfortably consistent with both the correlations. We compared this GRB to other low luminosity GRBs. A fundamental correlation predicts a duration that makes the first episode consistent with a shock breakout. Additionally, peculiar central engine activities are observed during the afterglow phase. This includes a long-lasting flare in X-rays and optical emission that requires the central engine to be active for a long duration ($\sim 10^4 \s$).We analyzed the late time \fermi-LAT emission that encapsulates the H.E.S.S. detection also. Some of the LAT photons are likely to be associated with the source and might have inverse Compton origin as seen in previously detected TeV-GRBs.

Maria Charisi
Caltech, USA
Review Talk
Searching for supermassive black hole binaries
Supermassive black hole binaries are a natural end-product of galaxy mergers. Despite their expected abundance, at small sub-parsec separations, they remain undetected. A promising method is to detect quasars with periodic variability. I will describe efforts to identify binary candidates in the large quasar samples from time domain surveys. I will also discuss efforts to identify additional binary signatures (e.g., relativistic Doppler boost) with multi-wavelength data.

Yanping Chen
New York University Abu Dhabi, UAE
An all-sky optical AGN catalog

We have constructed an all-sky catalog of optical AGNs with z<0.09, based on optical spectroscopy, from the parent sample of galaxies in the 2MASS Redshift Survey (2MRS), a near-complete census of the nearby universe. Our catalog consists of 1929 broad line AGNs, and 6562 narrow line AGNs which satisfy the \citet{Kauffmann03} criteria, of which 3607 also satisfy the Kewley20001 criteria. We also report emission line widths, fluxes, flux errors, and signal-to-noise ratios of all the galaxies in our spectroscopic sample, allowing users to customize the selection criteria. Although we uniformly processed the spectra of galaxies from a homogeneous parent sample, inhomogeneities persist due to the differences in the quality of the obtained spectra, taken with different instruments, and the unavailability of spectra for ∼20\% of the galaxies. We quantify how the differences in spectral quality affect not only the AGN detection rates but also broad line to narrow line AGN ratios. We find that the inhomogeneities primarily stem from the continuum signal-to-noise (S/N) in the spectra near the emission lines of interest. We fit for the AGN fraction as a function of continuum S/N and assign AGN likelihoods to galaxies which were not identified as AGNs using the available spectra. This correction results in a catalog suitable for statistical studies. This work also paves the way for a truly homogeneous and complete nearby AGN catalog by identifying galaxies whose AGN status needs to be verified with higher quality spectra, quantifying the spectral quality necessary to do so.

Igor Chilingarian
Smithsonian Astrophysical Observatory, USA

Active Galactic Nuclei Powered by Intermediate Mass Black Holes

Nearly every massive galaxy harbors a supermassive black hole (SMBH) in its nucleus, The origin of SMBHs remains uncertain: they could have emerged either from massive ``seeds'' (100k-1M MSun) formed by direct collapse of gas clouds in the early universe or from smaller (100 MSun) stellar mass BHs. The latter channel would leave behind numerous intermediate-mass BHs (IMBHs, 100-100k M). Using data mining in wide-field sky surveys and applying dedicated analysis to optical spectra, we identified hundreds of IMBH candidates, which reside in galaxy centers and are currently accreting gas that creates optical signatures of type I AGN. 14 candidates were confirmed by X-ray emission as bona fide IMBHs. In the follow-up campaign, we identified 3 objects accreting close to the Eddington limit. We also re-measured virial masses for about 40 low-mass BHs (below 1M MSun) and demonstrated that scaling relations between SMBHs and their host galaxies (MBH-sigma and MBH-Mbulge) in the IMBH regime follow the trends established by more massive SMBHs. The very existence of numerous nuclear IMBHs supports the stellar mass seed scenario of the massive BH formation.

Ariel Chitan, Aleksandr Mylläri, Shirin Haque
The University of the West Indies, Trinidad & Tobago

The Influence of Relativistic Effects on the Evolution of Triple Black Hole Systems

The influence of relativistic corrections on the evolution of triple black hole systems was studied. The initial conditions used were followed from Burrau (1913) and Valtonen et al. (1995) i.e. bodies were placed at the vertices of a Pythagorean triangle(s) with their mass being

proportional to the length of the opposite side of the triangle all with zero initial velocity. For each configuration, masses of the black holes were scaled in factors of ten from 10^0 M⊙ to 10^12 M⊙. As a descriptor of the evolution of the system, the lifetimes, the number of binary encounters and the number of mergers were all analysed. In total, sixteen different configurations were studied (Pythagorean triangles with c<100) and thirteen individual simulations were conducted for each (mass factors from 10^0 M⊙ to 10^12 M⊙). Numerical integration of orbits was conducted using FORTRAN code ARCcode2 which was provided by Prof. Seppo Mikkola with relativistic corrections (pN) up to the 2.5th order. Larger mass systems resulted in almost instantaneous merging of all three bodies whereas smaller mass cases demonstrated longer lifetimes with complicated trajectories that most typically ended in binary pair formation and the third body being ejected.

Paolo Ciliegi
INAF Bologna Astrophysics Observatory, Italy

Extremely Big Eyes on the Black Holes formation and evolution

In the next decade the commissioning of ground based Extremely Large Telescope (30-40 m class) will allow us to see the black hole formation and evolution using new eyes of unprecedented power. The European Extremely Large Telescope (ELT) will be the biggest telescope of these outstanding family, with its first light foreseen by end 2025.
I will review the status of the ELT high resolution instruments and illustrate its science drivers. I will emphasize what we can expect from ELT both in terms of formation and evolution of Black Holes with different mass.

Anca Constantin
James Madison University, USA

Constraints on the modes of black hole accretion from a holistic search for water megamaser disks

If water megamaser disk activity is, as suspected, intimately related to the black hole accretion process, a thorough understanding of the co-evolution of galaxies with their central massive dark objects should consider the degree to which the maser production and properties correlate to those of their hosts. This contribution presents a novel multi-wavelength comparative investigation of nuclear and circus-nuclear properties of galaxies with and without megamasers, with results that reveal not only greatly superior prospects for detecting new disk systems, but also a rather narrow multi-dimensional parameter space associated with this particular exotic activity. This “goldilocks” region embodies the availability of gas, the degree of dusty obscuration and reprocessing of the central emission, the age of the associated stellar population, the accretion rate, the black hole masses, and their environments. These findings suggest that the disk megamaser phenomenon is linked to a particular short-lived phase in the black hole/galaxy evolution, at least at an intermediate mass level, with independent support to the idea that quantifying the type 1-2 AGN dichotomy is not merely a function of inclination but must involve the growth process of the incumbent AGN, and therefore their variability and possibly their changing look.

Kristen Dage
Michigan State University, US
Multiwavelength Studies of Ultraluminous X-Ray Sources in Extragalactic Globular Clusters
The question whether globular clusters host black holes has been of longstanding interest. This interest has grown dramatically with the LIGO detection of merging black holes, as black hole mergers formed in globular clusters is one of the leading explanations for these LIGO sources. Determining whether black holes are common in globular clusters (GCs) has been an observational challenge. One of the most successful ways to identify candidate black holes in globular clusters is to identify globular cluster X-ray sources with very high luminosities that are much greater than the Eddington limit for neutron stars. We have found a number of ultraluminous X-ray sources (ULXs) within extragalactic globular clusters, which are candidate accreting black holes. These sources have a potential correlation between X-ray parameters of the sources and the presence of optical emission. One GC ULX has over ten years of both optical and X-ray monitoring, with the optical steadily declining over ten years before showing an increase. In this talk, I will discuss the search for new sources in other galaxies and X-ray and optical studies of GC ULXs.

Thomas Davison
JHI, University of Central Lancashire, UK
Measuring Ex-situ Populations in Galaxies
We are currently experiencing a revolution in the study of galaxies, driven by the arrival of large field-of-view IFUs providing high S/N spectroscopy. When combined with novel statistical methods for decomposing spectra into their constituent stellar populations we have the opportunity to dramatically improve our understanding of the galaxy formation process. Using these methods we are now able to break down galaxies into their individual stellar populations, and further, to classify such populations as having been formed in or ex-situ. This allows us to examine not just the star formation and chemical enrichment histories of the galaxies, but also their assembly histories. In this talk, I will present predictions of the ex-situ fractions for galaxies drawn from the EAGLE simulations. We tailor these predictions for observers by providing them as a function of observable parameters such as surface brightness as well as mass and galaxy size. Furthermore, I will present the first large scale attempt to directly measure in and ex situ fraction on a sample of real galaxies drawn from the SDSS survey. By binning galaxies by mass, size, and fraction of light contained within the SDSS fibre, we produce high S/N spectra, from which we determine ex-situ fractions. I will describe how trends in ex-situ fraction vary across the mass-size plane, and how this compares to our predictions from simulations.

Colin DeGraf,
University of Cambridge, United Kingdom
Supermassive black hole merger rates, masses, and the morphological evolution of their host galaxies

Supermassive black holes (SMBHs) are known to be found in the central regions of galaxies, and mergers between these black holes are expected to occur when their host galaxies merge. In the near future, upcoming projects, including LISA and Pulsar Timing Arrays, are expected to detect gravitational wave signals from SMBH mergers for the first time, making now the ideal time to make predictions for what we can expect. Using high-resolution cosmological simulations, I will discuss the expected merger and detection rates for such black hole mergers, including the need to incorporate inspiral/hardening times, with particular emphasis on the impact the merger timescale has on the merging masses. Furthermore, I will discuss what we can expect for the morphologies of the galaxies which host SMBH mergers (important for multimessenger followup observations to gravitational wave detections), and show that we can expect the host morphologies to exhibit evidence of recent galaxy mergers, with the strongest morphological signals at z~0.5 and typically surviving on the order of ~500 Myr.

Valerio D'Elia
ASI-SSDC & INAF-OAR, Italy

GRB 171205A/SN 2017iuk: A local low-luminosity gamma-ray burst

Gamma-ray bursts (GRBs) occurring in the local Universe constitute an interesting sub-class of the GRB family, since their luminosity is on average lower than that of their cosmological analogs. Attempts to understand in a global way this peculiar behaviour is still not possible, since the sample of low redshift GRBs is small, and the properties of individual objects are too different from each other. In addition, their closeness (and consequently high fluxes) make these sources ideal targets for extensive follow-up even with small telescopes, considering also that these GRBs are conclusively associated with supernova (SN) explosions.
We aim to contribute to the study of local bursts by reporting the case of GRB 171205A. This source was discovered by Swift Burst Alert Telescope (BAT) on 2017, December 5 and soon associated with a low redshift host galaxy (z = 0.037), and an emerging SN (SN 2017iuk).
Methods: We analyzed the full Swift dataset, comprising the UV-Optical Telescope (UVOT), X-ray Telescope (XRT) and BAT data. In addition, we employed the Konus-Wind high energy data as a valuable extension at γ-ray energies.
The photometric SN signature is clearly visible in the UVOT u, b and v filters. The maximum emission is reached at̃ 13 (rest frame) days, and the whole bump resembles that of SN 2006aj, but lower in magnitude and with a shift in time of +2 d. A prebump in the v-band is also clearly visible, and this is the first time that such a feature is not observed achromatically in GRB-SNe. Its physical origin cannot be easily explained. The X-ray spectrum shows an intrinsic Hydrogen column density NH,int = (7.4+4.1-3.6)E20 cm-2, which is at the low end of the N H, int, even considering just low redshift GRBs. The spectrum also features a thermal component, which is quite common in GRBs associated with SNe, but whose origin is still a matter of debate. Finally, the isotropic energy in the γ-ray band, Eiso = (2.18+0.63-5.0)E49 erg, is lower than those of cosmological GRBs. Combining this value with the peak energy in the same band, Ep = 125+141-37 keV, implies that GRB 171205A is an outlier of the Amati relation, as are some other low redshift GRBs, and its emission mechanism should be different from that of canonical, farther away GRBs.

Massimo Della Valle
INAF- Capodimonte Astronomical Observatory, Napoli
Review Talk
SN-GRB connection, & memories of Sergio Colafrancesco
Abstract
We review the status of the Supernova/Gamma-Ray Burst connection. Several pieces of evidence suggest that long duration Gamma-ray Bursts (GRBs) are associated with type Ib/c Supernovae (SNe). Current estimates of SN and GRB rates show that only a tiny fraction of massive stars, likely less than 3%, are able to produce GRBs.

Ivan Delvecchio
Department of Astrophysics, France
The dark matter halo mass drives a superlinear BH-galaxy relation
Supermassive black holes (SMBHs) are tightly correlated with their hosts, but the origin of such connection remains elusive. To explore the cosmic buildup of this scaling relation, I will present an empirically-motivated model that tracks galaxy and SMBH growth down to z=0. Starting from a random mass seed distribution at z=10, we assume that each galaxy evolves on the star-forming "main sequence" (MS) and each BH grows through gas accretion following observed relations between BH accretion rate (BHAR) and star formation rate (SFR). Our phenomenological recipe naturally describes the BH-galaxy buildup in two stages, regardless of the BH seed mass. At first, the SMBH lags behind the host that evolves along the MS. Later, as the galaxy grows in stellar mass (M*), the BH catches up along a tight superlinear M_BH/M* relation. Our empirical trend agrees with both high-redshift model predictions and bias-corrected scaling relations of local BHs. We speculate that the observed nonlinear BH-galaxy buildup is reflected in a twofold behavior with dark matter halo mass (M_DM), displaying a clear turnover at M_DM ~ 2*10^12 Msun. While supernovae-driven feedback suppresses BH growth in smaller halos, above that M_DM threshold cold gas inflows might provide the fuel to sustain both BH accretion and star formation.

Barbara De Marco
N. Copernicus Astronomical Center PAN, Poland
ReviewTalk
Timing properties of hot coronae in accreting sources
A hot corona is a fundamental component of accreting BH systems. Such a hot plasma can indeed explain the production of hard X-ray emission in AGN and BH X-ray binaries, and the formation of a reflection spectrum. However, there are many open issues regarding the nature of hot coronae, one of the most outstanding being the exact geometry. This talk will be focused on the current debate around the geometry of hot coronae, and will provide an overview of the way X-ray variability studies can address this issue.

Antonio de Ugarte Postigo
IAA-CSIC, DARK/NBI, Spain
GRB 171205A/SN2017iuk: A new standard for GRB studies
GRB 171205A was one of the closest and better followed events. In this talk I will present the result of several studies of this GRB, its afterglow, associated supernova SN2017iuk, and host galaxy. Optical spectroscopy ranges from one hour after the event to more than 7 months later. These data served to identify cocoon signatures during the first 3 days, with material expanding at speeds that reached 0.3c (Izzo, de UgartePostigo et al. 2019, Nature 565, 324), and study the supernova evolution into the nebular phase. The interaction of the jet that emerged from the collapsing star with the interstellar medium generated a weak afterglow. In spite of its intrinsic faintness, thanks to the proximity of the GRB, we have been able to follow the radio emission for over 2 years now, obtaining a detailed insight on the physics involved in this event. Finally the data are complemented with a very detailed study of the host galaxy in which this GRB happened, thanks to high-resolution HST imaging, resolved molecular spectroscopy from ALMA and optical integrated field spectroscopy from VLT/MUSE. The GRB is located in the outskirts of a barred, grand design spiral galaxy, a very unique environment for a long GRB.

Gulab Dewangan
IUCAA, India
Review Talk
Highlights of the AstroSat mission
AstroSat is India's first multi-wavelength space astronomy mission that was launched on 28 September 2015. AstroSat carries five payloads that perform observations in the optical, ultraviolet, soft and hard X-rays. The five scientific payloads are (i) a Soft X-ray Telescope (SXT), (ii) three Large Area X-ray Proportional Counters (LAXPCs), (iii) a Cadmium-Zinc-Telluride Imager (CZTI), (iv) two Ultra-Violet Imaging Telescopes (UVITs) one for visible and near-UV channels and another for far-UV, and (v) three Scanning Sky Monitors (SSMs). AstroSat is a proposal-driven observatory with observing opportunities available to national and international scientists. This talk will present the current status of the instruments onboard Astrosat and the main results obtained on X-ray binaries and active Galactic Nuclei including multiwavelength UV/X-ray observations.

Lankeswar Dey
Tata Institute of Fundamental Research, India
Spitzer observations of the predicted Eddington flare in blazar OJ 287
The binary black hole (BH) central engine description for the unique blazar OJ 287 predicted the next secondary BH impact-induced flare to peak on July 31, 2019, within a specified +- 4.4 hour interval. This prediction was based on detailed General Relativistic modeling of the secondary BH trajectory around the primary BH and its accretion disk. We report the multi-epoch Spitzer observations of the expected flare between July 31 and August 9, 2019. Except for the higher base-level flux at 3.55 and 4.49 microns than in the optical R-band, the flux behavior displays a strong similarity with the observed periastron flare from OJ 287 during September 2007.

Comparing the two light curves we find that the Eddington flare came around 3 hours ahead of time, but well within the expected time interval. Present observations firmly establish the presence of a nano-Hertz gravitational wave (GW) emitting spinning massive binary BH inspiraling along a general relativistic eccentric orbit in OJ 287. These GWs should be detectable by the International Pulsar Timing Array consortium during the Square Kilometre Array era. Further, Spitzer observations of the Eddington flare demonstrate the importance of hereditary contributions to GW emission in OJ 287.

2nd contribution:

InPTA: Indian contribution to detecting nanohertz gravitational waves

The International Pulsar Timing Array (IPTA) experiment aims to detect gravitational waves (GWs) in the sub-microHertz frequency range by observing a bunch of millisecond pulsars. This experiment is sensitive to both stochastic GW background as well as individual sources like supermassive black hole binaries (SMBHBs). The Indian Pulsar Timing Array (InPTA) currently uses upgraded Giant Meter-wave Radio Telescope (uGMRT) to observe six millisecond pulsars at around 10 days cadence. The wide frequency coverage provided by the uGMRT should enable very accurate characterization of dispersion measure (DM) variations seen in some of the IPTA MSPs. Additionally, we are pursuing several IPTA-relevant efforts such as developing prescriptions to search for nano-Hz GWs from spinning SMBH binaries in eccentric orbits.

Federica Duras
Aix Marseille Univ, CNRS, CNES, LAM, France

An X-ray-to-ALMA view of the AGN-galaxy connection

Several efforts have been made in the last years to shed light on the SMBH-galaxy connection, but a firm conclusion has not been reached yet. One of the possible routes attempted to study this co-evolution focuses on the investigation of the physical properties of active galaxies, which are tightly fasten in their emission and then in their spectral energy distribution. Within this scenario, we have built a sample of about 40 AGN with an extremely wide and accurate multi-wavelength photometric data-set, by matching the CANDELS/GOODS-S field with Chandra and ALMA observations. We applied the new X-ray fitting module of the SED-fitting code CIGALE, which allows to model the AGN SED from the X-ray to the IR simultaneously. X-rays are indeed generated from the immediate vicinity of the SMBH, and thus directly revealing the intrinsic AGN power. Therefore, they can be considered as tracers of the SMBH accretion rate. I will show how the inclusion of the intrinsic X-ray information could modify the best-fit physical parameters of both the nuclear engine and the host galaxy: this kind of comparisons assume a favoured importance in view of the impressive quality of data Athena will be able to provide.
Moreover, the inclusion of the ALMA photometry in our sample, allowed us to better shape the IR SED of each source. Therefore, we could consequently accurately study the star formation activity and gas consumption of the AGN, key parameters for understanding the BH-galaxy co-evolution, and which I will present compared with the sources' accreting properties.

Sergei Dyda

University of Cambridge, UK

Viscous Effects of Misaligned Accretion Discs

A possible explanation of high frequency QPO's is a radiatively hot accretion flow precessing due to the Lense-Thirring (LT) effect. A key physical question is how magnetic stresses allow angular momentum to flow in the disc and hence alter the LT, test particle assumption. We use magnetohydrodynamic simulations to study precession of misaligned discs in a classical background. We compare results for inviscid and viscous alpha discs using our grid based methods and to previous simulations of viscous discs using smooth particle hydrodynamics. We then compare results of viscous discs where viscosity is driven self-consistently via the MRI and characterize the importance of moving away from the thin-disc, isotropic alpha-disc viscosity to adequately model precessing disc systems.

Marta Dziełak
Nicolaus Copernicus Astronomical Center PAS, Poland

Comparison of spectral models for disc truncation in the hard state of GX 339–4

We probe models of disc truncation in the hard spectral state of an outburst of the X-ray transient GX 339-4. We test a large number of different models of disc reflection and its relativistic broadening, using two independent sets of codes. We apply it to a RXTE spectrum in the rising part of the hard state. Our main finding is that analysed spectra can be fitted with similar quality with models (with different physical assumptions) allowing significantly different disc truncation radii. Still, all of the fitted models prefer the inner radius of the disc to be much larger than ISCO at their best-fit values. Our statistically best model has a physical thermal Comptonization primary continuum, requires the disc to be truncated at a radius larger than that of > 2 ISCO, and predicts a disc inclination in agreement with that of the binary. Our results has been published in Dziełak et. al., 2019, MNRAS, 485, 3845.

Elise Egron
INAF-Observatory of Cagliari, Italy

Investigating the mini and giant radio flares of Cygnus X-3

Microquasars are ideal targets to study the accretion-ejection processes on human timescales. Cygnus X-3 is the brightest X-ray binary at radio wavelengths. It is the only known binary system in our Galaxy composed of a compact object wind-fed by a Wolf-Rayet star. This high-mass X-ray binary system has a very short orbital period of 4.8 hrs, which implies a very tight orbit and strong interactions between the compact object and the stellar wind from the donor. Cyg X-3 is characterized by a highly variable radio emission spanning from 1-30 mJy in the quenched radio state up to 20 Jy during giant flaring states. We present single-dish (SRT and Medicina) and VLBI observations performed during the giant flare episodes in September 2016 and April 2017. We study the evolution of the spectral index on very short timescale. Moreover, we investigate the radio orbital modulation of Cyg X-3 during mini-flares.

Martin Elvis
Center for Astrophysics | Harvard & Smithsonian, USA

Review Talk

Adolescent Black Holes may be Hard to Find

Finding adolescent black holes that are growing rapidly from their seed masses is a major goal of the next generation of large observatories. We have examined how these early quasars may appear in terms of their broad emission lines (BELs) in the optical and ultraviolet. We find that below 10**6 Msol, the equivalent widths of the BELs drop precipitously. Moreover, if the BELs originate in clouds that form as the cool phase of a multi-phase medium, then for metallicities Z/Zsol ~< 3, the thermal instabilities that create them will not exist. However, in observed quasars at high redshift Z/Zsol is >> 3, so quasars are preferentially found in special environments, perhaps with deep potential wells. The population that we see though could be biased by the Z/Zsol > 3 requirement. A stronger argument is that the thermal instability leading to cool clouds is predominantly due to line emission by iron. Iron comes primarily from type 1a supernovae, which take of order 1 billion years to ignite. Hence iron should be under-abundant relative to other elements until z ~ 6 - 7. That the highest redshift quasar is at z = 7.1 may be a consequence of this requirement. Quasars above z ~ 7 could still be found by their rest-frame ultraviolet or X-ray continuum.

Savithri H. Ezhikode
IUCAA, India

Relativistic reflection fraction in Seyferts

The primary X-ray power-law emission from AGN irradiates the accretion disc and the circumnuclear material, where the photons get reprocessed producing reflection features in the X-ray spectrum. The reflection features arising from the inner regions of the disc may be significantly modified by the relativistic effects near the black hole. We investigate the relationship between the relativistic reflection fraction R_f and the hard X-ray photon index Γ in a sample of Seyfert 1 galaxies observed with NuSTAR. The X-ray spectra are modelled using relxill which provides the reflection fraction of a relativistically smeared reflection component. The parameter R_f is defined as the ratio of the coronal intensity that illuminates the accretion disc to the coronal intensity observed directly, and it depends on the amount of Comptonised X-ray emission intercepted by the inner accretion disc. We found a positive correlation between Γ and R_f in our sample. The seed photons from a larger area of the accretion disc entering the corona lead to an increased rate of cooling of the plasma, giving rise to a steeper X-ray spectrum. Also, the corona irradiating the larger area of the disc will result in higher reflection fraction. Thus, the observed R_f−Γ relation in our sample is most likely related to the changes in the disc-corona geometry of AGN.

Pepi Fabbiano
Center for Astrophysics | Harvard & Smithsonian
Review Talk

Circum-Nuclear X-ray Emission from Galaxies

I will review recent Chandra results highlighting the sub-arcsecond morphology and spectral properties of the circumnuclear regions of nearby obscured AGNs. In comparison with ALMA

and IFU results, these data present a new picture of the AGN interaction with the surrounding ISM and molecular clouds, and on the structure of the torus and accretion flows.

Shokoufe Faraji
BU, Germany

Structure of the thin accretion disk around a distorted naked singularity versus a distorted static black hole

Accretion disk models are the key to connect observations of accretion disks with the theory. In this work, we consider the standard relativistic geometrically thin and optically thick accretion disk around a distorted static black hole and a distorted naked singularity. The distortion is the result of the existence of a static axisymmetric external distribution of matter in which this approach is developed by R. Geroch and J.B. Hartle in 1982.
Our main purpose of this work is to investigate whether the naked singularity models have their own observational fingerprint if they do exist. Indeed, understanding the astrophysical behavior of naked singularities seems to be extremely important for the general theory of relativity. We study the effects due to a distortion up to the quadrupole, and compare the physical characteristics of thin accretion disk for both cases. Also, the presence of the distribution can describe the exterior of a non-isolated object that in fact may be more realistic in the sense that it has many examples in nature, also it could consider as a solution that models the effect of the outer part of the disk on the inner part.

2nd contribution,

Polish donaught around a distorted static black hole in the presence of magnetic field

Several important astrophysical phenomena, such as active galactic nuclei or X-ray binaries, are powered by accretion onto black holes. The accretion of the matter is one of the most powerful energy sources in the universe. The spacetime in the vicinity of the horizon in the presence of a static and axially distribution of matter localized outside the black hole horizon is achieved by the solution so-called local black hole. In this case the distorted black hole allows a details description discussed by R. Geroch and J.B. Hartle in 1982. . If the effects due to the rotation are negligible, this distribution can describe the exterior of any axially symmetric astrophysical model. In this work, we construct the relativistic thick accretion disk, Polish donaught, around a distorted Schwarzschild black hole in the presence of a magnetic field. The distortion is up to the quadrupole correction of the static axisymmetric external distribution of matter. Also, the distortion could be related to the effect of outer parts of the disk on the inner part. We study the effects due to a distortion up to the quadrupole and compare the physical characteristics of this disk to the usual Schwarzschild case.

Christian Fromm
Goethe University Frankfurt, Germany
Review Talk

Theory of AGN Jets

Tbd

Isaura Fuentes-Carrera
Escuela Superior de Física y Matemáticas, Instituto Politécnico Nacional, Mexico
Multiwavelength and kinematical analysis of the surroundings of ultra-luminous X-ray sources in nearby spiral galaxies
With luminosities between 10^39and 10^41 erg/s in the 0.5-10 keV band, ultra-luminous X-ray sources(ULXs) lie between classic X-ray binaries and active galactic nuclei. These luminosities cannot be explained by the standard accretion of a stellar mass black hole, these sources are often associated with super-Eddington accretion and/or intermediate-mass black holes (IMBHs, 10^2-10^4 solar masses). In this work we present scanning Fabry-Perot observations of the ionized gas surrounding ultra-luminous X-ray sources in different nearby spiral galaxies. We identify non-circular motions probably associated with either isotropically or beamed expanding gas. Most of the sources observed show asymmetrical distribution of the ionized emission, as well as asymmetrical distribution of gas motions. We also study the location of these sources in the context of the whole galaxy in different wavelengths. This work is part of an analysis to determine the nature of these sources and their correlation (if any) with the kinematics of the host galaxy.

Simona Gallerani
Scuola Normale Superiore, Italy
Physical properties of z~6 quasars
High redshift quasars represent ideal laboratories for studying the black hole growth at early epochs, the properties of their host galaxies and the joint formation and evolution of these systems. Since the beginning of the new millennium, hundreds of luminous quasars have been discovered at z~6 and beyond through several surveys, and followed-up with multi-wavelength observations. For several of them, the mass of the hosted BH has been measured and found to be as massive as 1.e8-1.e10 Msun. The existence of such super massive black holes (SMBH) in the early Universe represents a challenging problem in modern cosmology. I will firstly review the most recent observations of z~6 quasars obtained with (sub-)millimeter and X-ray facilities. Then, I will discuss key observational challenges and open issues in theoretical models. Finally, I will highlight possible new strategies to improve our understanding of the galaxy-black hole formation and evolution in the early Universe, including multi-messenger observations of merging SMBHs that will become available in the next future.

Fatemeh Zahra Zeraat Gari
Xi'an Jiaotong University, China
Inflow-outflow structure of supercritical accretion flows
There is growing observational evidence supporting the existence of super-Eddington accretion in several distinct classes of objects. Good candidates for super-Eddington accretors are ultra-luminous X-ray sources (ULXs), bright X-ray compact sources of X-ray luminosity of 10^39–10^41 erg s^−1. Outflow is one of the signatures characterizing super-Eddington flow. These outflows, as either highly collimated jets or wider angle winds, can have a large mass and/or

kinetic power so they can have a significant impact on the accretion environment. We present two-dimensional inflow-outflow solutions of supercritical accretion flows and investigate the effects of outflow/wind on the structure of accretion flow. Our results show that the density and mass inflow rate are proportion to the radius as, \rho(r) \propto r^-0.5, and \dot(M){in}\propto r, respectively. We analysis the driving forces of the outflow. We further studied the properties of the outflow and also calculated the convective instability of the supercritical accretion flows. We found that the HD supercritical disks are convectively unstable.

Efrain Gatuzz
Max Planck Institute for Extraterrestrial Physics (MPE), Germany
Black hole X-ray binaries: the disc-jet-wind interaction
The accretion phenomena, observed in X-ray binary systems, constitutes one of the most promising challenges in modern astrophysics. Interesting open topics include the accretion-radiation energy balance, the relation between relativistic jets and the fundamental properties of the black holes (e.g. spin), the radiative feedback and the interplay between discs and outflows (in the form of relativistic jets or collimated winds). Here, we review some of our last results on the X-ray high resolution analysis of such environment including the detection of an ionized static absorber during a hard accretion state that could be the precursor of an outflowing wind, and the impact of photoionization and thermal instabilities in the evolution of outflowing winds.

Nicola Giacobbo
Università di Padova, Italy
Where do merging binaries come from: field or star clusters?
About four years after the first direct detection of gravitational waves, the formation channels of stellar-mass binary black holes (BBHs) are still a matter of debate. In particular, I will discuss in this talk the main differences between isolated binary evolution and dynamical formation of BBHs. In the former scenario, BBHs evolve from unperturbed stellar binaries in the field, while in the latter they assembly dynamically in star clusters. In this talk, I will show the results of a large sample of dynamical simulations of young star clusters and I will compare them against population-synthesis simulations of isolated binaries. BBHs evolving in star clusters are significantly more massive than isolated BBHs, reaching total masses up to ~ 120 Msun. In contrast, merging BBHs in isolated binaries have a maximum total mass around 85 Msun. Moreover, stellar collisions and dynamical exchanges allow the formation of black holes in the pair-instability mass gap (between ~60 and 140 Msun). In our simulations we find that ~ 2 % of merging BBHs in young star clusters have at least one component in the pair-instability mass gap and we predict that up to ~ 9 % of all BBHs detectable by advanced LIGO and Virgo at their design sensitivity have at least one component in the pair-instability mass gap. This represents a unique fingerprint of merging BBHs in star clusters.

Emanuele Giallongo
INAF - Rome Observatory, Italy
The Space densities and UV emissivities of AGNs at z > 4

The study of the space density of moderately bright AGNs at z > 4 has been subject to extensive effort given its importance for the estimate of the cosmological ionizing emissivity. In this context we have recently derived high space densities of AGNs at z = 4 and −25 < M1450 < −23 in the COSMOS field from a spectroscopically complete sample. Now we extend the knowledge of the AGN space density at fainter magnitudes (−23 < M1450 < −18) in the 4 < z < 6.1 redshift interval by means of a multiwavelength sample of galaxies in the CANDELS GOODS-South, GOODS-North and EGS fields. Including our COSMOS sample as well as other color selected spectroscopic samples of bright QSOs (M1450 < −27) allows a first guess on the broad shape of the UV luminosity function at z>4 characterized by a double power law with a sharp break. The resulting emissivity and photoionization rate obtained for AGNs with M1450 < −18 appear consistent with that derived from the photoionization level of the intergalactic medium at z = 4.5. An extrapolation to z = 5.6 suggests an important AGN contribution to the IGM ionization if there are no significant changes in the shape of the UV luminosity function.

Andreja Gomboc
University of Nova Gorica, Slovenia
TDEs in the LSST era
Tbd

Rosa A Gonzalez-Lopezlira
UNAM, Instituto de Radioastronomia y Astrofisica, Mexico
The globular cluster system of NGC 4258: a relic of cosmic high noon?
We present multi-object spectroscopic observations of 23 globular cluster candidates (GCCs) in the prototypical megamaser galaxy NGC 4258, carried out with the OSIRIS instrument at the 10.4 m Gran Telescopio Canarias. The candidates have been selected based on the (u* - i') versus (i' - Ks) diagram, in the first application of the \uiks\ method to a spiral galaxy. In the spectroscopy presented here, 70% of the candidates are confirmed as globular clusters. Our results validate the efficiency of the \uiks\ method in the sparser GC systems of spirals, and the agreement of the galaxy with the correlations between black hole mass, and total number and mass of GCs. We find that the metal-poor GCs co-rotate with the HI disk, even at large galactocentric distances. The ratio of rotation to velocity dispersion V/sigma of the system is ~ 1, consistent with the highly turbulent, rotating disks at z>=2 that constitute nowadays the favored environment for the formation of globular clusters. This system could be a z = 0 relic of this process.

A Gopakumar
TIFR, India
Review Talk
The blazar OJ287 and its nano-Hertz GW emitting massive BH binary central engine
Blazars are active galactic nuclei with strong jets. They tend to exhibit dramatic and unpredictable flux variations, namely outbursts. Certain observed outbursts from an exceptional Blazar OJ287 can be explained by invoking a massive black hole binary as its central engine.

Detailed General Relativistic modeling allowed us to predict a major optical outburst during November 2015. The outburst did occur within the expected time range, peaking on 5/12/2015. A multi-wavelength observational campaign confirmed the occurrence of certain impact flare and the presence of a major thermal component in the flare, as predicted. These observations and subsequent analysis allowed us to establish the possible presence of a spinning supermassive black hole binary that spirals in due to the emission of nano-Hertz gravitational waves in the central engine of OJ287. I will briefly list our on-going efforts that should be interesting to the Event Horizon Telescope consortium and the International Pulsar Timing Array.

Alister Graham
Swinburne University of Technology, Australia
Review Talk
Galaxy-BH scaling relations
Having carefully decomposed the images of 120+ galaxies, my group have established the latest (supermassive black hole mass)-(host galaxy) scaling relations involving the bulge stellar mass, the galaxy stellar mass, the bulge Sersic index, the spiral arm pitch angle, and other physical parameters such as the central velocity dispersion, the disk rotational velocity, and estimates of the dark matter halo mass. With such a large sample, we are now detecting morphological-dependent differences in the black hole scaling relations. Given the vast array of new results, I will focus on the late-type galaxy population while reviewing the scaling relations in general.

Jonathan Granot
The Open University of Israel
Review Talk
Binary NS mergers
Tbd

Kirill Grishin
SAI MSU, Russia
Internal Properties and Environment of Galaxies Hosting AGN Powered By Low-Mass Black Holes
There are two channels of SMBH growth: accretion of infalling material and galaxy mergers leading to the mergers of central black holes. The latter way of growth leads to scaling relations between central black hole mass and intrinsic properties of the host galaxy (e.g. bulge stellar mass, velocity dispersion of stars in a bulge). Our goal is to populate these relations at the low-mass end (<1M MSun including intermediate-mass black holes <200k MSun). We study the environment and internal properties of host galaxies for a sample of 305 IMBH candidates identified by Chilingarian et al. (2018) complemented with slightly more massive black holes. Low-mass BHs tend to reside in low density environments. We followed up over 40 galaxies using the MagE spectrograph (R=6000) and the FourStar NIR imager at the 6.5-m Magellan telescope. We obtained stellar velocity dispersions by using full spectrum fitting and the total bulge stellar masses from the 2D photometric decomposition. Our results demonstrate that host

galaxies of AGN powered by low-mass BHs follow scaling relations set by more massive SMBHs for both velocity dispersion and stellar mass. This supports the scenario of BH and host galaxy co-evolution in the low-mass regime.

Sudipta Hensh
Silesian University in Opava, Czech Republic

Evolution of rotating braneworld naked singularities

Naked singularities come as a solution to Einstein's field equations. Cosmic censorship hypothesis is not proved yet within the framework of general relativity. Therefore, naked singularities cannot be rejected as nonphysical. We study the simple accretion model of the Keplerian thin disk onto a naked singularity described by rotating braneworld metric. Our aim is to investigate the final fate of naked singularities due to matter accreting from the accretion disks. We show that the naked singularities are eventually converting into the extreme back hole as a result of swallowing matter.

Ahmad Hujeirat
University of Heidelberg

The cosmology of neutron stars

tba

Kohei Ichikawa
Tohoku University, Japan

Serendipitous discovery of a dying AGN in Arp 187

Arp 187 is one of the fading active galactic nuclei (AGN), whose AGN activity is currently decreasing in luminosity, and is a good laboratory to obtain the crucial information on the accretion disk physics and the lifetime of AGN. We investigate the observational signatures of AGN in Arp 187, which trace various physical scales from less than 0.1 pc to the nearly 10 kpc, to estimate the longterm luminosity change over 10^4 years. The VLA 5 GHz, 8 GHz, and the ALMA 133 GHz images reveal bimodal jet lobes with ~5 kpc size and the absence of the central radio-core. The 6dF optical spectrum shows that Arp 187 hosts a narrow-line region with an estimated size of ~1 kpc, and the line strengths give the AGN luminosity of Lbol = 1.5x10^46 erg/s. On the other hand, the current AGN activity estimated from the AGN torus emission gives the upper bound of Lbol < 2.2 x 10^43 erg/s. The obtained upper bound from the NuSTAR X-ray observation is Lbol < 3x10^42 erg/s, indicating an inactive central engine. These multi-wavelength signatures indicate that Arp 187 hosts a “dying” AGN: the central engine is already dead, but the large scale AGN indicators are still observable as the remnant of the past AGN activity. The central engine has experienced the drastic luminosity decline by a factor of ~10^{3-5} fainter within ~10^4 years, which is roughly consistent with the viscous timescale of the inner part of the accretion disk within ~500 years.

Naseer Iqbal
University of Kashmir, Srinagar, India

UV and X-Ray Emission from X-ray Binaries

The UV emission from X-ray binaries, may arise from the outer accretion disk. The structure of the outer disk may be altered due to the presence of X-ray irradiation and we discuss the physical regimes where this may occur and point out certain X-ray binaries where this effect may be important. The long term X-ray variability of these sources is believed to be due stochastic fluctuations in the outer disk, which propagate inwards giving rise to accretion rate variation in the X-ray producing inner regions. The motivation is to understand the effect of X-ray irradiation in such a scenario. To this end, a time dependent hydrodynamical framework with X-ray irradiation needs to be set up, such that the effect of fluctuations in the outer disk can be studied. We started, following earlier works, to solve for the steady state accretion disk structure taking into account irradiation. To understand the qualitative behavior, we adopt simplistic assumptions that the disk is fully ionized and it is not warped. We then proceeded to develop a time dependent hydrodynamic code, which in the absence of perturbations is numerically stable. A sinusoidal perturbation was introduced at different radii, and its effect on the mass accretion rate in the inner disk was computed. The code was carefully studied to verify that the results are invariant to the numerical time steps and radial bins used. While we didn't find any oscillatory or limit cycle behavior due to the X-ray irradiation feedback, our results show irradiation enhances the X-ray variability at time-scales corresponding to the viscous time-scales of the irradiated disk.

Emilia Järvelä
ESA / European Space Astronomy Centre, Spain

Extended radio emission in narrow-line Seyfert 1 galaxies

Narrow-line Seyfert 1 galaxies (NLS1) are an intriguing class of gamma-ray emitting active galactic nuclei (AGN). Contradictory to the traditional jet paradigm NLS1s mostly reside in spiral galaxies, harbour low or intermediate mass black holes, accreting at high Eddington ratio, and show preferably compact radio morphologies. These properties suggest that NLS1s are young AGN, possibly going through one of their very first activity cycles. However, NLS1s have proven to be a very heterogeneous class of sources: a handful of them are able to maintain powerful relativistic jets, but the majority has not even been detected in radio frequencies.

Recent radio imaging surveys targeting NLS1s have found that a considerable fraction of radio-detected NLS1s exhibit kpc-scale radio emission, and even diffuse emission resembling radio relics has been found, possibly indicating intermittent nuclear activity. These sources often belong to the radio quiet population, and might, in part, help explain the observed diversity of NLS1s. Studying their radio, as well as other properties is crucial to continue building a comprehensive picture of the NLS1 population, and to better understand the activity and duty-cycle of efficiently accreting supermassive black holes.

Here we present a detailed study of a sample of NLS1s with extended radio emission found in our earlier JVLA survey. We used optimal tapering to reveal low-intensity kpc-scale radio emission, and, for example, in-band spectral index maps to investigate its nature. Combined with

additional available data, we discuss how these sources fit into our current understanding of NLS1s, and the AGN phenomena in general.

Adithan Kathirgamaraju
UC Berkeley, USA
Off-Axis Short GRBs in the gravitational wave era
The advent of gravitational wave detectors has led to many breakthrough observations. Among them is the neutron star merger GW170817, which has provided us with the most conclusive detection of an off-axis short GRB to date. I will discuss off-axis GRBs in the paradigm of structured jets and how this model can successfully reproduce the observations of GW170817.

Ivan Katkov
New York University Abu Dhabi, United Arab Emirates
Multi-wavelength view of large-scale galactic outflows
Galaxy-scale outflows are an important component of galaxy evolution models. Nevertheless, how they affect the host galaxy's star formation and metal enrichment histories remain unclear. Such outflows are currently thought to be generated by Active Galactic Nucleus (AGN) and starburst activity. Both mechanisms can produce hot gas and relativistic particles, which generate radio and optical emission. In this project, we are combining optical integral-field spectroscopy data from the MaNGA survey and sensitive radio (Jansky Very Large Array; JVLA) observations to measure the properties of both components with comparable (~1-2") angular resolution. In the talk we will present a joint analysis of the radio morphology and spectrum, ionized gas kinematics, and the properties of the host galaxy for a sample of 30 targets including AGN, starbursts, and composite sources whose optical spectrum indicate high-velocity components in the [OIII] emission line. We demonstrate how, together, spatially resolved radio and optical data offer a more complete picture of the outflow's energetics, kinematics, origin, and interaction with their surroundings.

Michael Kavic
State University of New York at Old Westbury, United States
Accessing the axion via compact object binaries
Tests of ideas at the frontier of physics, whether in the realm of dark matter detection or quantum gravity, are hard to conduct on Earth. For example, accelerator energies are many orders of magnitude too low to directly test GUT-scale physics and the even more prohibitive compactification scale of extra spatial dimensions. But astrophysical "laboratories" have no such limits. On the other hand, astrophysical systems can be complex. We will discuss a relatively "simple" binary system consisting of a Kerr black hole and pulsar. The pulsar, acting as a precision orbiting clock, would enable measurements that can test specific predictions beyond the standard model. This talk will consider the case of black hole superradiance which allows axions to be generated in a cloud around a Kerr black hole. This cloud drains the rotational kinetic energy, and thus mass, emitting gravitational waves in the process. Axions are central to many theoretical ideas at the frontier of physics including as a dark matter candidate and are a

prediction of models of quantum gravity such as string theory. We will discuss how precision measurements of the changing orbital period of the system (at the level accomplished in the case of the binary pulsar) can test this axion production process, and set limits on the mass scale of the axions produced. The Square Kilometer Array will be able to discover and observe black hole-pulsar binaries and will be able to search for axions in such systems.

Nobuyuki Kawai
Tokyo Tech, Japan

Classification of 27-year X-ray activities of GRS 1915+105

GRS 1915+105 is a black hole X-ray binary known for its characteristic variabilities of X-ray fluxes on timescales of minutes to hours, sometimes showing limit-cycle behavior in its X-ray light curves. More than ten patters of light curves has been recognized and classified. However, its long-term behavior, in particular, transitions among these variability classes have been difficult to study, since their classification required dedicated pointed observations.
Here, we investigated the long-term behavior of GRS 1915+105 using the data obtained over 10 years (2009-2019) with the Gas Slit Camera (GSC) of Monitor of All-sky X-ray Image (MAXI) on the ISS and the Burst Alert Telescope (BAT) of the Neil Gehrels Swift Observatory. MAXI scans the source for about 60 seconds every 92 minutes (ISS orbit). While it is difficult to recognize the variability class by the light curves within such short transits, we find it is possible to classify its activity state using the flux and the hardness ratio averaged over one day. With the appropriate choice of the energy bands for the flux and hardness ratio, the daily X-ray activities of GRS 1915+105 can be classified into four distinct branches in the hardness-intensity diagrams. We also find rules in transitions among the branches. We further studied
We attribute these state transitions in GRS 1915+105 to a "state machine" in the GRS 1915+105 system that can hold the memory of its state over several months.

Fazeel Mahmood Khan
Institute of Space Technology, Islamabad, Pakistan
Review Talk

From Dwarfs to Giants: Dynamics and Mergers of Massive Black Hole Pairs in Galaxies

Massive Black Holes (MBHs), with masses from 10^4--10^{10} M_sun, are ubiquitous in a surprisingly wide range of galaxy types, from giant ellipticals, to bulgeless spirals, to low surface brightness galaxies, to dwarfs. Galaxies over this wide mass range feature a wealth of distinct structures, morphologies, and kinematics. MBH pairs are expected to form from galaxy mergers, as each progenitor injects its MBH in merger remnant. However, the dynamics, evolution and ultimate fate of these MBHs depend on the stellar environment, morphology and kinematics of the vast variety of host nuclei. Here, we shall review key outcomes of high resolution direct N-body simulations, including Post-Newtonian dynamics, of MBH pairs in realistic galactic nuclei. MBH binaries merge efficiently in all types of host galaxies and avoid the famous “final parsec problem” by interacting with a large pool of stars on low angular momentum orbits in the merger in remnants having non-spherical geometries. Merger times are significantly shorter for binaries hosted by low mass galaxies, owing to higher stellar densities and rotation. MBH binary

evolution is particularly dramatic in rotating stellar environments. Mergers between low mass MBHs emit gravitational waves that will be detectable by LISA with signal-to-noise ratios in the hundreds to thousands even into the epoch of reionization, which allows us to map growth and evolution of MBHs and their galaxy hosts from birth to the present day.

Rubinur Khatun
NCRA-TIFR, India

Searching for dual AGN in galaxy mergers and its effect on galaxy evolution

Dual Active galactic nuclei (AGN) are accreting supermassive black hole (SMBH) pairs that are expected to form during galaxy mergers and minor accretion events. Galaxy formation theories suggest that DAGN should be fairly common but observations show that confirmed DAGN are still relatively rare. High-resolution radio or X-ray observations are the best ways to confirm their presence. DAGN are important to study as they have a significant effect on the evolution of galaxy mergers via AGN feedback, both positive and negative which can have a considerable effect on the gas in the nuclear region. In addition, the DAGN may affect the galaxy environment through star-formation and AGN related outflows. The SMBH masses also have a strong effect on the merging process. There are a few indirect signatures of DAGN/binary AGN: (1) periodicity in optical variability; (2) double-peaked AGN (DPAGN) emission lines in optical nuclear spectra; (3) S- or X-shaped radio morphology. However, these signatures can be explained by other mechanisms also. Hence, one needs to high-resolution observation to confirm dual/binary AGN. We have observed a sample of 20 DPAGN at two or more frequencies using the Expanded Very Large Array (EVLA), in order to detect dual AGN. We have detected three dual AGN, two S-shaped radio jets which are also DAGN candidates. We have also obtained multi-frequency observation of a dual-core merger system using UVIT, HCT and EVLA to confirm the DAGN and understand the merger affect on this galaxy. I will discuss the results we have obtained so far and their implications for the galaxy merging process.

Dongwoo Kim
Center for Astrophysics | Harvard & Smithsonian, USA

X-ray Scaling Relations of Early Type Galaxies

The X-ray emitting hot ISM in early type galaxies (ETGs) plays a crucial role in understanding their formation and evolution. The structural features of the hot gas identified by Chandra and XMM-Newton observations point to key evolutionary mechanisms, (e.g., fueling SMBH, and feedback). In our X-ray Galaxy Atlas project, we have systematically analyzed the archival Chandra (XMM-Newton) data of 70 (50) ETGs and produced uniform data products with spatially resolved 2D spectral maps of the hot gas from individual galaxies. Utilizing our data products, we will discuss the hot gas properties in relation to SMBH, AGN/stellar feedback and environmental effects; the hot gas global properties and scaling relations; and the possibility of the universal T profile in ETGs.

Karri Koljonen
The Finnish Centre for Astronomy with ESO, Finland
The anomalous accretion state of GRS 1915+105
GRS 1915+105 entered recently (May 2019) in a new accretion state, which presents lower fluxes throughout its spectral energy distribution than ever before during its 27 years long outburst. However, it is not clear whether the outburst of GRS 1915+105 is switching off or just highly obscured. Surprisingly, during this low state, there have been observations of strong and sporadic X-ray and radio flares indicating episodic jet emission similar to what has been seen from V404 Cyg and Cyg X-3. In this presentation, I will discuss the striking similarity of their multiwavelength evolution and X-ray spectra and show that they most likely arise from our obscured view of the sources.

S. Komossa, D. Grupe, A. Kraus, et al.
Bonn, Germany
Multi-wavelength observations and modelling of the blazar and candidate binary SMBH OJ 287 (*Just as a filler; preference shall be given to other participants*)
We present results from our long-term Swift and radio monitoring of the blazar and candidate binary supermassive black hole OJ 287.

Orsolya Kovacs
Eotvos University, Hungary
Searching for AGN in ultra-diffuse galaxies
Ultra-diffuse galaxies (UDGs) are curious objects that have unusually large extent relative to their low-surface brightness. These galaxies have been detected in large numbers in the Coma cluster, which hosts at least 800 UDGs. Although a number of studies attempted to study their origin, it remains unclear whether UDGs host supermassive black holes. In this project, we utilized Chandra X-ray and Subaru Hyper Suprime-Cam observations to search for actively accreting black holes in UDGs residing in the Coma cluster. We find two UDGs that have an X-ray source at 3.0″ and 3.2″ off-center position. In addition, we measure the AGN occupation fraction of dwarf and normal galaxies in the Coma cluster, which galaxies serve as a control sample. We confront the AGN occupation fraction of the control sample galaxies with that obtained for UDGs.

Rajesh Kumar Dubey
LOVELY PROFESSIONAL UNIVERSITY-INDIA AND MINISTRY OF EDUCATION, GOVT OF UAE, INDIA
Gravitational Waves for Measuring Hubble’s Constant in the Accelerating Universe
Gravitational Waves for Measuring Hubble’s Constant in the Accelerating Universe
There could be different ways for observations and calculations for Hubble’s Constant. These methods primarily include estimation from the cosmic microwave background and measurement from the distance ladder using standard sirens. After the detection of Gravitational Waves and

modern technology for their advanced sensitivity, the measurement of Hubble's Constant has attained a new platform. The detection of GW170817 in both gravitational waves and electromagnetic waves heralds the age of gravitational-wave multi-messenger astronomy. On 17 August 2017, the Advanced Laser Interferometer Gravitational-wave Observatory (LIGO) and Virgo detectors observed GW170817, a strong signal from the merger of a binary neutron-star system. Less than 2 seconds after the merger, a gamma-ray burst (GRB170817A) was detected within a region of the sky consistent with the LIGO-Virgo-derived location of the gravitational-wave source. This sky region was subsequently observed by optical astronomy facilities resulting in the identification of an optical transient signal within$\sim$ 10 arcsec of the galaxy NGC4993 These multi-messenger observations allow us to use GW170817 as a standard siren the gravitational-wave analog of an astronomical standard candle, to measure the Hubble constant. This quantity, which represents the local expansion rate of the Universe, sets the overall scale of the Universe and is of fundamental importance to cosmology. This measurement combines the distance to the source inferred purely from the gravitational-wave signal with the recession velocity inferred from measurements of the redshift using electromagnetic data. This approach does not require any form of cosmic "distance ladder"; the gravitational-wave (GW) analysis can be used to estimate the luminosity distance out to cosmological scales directly, without the use of intermediate astronomical distance measurements. Additional standard-siren measurements from future gravitational-wave sources will provide precision constraints of this important cosmological parameter.

Rajiv Kumar
Department of Astronomy, University of Science and Technology of China

Accretion disk structure around a black hole

We study the accretion and accretion physics around the black hole with various outer boundary conditions (OBCs) and outer boundary locations (OBLs). Doing so, we investigated global accretion solutions and self-consistent jet mechanism, which can give us the global jet/outflow solutions in the two-dimensional (2D) disk. We also explored all kinds of advective transonic solutions and possible hybrid flow disk geometries with including viscous/radiative dissipations in the disk. Moreover, We also studied the effect of the Kerr spin parameter and fluid composition on the accretion-ejection dynamics using a relativistic multi-species equation of state (EoS).

Kiran Lakhchaura
Eötvös Loránd University, Hungary

Correlations between supermassive black holes, hot atmospheres, and the total masses of early type galaxies

Several previous studies have suggested that the supermassive black holes (SMBHs) and their host galaxies co-evolve leading to the observed tight correlations between the masses of the SMBHs (M_BH) and the luminosities and velocity dispersions of the stellar bulges of their host galaxies. While the popular view is that the connection between the two is causal in nature and originates from the active galactic nucleus feedback mechanism, a number of studies have argued that it may instead be of non-causal origin and resulted from the central-limit-theorem,

according to which a sufficient number of mergers should lead to a simultaneous and almost linearly correlated growth of M_BH and the total mass of the host galaxy (M_tot). This would further imply that any quantity that traces M_tot should also serve as a good proxy for M_BH. State-of-the-art cosmological simulations in fact show that galaxy merger followed by the merger of their SMBHs, is the main channel of growth for M_BH of the most massive galaxies. In our recent work, based on an analysis of the Chandra X-ray observations of a sample of 49 early-type galaxies, we discovered a tight correlation between the atmospheric temperatures (kT) of the brightest central cluster/group galaxies (BCGs) and M_BH. Under hydrostatic equilibrium, kT is determined primarily by the gravitational potential of the underlying dark matter halo of the host galaxy and therefore, can serve as a proxy for M_tot. From our hydrostatic analysis, we also found an approximately linear correlation between M_tot and M_BH, for the BCGs. Our results, therefore, suggest that the observed correlations between the SMBHs and their host galaxies may primarily be a natural consequence of the central-limit-theorem, which may be further strengthened by the AGN feedback mechanism.

Ari Laor
Technion, Israel

Is there an ADAF transition in very low luminosity AGN?

The very low luminosity AGN, NGC 3147, with L/L_Edd = 10^-4, was considered to be a true type 2 AGN, i.e. an AGN which lacks a Broad Line Region (in contrast with regular type 2 AGN, where the BLR is simply obscured). Our recent HST observation managed to exclude the host galaxy light, and revealed that the BLR is actually there, at the expected luminosity and position. The BLR is extremely compact, and indicates a thin disk of cold gas extending below 100 gravitational radii, which is most likely the accretion disk itself. Such low luminosity AGN are commonly believed to be powered by Advection Dominated Accretion Flows, which form a thick hot dilute gas, in contrast with the observations. Further possible followups will be briefly described.

Andy Lawrence
University of Edinburgh, United Kingdom
Review Talk

The crisis caused by changing-look AGN

Variability has always been a serious difficulty for standard AGN theory involving viscous accretion onto a massive black hole, but until recently the problem could be avoided by combining viscous dissipation with some reprocessing. However, observations of changing look AGN, and more generally extreme variability - i.e. by factors of several - rule out any viscous disc model. I will review observations of extreme variability, why they matter so much, and the response of the broad line region gas. I will then look at the options for escaping the crisis - either extreme reprocessing or non-viscous accretion - and also the implications for understanding the fast transients that have been labelled as Tidal Disruption Events.

Mariana Lazarova
University of Northern Colorado, USA

Low-z LoBAL QSOs are dominated by mergers

The ultrafast outflows characteristic of broad absorption line (BAL) QSOs suggest that, in those systems, we might be observing AGN-driven kinetic feedback capable of affecting the growth of the host galaxy. Particularly relevant to this picture might be low-ionization BAL QSOs (LoBALs) at low redshifts because anecdotal studies find that they might be connected to major mergers and ultra-luminous infrared galaxies. We take a detailed look at the host galaxy morphologies and SEDs of a complete, volume-limited sample of optically-selected LoBALs at $0.5 < z < 0.6$. Their infrared luminosities and star formation rates do not suggest they are different from typical type-1 QSOs. After correcting for the AGN contribution to the FIR SED, LoBALs show levels of star formation similar to those of type-1 QSOs. However, the observations of their host galaxies with HST/WFC3 reveal apparent signs of recent or on-going tidal interaction in 2/3 of the sample, which is in contrast to recent work on QSO hosts showing merger fraction of less than 1/4. The mergers in our sample represent various stages of the merger process: from double nuclei to settled morphologies with extended low surface-brightness tidal tails. If the rarity of BALs is due to the short duration of the outflow phase, then these results might be consistent with theoretical predictions of short-lived, sporadic episodes of AGN activity during various stages of the merger process.

Xiangdong Li
School of Astronomy and Space Science, Nanjing University, China

POPULATION SYNTHESIS OF BLACK HOLE BINARIES

We have performed binary population synthesis calculations to simulate the potential population of binaries containing BHs and normal-star companions in the Galaxy. We focus on the influence of the black hole progenitors, and provide the expected distributions of various parameters for both detached and mass-transferring BH binaries with normal-star companions, including the component masses, the orbital parameters of the binary systems, the radial velocity semi-amplitudes, and the astrometric signatures of the optical companions.

Matthew Liska
Review Talk

GRMHD simulations of thin and tilted accretion disks and jets: How precessing disks and jets form

In most accreting black hole systems the spin axis of the black hole and rotation axis of the disk may be initially misaligned. Furthermore, most gas falls into black holes during outbursts when the disk is luminous and geometrically thin. However, due to the tremendous resolutions and long runtimes required to simulate (tilted) thin accretion disks, GRMHD simulations (with a few exceptions) only considered thick aligned accretion disks, severely limiting our ability to fully understand black hole accretion. This motivated me to develop the GPU accelerated GRMHD code H-AMR, which has produced a set of cutting-edge GRMHD simulations of tilted accretion disks and jets. These simulations have shown that jets can precess due to the torque from the

precessing disk and corona. I will subsequently show that a 10-100 r_g sized precessing disk can form by tearing of from a larger accretion disk. Tearing events occur in coherent cycles which last 5 precession periods and thus may explain certain types of quasi-periodic oscillations (QPOs). I will finish my talk by showing that very thin accretion disks can Bardeen-Petterson align with the BH spin axis irrespective of the magnetic field geometry or the presence of a jet. This provides further constraints on the amplitude and period of the emission from QPOs.

Fukun Liu
Peking University

TDEs in SMBBHs

Supermassive black hole binaries (SMBHBs) are expected to form at galactic nuclei during frequent galaxy mergers. However, it is very challenging to observe the quiescent SMBHBs in galaxies. When astar is scattered over a SMBH, it may be disrupted by the strong tidal force of the SMBH. The subsequent accretion of the stellar debris ignites the otherwise dormant SMBH at galactic nuclei. Because the dynamic scattering and the Kozai effect of the secular perturbation of the companion of SMBHB, the rate of stellar tidal disruption events (TDEs) could be enhanced by orders of magnitudes relative to single SMBHs. The dynamic perturbation of the companion would lead to unique interruptions of the light curves of TDEs, when a TDE occurs in a SMBHB system. With the enhanced TDE rates and the characteristic drops of light curves of TDEs, we could statistically investigate the distributions of SMBHBs in galaxies and extract the parameters of a SMBHB system in the multi-messenger era. In this talk, I will review the current understanding of TDEs of SMBHBs.

Andrew Lobban
ESA - European Space Astronomy Centre, Spain

A Wealth of Spectral-Timing Results on the Variable AGN NGC 3227 from 800ks of XMM-Newton and NuSTAR Data

I will present a wealth of spectral-timing results from a long XMM-Newton + NuSTAR campaign on the bright, variable AGN NGC 3227, consisting of >800ks of X-ray data. I will present an analysis of the lightcurves, showing that the source exhibits a curious, transient period of spectral hardening. The spectral hardening event is accompanied by a change in the depth of an unresolved transition array (UTA), whose time-dependent behaviour is resolved using the high-resolution RGS data. This UTA fingerprint allows us to identify this as a transit event, where a clump of mildly ionised gas, having a column density of ~5 x 10^{22} atoms/cm^{2}, occults ~60% of the continuum photons over the course of approximately a day. This occulting gas is likely associated with clouds in the inner broad-line region. An additional zone of gas with lower column and higher ionisation, matches the outflow velocity of the variable zone, and may represent transmission through the cloud limb.

We additionally spectrally decompose the data and I will show that the bulk of the variability is continuum-driven and, through rms variability analysis, strongly enhanced in the soft band. I will show that the source largely conforms to linear rms-flux behaviour and that the behaviour of the

frequency-dependent X-ray power spectrum is largely consistent with existing scaling relations. Additionally, we compute X-ray Fourier time lags using both the XMM-Newton and - through recently-developed maximum-likelihood methods - NuSTAR data, revealing a strong low-frequency hard lag and evidence for a soft lag at higher frequencies at both low and high X-ray energies. The discovery of a negative lag between the 3-5 and 15-50 keV bands may have implications for existing reverberation models, which I will discuss.

Filippo Maccagni
INAF-OAC, Italy

The flickering nuclear activity of Fornax A

The energy ejected by an active galactic nucleus (AGN) can displace the gas in a galaxy, prevent it from cooling and quench star formation, playing a crucial role in the evolution of galaxies. No consensus has yet been reached on how this disruptive, but short and stochastic events may influence the host galaxy throughout its lifetime. Radio AGN may be key to understand this, because by measuring the age of the synchrotron AGN emission it is possible to relate the timescales of the nuclear activity to the ones of the dynamical and star formation history of the host galaxy.
In this talk, I will show new MeerKAT 1.4 GHz and SRT 6 GHz observations of Fornax A, the third nearest radio AGN, which allowed us to unlock the history of the nuclear activity of this source, revealing its rapid flickering (on scales of 1-10 Myr; Maccagni et al. 2019). The distribution and kinematics of the neutral, molecular and ionised gas further show the effects of the recurrent nuclear activity on the evolution of its host galaxy. Multiple neutral hydrogen (HI) clouds and streams, likely the remnant of a past gas-rich merger, in the centre and outskirts of Fornax A form a large cool gas reservoir (10^8 Msun) that fuel the nuclear activity. In the very centre (r<6 kpc), not only HI but also molecular and ionised clouds revealed by ALMA and MUSE observations show strong deviations from the regular rotation of the stellar body, possibly tracing in-flowing and out-flowing gas. In this talk, I will show how the radiative and mechanical effects of the last episode of nuclear activity changed the physical conditions of the circum-nuclear regions of Fornax A.

Michela Mapelli
Padova University, Italy
Review Talk

Cosmic merger rate of (stellar-mass) BHs

tbd

Paola Marziani
INAF - Astronomical Observatory of Padua
Review Talk

The main sequence of quasars and its potential for cosmology

The main sequence offers a method for the systematization of quasar spectral properties. After reviewing some defining trends, we stress how the main sequence contextualization offers a

privileged view on several outstanding issues, from the definition of radio loudness to changing-look active galactic nuclei, and to high-redshift distance indicators for cosmology. In this respect, sources with extreme FeII emission at one end of the main sequence are easily identifiable in large spectroscopic surveys over a broad redshift range from their optical and UV spectrum. These extreme quasars — believed to radiate at high Eddington ratio, close to the Eddington limit — turn out to be potential distance indicators, according to a preliminary analysis that provides evidence of the conceptual validity of redshift-independent luminosity estimates based on broad emission line width measures.

James Miller-Jones
ICRAR - Curtin University, Australia
Review Talk
Radio observations of jets and the case of V404 Cygni
The stellar-mass black holes in X-ray binaries provide excellent laboratories for studying in real time the evolution and propagation of jets, and their coupling to the underlying accretion flow. With high angular resolution radio observations, we can track the bright, relativistically-moving jets launched at the peak of the sporadic outburst phases of black hole X-ray binaries. These jets are typically seen to move ballistically away from the central binary, evolving on timescales of a few days, and occasionally decelerating as they interact with the surrounding medium. The 2015 outburst of the nearby black hole X-ray binary V404 Cygni was an exceptional event, whose peak X-ray luminosity exceeded the Eddington limit. With high-resolution VLBA observations, we resolved multiple jet ejecta launched over a four-hour period, with differing orientations as viewed on the plane of the sky. We interpret this behaviour as evidence for jet precession, caused by Lense-Thirring precession of a geometrically thick slim disk due to a misalignment between the binary orbit and the black hole spin. In this talk, I will give a brief overview of X-ray binary jets before focusing on our recent results on V404 Cygni, presenting our full high-resolution radio coverage of the outburst, and the insights it has provided into the behaviour of the jets in this well-characterised system.

Yosuke Mizuno
ITP, Goethe University Frankfurt, Germany
Review Talk
The Shadow of the Supermassive Black Hole in M87
The Event Horizon Telescope (EHT) has mapped the central compact radio source of the elliptical galaxy M87 at 1.3 mm with unprecedented angular resolution. These images show a prominent ring with a diameter of ~40 micro-arcsecond, consistent with the size and shape of the lensed photon orbit encircling the “shadow” of a supermassive black hole. The ring is persistent across four observing nights and shows enhanced brightness in the south. Here we consider the physical implications of the asymmetric ring seen in the 2017 EHT data. To this end, we construct a large library of models based on general relativistic magnetohydrodynamic simulations and synthetic images produced by general relativistic ray tracing. We compare the observed visibilities with this library and confirm that the asymmetric ring is consistent with

earlier predictions of strong gravitational lensing of synchrotron emission from a hot plasma orbiting near the black hole event horizon. Overall, the observed image is consistent with expectations for the shadow of a spinning Kerr black hole as predicted by general relativity. If the black hole spin and M87's large scale jet are aligned, then the black hole spin vector is pointed away from Earth. Models in our library of non-spinning black holes are inconsistent with the observations as they do not produce sufficiently powerful jets. I also briefly discuss the possibility of the alternatives to a black hole for the central compact object.

Philipp Moesta
University of Amsterdam, Netherlands
Review Talk
Dynamics of binary black-hole mergers
I will review the dynamics of binary black-hole mergers.

Tushar Mondal
Indian Institute of Science, Bangalore, India
Magnetized disc-outflow symbiosis to unify blazar classification: FSRQ/BL Lac dichotomy
The Fermi blazar observations show a strong correlation between γ-ray luminosities and spectral indices. BL Lac objects are less luminous with harder spectra than flat-spectrum radio quasars (FSRQs). Interestingly FSRQs are evident to exhibit a Keplerian disc component along with a powerful jet. We compute the jet intrinsic luminosities by beaming corrections determined by different cooling mechanisms. Observed γ-ray luminosities and spectroscopic measurements of broad emission lines suggest a correlation of the accretion disc luminosity with jet intrinsic luminosity. Also, theoretical and observational inferences for these jetted sources indicate a signature of hot advective accretion flow and a dynamically dominant magnetic field at jet-footprint. Indeed it is difficult to imagine the powerful jet launching from a geometrically thin Keplerian disc. We propose a magnetized, advective disc-outflow symbiosis with explicit cooling to address a unified classification of blazars by controlling both the mass accretion rate and magnetic field strength. The large scale strong magnetic fields influence the accretion dynamics, remove angular momentum from the infalling matter, help in the formation of strong outflows/jets, and lead to synchrotron emissions simultaneously. We suggest that the BL Lacs are more optically thin and magnetically dominated than FSRQs at the jet-footprint to explain their intrinsic γ-ray luminosities. References: Mondal T., Mukhopadhyay B., MNRAS, 486, 3465 (2019), Mondal T., Mukhopadhyay B., MNRAS, 476, 2396 (2018).

Jorge Moreno
Pomona College, USA
The role of galaxy mergers in the evolution of the interstellar medium and the growth of central stellar bulges
In this talk I will review the role of galaxy mergers in triggering star formation, and their effect on the interstellar medium. For many years, observations have suggested that star formation is

enhanced in mergers. Recently, however, a number of IFU campaigns and HI-survey suggest that mergers also enhance the H2 budget in galaxies, whilst leaving its HI content largely unaffected. Understanding how baryons migrate between ISM phases and/or become stars is a questions that has eluded us, because of lack of sufficient resolution in our simulations or lack of sophisticated models at scales both relevant to galaxies and the ISM. I will share recently published results where we employ a comprehensive suite of parsec-scale galaxy merger simulations using FIRE, the "Feedback In Realistic Environment" physics model. This framework allows us to resolve Giant Molecular Clouds and follow feedback physical processes that regulate star formation. I will describe the ISM as a pipeline where atomic gas can cool and compress into molecular gas, but the onset of star formation can turn these ISM components into warm ionized gas, or hot gas (with temperatures above 1 million Kelvin). The net result is the build-up of a molecular gas reservoir, hand in hand, with enhanced star formation - thus providing a physical picture to H2 and HI observations. I will describe the role of this baryon cycle in building up stellar bulges in galaxies, which is fundamental for our understanding of supermassive black hole growth in mergers.

Raffaella Morganti
ASTRON and Kapteyn Institute Groningen, The Netherlands
Review Talk
The impact of jets on the multi-phase gas
Radio jets have been found to affect the surrounding gas in various ways. The energy that they release can couple well with the ISM and can prevent the gas from cooling, can produce fast gaseous outflows and/or can increase the turbulence of the gas, possibly preventing starformation. In this talk I will focus on what we have learned about the impact of jets by studying the kinematics and physical conditions of the gas in the inner few kpc of the host galaxy. I will present recent results showing examples of radio jets covering a broad range of radio power and medium in which they are embedded. I will illustrate how we have traced these effects by study the kinematics of the colder component of the gas (HI and molecular) with high spatial resolution observations. In this way we have derived the physical conditions of the gas (density, mass, mass outflow rate in the case of outflows, kinetic energy etc.). One interesting finding is that even low power radio jets can percolate through this medium and drive shocks into the ISM at distances much larger than their physical extent. However, despite seeing the impact of the jets on the medium, the actual effect on the evolution of the host galaxy is still unclear and likely more subtle that naively expected so far.

Amin Mosallanezhad
Xi'an Jiaotong University, China
Radiation-driven outflows in AGNs
AGN feedback plays an important role in the formation and evolution of their host galaxies. The importance of AGN feedback has also been confirmed by many theoretical studies especially numerical simulations. For our numerical simulation, we perform two-dimensional hydrodynamical simulations of slowly rotating accretion flows in the region of 0.01−7 pc around a

supermassive black hole with M_BH = 10^8 M⊙. The accretion flow is irradiated by the photons from the central active galactic nucleus (AGN). In addition to the direct radiation from the AGN, we have also included the “re-radiation”, i.e., the locally produced radiation by Thomson scattering, line and bremsstrahlung radiation. Compare to previous works, we have improved the calculation of the radiation force due to the Thomson scattering of X-ray photons from the central AGN. We find that this improvement can significantly increase the mass flux and velocity of the outflow. We have compared properties of the outflow — including mass outflow rate, velocity, and kinetic luminosity of the outflow — in our simulation with observed properties of the outflow in AGNs and found that they are in good consistency. Our results imply that the combination of line and re-radiation forces is the possible origin of observed outflow in luminous AGNs.

Sneha Prakash Mudambi
CHRIST (Deemed to be University), India

AstroSat investigations of spectral and temporal properties of black hole candidate MAXI J1820+070 during the rising phase of its outburst

MAXI J820+070, the brightest X-ray novae discovered till date, was first detected in optical on 6th March by ASSASSN survey and later in X-rays on 11th March 2018 by MAXI/GSC. The follow up multi-wavelength observations revealed that the source is indeed a black hole candidate. Low inclination angle (~ 30°), proximity of the source (~ 3.46 kpc) and high X-ray flux rate (~10^(-8) erg /cm2/s) provided a unique opportunity to study the physics of accretion and relativistic effects on matter in strong gravity regime with great detail, resulting in observations by almost all leading missions including India’s first multi-wavelength astronomical satellite “AstroSat”. In this work, we present for the first time the broadband spectral and temporal analysis results using data from SXT and LAXPC onboard AstroSat. AstroSat observed MAXI J1820+070 on 30th and 31st March 2018, during the rising phase of its outburst. The combined SXT and LAXPC spectrum were modelled using thermal Comptonization along with disk blackbody and reflection components. Spectral analysis revealed that the source was in its hard-spectral state (Γ = 1.61) and with a cool accretion disk (kTin= 0.22) truncated at a large distance. Temporal analysis has revealed frequency-dependent hard lags of the order of 100 ms. Power density spectra showed a presence of a type C quasi-periodic oscillation (QPO) at 47.7 mHz and this is the first confirmed report of such a detection. Additionally, we have modelled the single temperature stochastic propagation model proposed by Maqbool et al., (MNRAS, 486, 2964, 2019) to the observed energy-dependent time-lags and fractional rms and found that the predictions of the model match well with observations. We also compare our findings with that of Cygnus X-1.

Banibrata Mukhopadhyay
Indian Institute of Science

Hard state ULXs as magnetized sub-Eddington mass accretion flows around a stellar mass black hole

There are several variable ultra-luminous X-ray sources (ULXs) in hard states. Their high luminosity can not be explained by intermediate mass black holes, as then it might not be

variable, as seen is upto factor of 30. Their hard states also argue against significant radiation in them. I will show that the presence of large-scale strong magnetic fields, with super-Eddington magnetic energy far away from the black hole, but sub-Eddington mass energy, is the potential reason to produce ULXs in hard states. These ULXs are expected neither to be harboring intermediate mass black hole holes nor to be super-Eddington mass accretors. This talk is primarily based on the work published in MNRAS, 476, 2396, 2018; MNRAS, 482L, 24, 2019 and also in arXiv191008564.

Diego Munoz
Northwestern University, USA
Review Talk
Accreting Black Hole Binaries: their Growth and Migration
Circumbinary gas disks are expected to assemble around the supermassive binary black holes that form in galactic nuclei as a consequence of galactic mergers. These disks are thought to play a fundamental role in the process of binary migration and, in particular, in overcoming the "last parsec problem." Despite the long-recognized importance of circumbinary disks, the gravitational and accretional coupling between the gas and the binary is still not fully understood. Theory and numerical simulations indicate that circumbinary disks can modify the orbital elements of the binary; however, whether the gas reduces or increases the angular momentum of the binary is not a settled issue. In this talk, I will discuss how non-linear circumbinary hydrodynamics still hold many surprises for the long-term evolution of super-massive black hole binaries. In particular, I will provide an overview on the state-of-the art of long-term hydrodynamical simulations of circumbinary accretion, highlighting recent developments on viscous steady-state simulations and their impact on the secular evolution of binaries. I will describe a newly emerging consensus on the migration rate of accreting binaries. I will explain how binaries can gain angular momentum from the gas and thus increase their separation, and how this surprising outcome was previously overlooked. I will discuss the implications that these new findings have for low-frequency gravitational waves sources, and for the gravitational wave background.

Krzysztof Nalewajko
Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences
Review Talk
Physical processes in jets
Relativistic jets are spectacular collimated outflows that carry a substantial fraction of energy involved in accreting black hole systems. Multiwavelength observations provide evidence for a variety of physical processes operating in jets, and crucially observations put constraints on their efficiencies. I will review the following selected topics relevant for the physics of relativistic jets: (1) launching and powering, (2) acceleration and collimation, (3) stability, (4) energy dissipation, (5) particle acceleration, (6) radiative processes, (7) plasma composition, (8) origin of matter.

Ramesh Narayan
Center for Astrophysics, Harvard & Smithsonian, USA
Review Talk
Accretion Disk Theory: Overview
TBD

Andrzej Niedzwiecki
University of Lodz, Poland
Constraining accretion flows with X-ray spectral data
I present GR models of spectral formation in both optically thin as well as optically thick black-hole accretion flows and their application to selected black hole systems accreting at low, moderate and high accretion rates.

Tom Oosterloo
Astron & Kapteyn Institute, Netherlands
Molecular outflows in young AGN
AGN-driven gas outflows are thought to play an important role in the evolution of galaxies, through their impact on the evolution of star formation in galaxies as well as on the growth on the central supermassive black hole of the host galaxy. Much of the detailed physics of these gas outflows, what drives them, and their actual impact on the host galaxy, is still not well understood.
We will present the results from recent ALMA observations of the nearby quasar PKS 1549-79. This object is one of the closest (z = 0.1525) examples of a young, radio-loud quasar where the AGN appears to be in the process of clearing the gas-rich surroundings in which it is enshrouded as the result from a recent merger. We detect a large reservoir of molecular gas (~10^10 Msol) in PKS 1549-79. Most of the gas is in the form of large tidal tails, but we also see the formation of a circum-nuclear disk of a few hundred pc in size. In the very centre of PKS 1549-79 we detect a very fast, massive outflow of molecular gas driven by the AGN. Our observations clearly reveal the effect of the AGN on the ISM. While on kpc scales the observed line ratios suggest that the conditions in the ISM are normal, in the inner few hundred parsec they show that the conditions in the circum-nuclear disk are clearly affected by the AGN. We also present the results from detailed numerical simulations of a young radio jet moving through a clumpy ISM. Comparing these simulations with the observations allows us to build a 3D picture of the AGN-ISM interaction in PKS 1549-79. In addition, we compare the results on PKS 1549-79 with those obtained on the molecular outflow we earlier detected in the much less powerful Seyfert galaxy IC 5063. This comparison shows that some aspects of the jet-ISM interaction are very similar (e.g. line ratios), but there are also important differences. Interestingly, the physical extent of the region with fast outflowing gas is much smaller in the more powerful PKS 1549-79. This is consistent with the predictions from the simulations.

Alberto Pellizzoni
INAF - Osservatorio Astronomico di Cagliari, Italy
The Study of Radio Transients through Single-Dish Observations with INAF Radio-Telescopes
Black holes of all masses and compact object mergers at all scales can provide significant transient and/or variable radio emission. For example, multi-frequency radio monitoring of microquasars during outbursts through single-dish imaging can reveal spectral variations and periodicities associated with fast changes of the radio plasmons and jets over timescales of hours. Furthermore, a typical sensitivity at mJy/sub-mJy level in the 1-30 GHz range is suitable not only for the monitoring of relatively bright X-ray Binaries and AGNs, but also for the study of afterglows of GRBs and counterparts of gravitational waves. Relativistic shock microphysics and energetics, progenitor studies, jet/ejecta geometry and magnetization are among the issues than can be investigated through radio single-dish observations in this field. We present the current status and challenges for the scientific exploitation of radio observations of X-ray binaries, AGNs, GRBs and GW counterparts with INAF radio-telescopes and related state-of-the-art data analysis techniques.

Hugo Pfister
DARK / Niels Bohr Institute, Denmark
Tidal disruption events on cosmological scales
When a star passes by a black hole (BH), the former might be disrupted due to the tidal effects from the latter: this is a tidal disruption event (TDE). The LSST and eROSITA will detect hundreds of TDEs but, to date, it is still debated how the TDE rate depends on the properties of galaxies, depends on redshift etc... Consequences are tremendous: BHs could grow by a significant amount accreting stars, and subsequent feedback could affect the entire galaxy. In order to study this, I developed a unique subgrid model to take into account TDEs in cosmological simulations and study their origin and consequences. In this talk, after a brief introduction on TDEs, I will present this new model, and detail the results of a cosmological zoom simulation, particularly focusing on the effects of galaxy mergers on the TDE rate.

Olmo Piana
Kapteyn Astronomical Institute, Netherlands
The mass assembly of the high-redshift black hole population
In the past months we have applied the semi-analytic model of galaxy formation and evolution Delphi to the study of the evolution of the high-redshift black hole population across its full mass range, in order to provide its physical characterisation as a function of mass and redshift. The model, based on analytical merger trees, consistently follows the emergence of galaxies and black holes from z=20 to z=4, accounting for dark matter and gas accretion onto the galaxy, star formation, black hole growth and feedback from both supernovae and AGN activity. Motivated by the results of several numerical simulations, our black hole growth implementation introduces a critical halo mass below which the black hole is starved and above which we allow it to grow either at the Eddington limit or proportionally to the gas content of the galaxy. The free

parameters of the model are tuned to reproduce the main galaxy and black hole statistical observables at z > 4. We analyse the mass assembly history along the merger trees, and we find that, after a merger-dominated growth phase lasting until z = 8–12 (depending on the halo mass), black holes grow mainly by gas accretion from the ISM. For intermediate-mass haloes the accretion activity occurs almost exclusively within the major branch of the merger tree, while secondary branches become an important growth channel in high-mass haloes. We also predict the Eddington ratio distribution as a function of redshift, finding an increasing trend for low-mass black holes, as opposed to the decreasing trend found at higher masses. We show how black holes can grow to supermassive regimes in the first Gyr of the universe without needing super-Eddington accretion phases but rather undergoing episodes of Eddington-limited accretion that can last from ≈ 400 Myr up to ≈ 650 Myr for the black holes sitting in the deepest potential wells.

Tsvi Piran
The Hebrew University Jerusalem, Israel
Review Talk
Stellar tidal disruption events (TDEs)
Tbd

Silvia Piranomonte
INAF - Osservatorio Astronomico di Roma
The Italian follow-up observations of GW triggers in the Multi-Messenger Era
On August 17th, 2017 the first electromagnetic counterpart of a gravitational wave (GW) event originated by the coalescence of a double neutron star system (GW 170817) was finally observed. A world-wide extensive observing campaign was carried out to follow-up and study this source, with the forefront participation of the Italian team GRAWITA (Gravitational Wave INAF TeAm). In particular, our unique VLT dataset provided the first compelling observational evidence for the existence of “kilonovae”, transient sources powered by radioactive decay of heavy elements resulting from the r-process nucleosynthesis of ejected neutron star matter. In this talk, I will present the activities we carried out to optimize the response of the Italian GRAWITA network of facilities to expected GW triggers and our results for past (O1 and O2) and current (O3) observing runs. All the activities I will describe are expected to provide means and opportunities to the Italian and European astronomical communities to have a leading role in the GW and Time Domain Astronomy.

Isabella Prandoni
INAF-IRA, Italy
Review Talk
SKA and its precursors
The Square-Kilometer Array (SKA) is an integral part of the next-generation observatories that will survey the Universe across the electromagnetic spectrum, and beyond, revolutionizing our view of Fundamental Physics, Astrophysics and Cosmology. In the present talk I will provide an

overview of the science enabled by large and/or deep radio continuum surveys with the SKA and its precursors, focusing on AGNs and on their role in galaxy evolution.

Yanli Qiu
Tsinghua University, China
An short-orbit Wolf-Rayet X-ray binary in Circinus as an precursor of BH-BH merger
Compact Wolf-Rayet X-ray binaries with orbital periods of less than a day are a rare class of sources, probing a short-lived (few 10^5 yr) but key evolutionary stage of binary systems. They emerge from a common envelope phase and (if they survive the second SN explosion) they form double compact objects that can merge via gravitational decay in less than a Gyr. We studied the candidate Wolf-Rayet X-ray binary CG X-1 in the Circinus galaxy, using 20 years of Chandra and XMM-Newton data. CG X-1 is an eclipsing source and one of the most luminous ULXs in the local universe (peak L_X = 3 x 10^{40} erg/s at a distance of 4.2 Mpc). We phase connected the lightcurves in the archival data and derived a period of (25,970.0 +/- 0.1) s and a period derivative Pdot/P = (10.2 +/- 4.6) x 10^{-7} yr^{-1}. The intriguing dipping and eclipsing behavior of CG X-1 is different from the orbital modulations seen in other classes of X-ray binaries. We suggest that such lightcurves are a defining property of this class of super-Eddington sources, in which both the primary and the secondary launch dense, fast outflows with similar kinetic power. We propose a model for the asymmetric dips and occultations, based on partial covering by Compton-thick clouds. We speculate that the main occulting material is dense, shocked wind between black hole and donor star, and in a bow shock ahead of the black hole.

Amy Reines
Montana State University, United States
Review Talk
IMBHs in dwarf galaxies
The origin of supermassive black holes remains a major outstanding issue in modern astrophysics since we do not yet have the capabilities to directly detect the first “seed” black holes in the early Universe. However, present-day dwarf galaxies are within observational reach and offer another avenue to learn about black hole seeds since low-mass galaxies can host relatively pristine black holes. In this talk, I will provide a review of intermediate-mass black holes in dwarf galaxies that are beginning to provide the much needed observational constraints on the otherwise theory-dominated work on the formation of the first black hole seeds.

Mathieu Renzo
Flatiron Institute, CCA, United States
Mind the gap: pair instability and binary evolution influence on merging stellar mass binary black holes
At the end of their life, the most massive stars are predicted to encounter the (pulsational) pair instability. This process can lead to mass ejections - decreasing the mass of the black hole (BH) they produce, fully disrupt the star - leaving no BH, or, fail and lead to BH formation again. Thus, stellar evolution theory predicts a "Pair Instability BH gap" between ~45-130Msun, whose

existence is currently beeing probed by ground-based gravitational wave detectors. In this talk, I will show that this is one of the most robust predictions of massive star evolution. Variations in uncertain physics and numerics have a limited impact on the position of the gap, and so does accretion in isolated binaries: if a black hole is allowed to stably accrete at an arbitrarily high rate from a companion, the binary widens and does not merge within the age of the Universe. Most importantly, this prediction depends only very weakly on metallicity, thus, the mass location of the gap might be a "standardizable candle". Only one reaction rate (c12(alpha,gamma)o16) has a large impact on the maximum black hole mass below the gap, which means gravitational waves might be used in the future as nuclear astrophysics instruments. Finally, black hole progenitors are likely to evolve in binary systems: I will also show that it is possible to put statistical constraints on the black hole natal kicks using their (former) companions without ever seeing the black holes or the transients that lead to their formation.

Dorota Rosinska
University of Warsaw, Poland

Merging and colliding black holes from globular clusters as sources of gravitational waves

Stellar mass binary black holes are the most important sources of gravitational waves for ground based interferometric detectors. We analyze about a thousand globular cluster (GC) models simulated using the MOCCA Monte Carlo code for star cluster evolution to study black hole - black hole interactions in these dense stellar systems that can lead to gravitational wave emission. We extracted information for all coalescing binary black holes (BBHs) that merge via gravitational radiation from these GC models and for those BHs that collide due to 2-body, 3-body and 4-body dynamical interactions. By obtaining results from a substantial number of realistic star clusters evolution model, that cover different initial parameters (masses, metallicities, densities etc) we have an extremely large statistical sample of two black holes which merge or collide within a Hubble time. The existence of Intermediate Mass Black Hole strongly influences the results. I will discuss the importance of merging and colliding black holes originating from GC for gravitational waves observations.

Namrata Roy
University of California Santa Cruz, United States

Possible signatures of maintenance mode feedback in typical quiescent galaxies

A new class of quiescent galaxies harboring possible AGN-driven winds has been discovered using spatially resolved optical spectroscopy from the ongoing SDSS-IV MaNGA survey. These galaxies, termed “red geysers”, constitute 5 - 10% of the local quiescent population and are characterized by narrow bisymmetric patterns in ionized gas emission features that extend to several Kiloparsecs comparable to/ beyond the extent of the galaxy. They show high ionized gas velocity values (~250 km/s) compared to stellar velocity (~50 km/s) and the velocity fields are roughly co-aligned with the axis of the bi-symmetric emission. These galaxies have no star formation in them and the primary ionizing source is old, evolved post-AGB stars. The kinematics and emission line features indicate that these galaxies exhibit bi-conical outflowing

wind signatures driven by a central source, possibly by a low luminosity radio mode AGN. We compare the nuclear radio activity of the red geysers to a matched control sample with similar global galaxy properties and found a higher rate of radio detection as well as a higher radio flux from the red geyser sample, confirming the presence of radio-mode AGN. In addition to that, higher-resolution optical spectra from the Keck ESI instrument on a subset of the sample has confirmed the wind hypothesis based on the shapes of emission line profiles. Our results support a picture in which episodic AGN activity drives large-scale-relatively weak ionized winds that may provide a feedback mechanism for many early-type galaxies.

Jessie Runnoe
Vanderbilt University, USA
Review Talk
Kiloparsec-scale Outflows in AGN
Feedback driven by active galactic nuclei (AGN) is a potentially important ingredient in the coupled growth of supermassive black holes and their host galaxies. However, how ubiquitously or to what degree the large amounts of energy and momentum that are produced by AGNs can actually couple to the surrounding interstellar medium of the host galaxy is poorly constrained observationally. I will review our knowledge of kiloparsec-scale outflows in AGN and in particular, observations of spatially resolved quasar-mode feedback in Type 1 AGN that remain scarce. I will draw examples from a multi-wavelength observing program to study the multiphase outflows of nearby (z~0.1) Type 1 quasars. As the nearest unobscured supermassive black holes that approach the accretion rates seen in AGN at the epochs of peak accretion activity at high redshift, these are prime laboratories for studying quasar-mode feedback in galaxies. Targets for this survey are all Type-1 quasars selected from a parent sample of nearby ultraluminous infrared galaxies and Palomar-Green quasars. Observations with the NOrthern Extended Millimeter Array (NOEMA) to resolve molecular outflows in CO and with Magellan and Gemini to trace outflows of ionized gas using integral field spectroscopy are underway. Here I will present initial results from this ongoing effort, particularly highlighting the power and importance of multi-wavelength datasets to characterize outflow properties in these systems.

Kailash Sahu
Space Telescope Science Institute, USA
Where Are the 100 Million Black Holes in the Galaxy and How Can We Discover Them?
The estimated number of black holes in the Galaxy from simple stellar evolution considerations is about 100 million, a large fraction of which are expected to be single. Yet, not a single isolated black hole has been detected to date -- all the few dozen black hole mass determinations so far have been in binaries. Furthermore, the measured masses of black holes in our Galaxy are not consistent either with the theoretical expectations, or with the LIGO measurements of black hole masses in external galaxies. Mass determinations of a few isolated, stellar-mass black holes will provide important clues in our understanding of black holes. Relativistic deflection is the only available technique capable of detecting isolated black holes and measuring their masses. I will

discuss the technique, and the initial results from our two HST programs aimed at the first detections of stellar-mass black holes through this technique.

Nandini Sahu
Swinburne University of Technology, Australia
New (Morphological Type)-dependent Black Hole Scaling Relations and the Pursuit of Long-wavelength Gravitational Waves
Our multi-component photometric-decomposition of the largest galaxy sample to date with dynamically measured black hole masses nearly doubles the number of such galaxies. We have discovered substantially modified scaling relations between the black hole mass and the host galaxy properties, including the spheroid/bulge stellar mass, the total galaxy stellar mass, and the central stellar velocity dispersion. This partly arose because we were able to explore the scaling relations for various sub-populations of galaxies built by different physical processes, as traced by the presence of a disk, or early-type versus late-type galaxies, or a Sersic versus a core-Sersic spheroid light profile. The new relations appear to be fundamentally linked with the evolutionary paths followed by galaxies, and they have ramifications for simulations and formation theories involving both quenching and accretion. These scaling relations will improve predictions for the much-anticipated detection of long-wavelength gravitational waves by the International Pulsar Timing Array, to which the GMRT in India is actively contributing.

Om Sharan Salafia
INAF - Osservatorio Astronomico di Brera
Review Talk
GRBs from binary mergers
The connection between gamma-ray bursts (GRBs) and compact binary mergers was foreseen as early as the late 80's by Packzynski (1986) and Eichler et al. (1989), who understood that the conditions required to produce these extraordinary emission episodes (if located at cosmological distances) naturally pointed to a cataclysmic event involving a stellar-mass compact object. Ironically, the association between GRB980425 and SN1998bw clearly favoured the alternative scenario of a massive star core-collapse progenitor for at least some gamma-ray bursts. Despite the mounting circumstantial evidence in favour of the connection between compact binary mergers and GRBs of the short/hard class, the final (and spectacular) confirmation only came on the 17th of August 2017 with GW170817 and GRB170817A. I will review what we have learnt from this single extraordinary event in terms of new insights about the physics of the jet formation and launching, its interaction with the other merger ejecta, the processes behind the prompt and afterglow emission and the structure of the shock that produces the afterglow. I will then critically discuss the possibility and relevance of other binary mergers as progenitors of gamma-ray bursts.

Filippo Santoliquido
University of Padova, Italy
The cosmic merger rate density of compact binaries

The next generation of ground-based gravitational wave interferometers will possibly observe mergers of binary black holes (BBHs) and binary neutron stars (BNSs) to redshift > ~10 and > ~2, respectively. We investigate the cosmic evolution of compact binaries (CBs) by evaluating the merger rate density (MRD) across cosmic time. We developed a data-driven model that combines catalogues of merging CBs simulated by MOBSE, a population-synthesis code, with observational constraints on the cosmic star formation rate density (SFRD) and on the average metallicity evolution of the Universe. We have performed various simulations considering different assumptions for the efficiency of the common envelope (CE) ejection and a new supernova (SN) kick prescription, which is consistent with observations. We found that the MRD evolution of DNSs strongly depends on CE efficiency and natal kicks, while it is almost unaffected by metallicity evolution. In contrast, the MRD evolution of BBHs is sensitive to the adopted metallicity evolution. The MRD evolution of black hole - neutron star binaries (BHNSs) shows an intermediate behaviour. We also provide the mass distributions as functions of merging redshift.

Shobita Satyapal
George Mason University, United States

Buried Black Hole Growth in Mergers

Interactions between galaxies are predicted to cause gas inflows that can potentially trigger nuclear activity. Since the inflowing material can obscure the central regions of interacting galaxies, a potential limitation of previous optical studies is that obscured active galactic nuclei (AGNs) can be missed at various stages along the merger sequence. In a recent mid-infrared and X-ray investigation , we demonstrated that the fraction of obscured AGNs increases with merger stage, with the most energetically dominant optically obscured AGNs becoming more prevalent in the most advanced mergers, consistent with theoretical predictions. Moreover, X-ray and infrared spectroscopy has revealed a population of buried dual and triple AGNs with separations of a few kilo parsecs consistent , demonstrating that mid-infrared selection may be effective in identifying a new population of optically invisible dual and triple AGNs. Our results also reveal the presence of powerful outflows, with outflow velocities increasing in the final stages of the merger. These observations reveal that infrared and X-ray observations are critical in uncovering the most efficient environments for supermassive black hole accretion and a key stage in galaxy evolution. In this talk, I will discuss our most recent work on the X-ray and IR properties of a sample of optically obscured AGNs in the most advanced mergers and recent hydrodynamic simulations that predict that this key stage in galaxy evolution is expected to be highly obscured.

Zachary Schutte
Montana State University, United States of America

The Black Hole - Bulge Mass Relation Including Dwarf Galaxies Hosting Active Galactic Nuclei

We present a new relationship between central black hole (BH) mass and host galaxy stellar bulge mass extending to the lowest BH masses known in dwarf galaxies ($M_{\rm BH} \leq

10^{5} M_{\odot}$; $M_{\star} \sim 10^{9} M_{\odot}$). We have obtained visible and near-infrared {\it Hubble Space Telescope (HST)} imaging of seven dwarf galaxies with optically-selected broad-line active galactic nuclei (AGN) and BH mass estimates from single epoch spectroscopy. We perform 2D photometric modeling with GALFIT to decompose the structure of these galaxies and find that the majority have an inner bulge/pseudobulge component with an exponential disk that dominates the total stellar mass. Using the modeling results and color-dependent mass-to-light ratios, we determine the stellar mass of each photometric component in each galaxy. We determine the $M_{\rm BH} - M_{\rm bulge}$ relation using a total of 12 dwarf galaxies hosting broad-line AGNs, along with a comparison sample of 88 galaxies with dynamical BH masses and 37 reverberation-mapped AGNs. We find a strong correlation between BH mass and bulge mass with ${\rm log}(M_{\rm BH}/M_\odot) = (1.24\pm 0.08)~{\rm log}(M_{\rm bulge}/10^{11} M_\odot) + (8.80\pm 0.09)$. The near-linear slope and normalization are in good agreement with correlations found previously when only considering higher mass systems. This work has quadrupled the number of dwarf galaxies on the BH-bulge mass relation, with implications for BH seeding and predictions for gravitational wave detections of merging BHs at higher redshifts with {\it LISA}.

Megumi Shidatsu
Ehime University, Japan
Review Talk
Galactic Black Hole X-ray Binaries: MAXI highlights
In the 10-year operation, MAXI has discovered 13 new Galactic black hole candidates and detected many more outbursts of known black hole X-ray binaries. The detections were promptly reported to the astronomical community and triggered intensive follow-up observations in various wavelengths. MAXI's continuous monitoring has also provided unique long-term data of these sources covering almost entire periods of their outbursts. We review the outburst behaviors of Galactic black hole candidates that MAXI detected in the last couple of years, with a particular focus on the spectral evolution of the two brightest MAXI sources: MAXI J1535-571 and MAXI J1820+070, combining the MAXI data with the Swift/BAT data. In addition, we also present results of coordinated optical photometric observations of MAXI J1820+070, if time permits.

Chandra Bahadur Singh
South-Western Institute for Astronomy Research, Yunnan university, China
Black Hole Accretion and Gap Paradigm
Besides high/low black hole spin and radiatively efficient/inefficient accretion flow, retrograde/prograde directions between disk and black hole play significant role in determining outflow properties. We present details regarding framework of gap paradigm combining Blandford-Znajek and Blandford-Payne processes. Most radio-loud objects are likely to harbour highly spinning black holes in retrograde configurations while most radio-quiet objects are likely to have highly spinning black holes in prograde configurations. The gap paradigm is also successful in addressing range of issues: (1) jet suppression across the BH mass scale, (2) distribution of HERGs and LERGs, (3) distribution of BL Lacs and FSRQs.

Neha Singh
Astronomical Observatory, University of Warsaw, Poland
Constraining parameters of coalescing binary systems with Einstein Telescope alone
Einstein Telescope, a future third-generation gravitational wave detector, is expected to have an increased broadband sensitivity by a factor of approximately 10 with respect to the advanced detectors, and also extending the low frequency sensitivity of ground based gravitational wave interferometers below 10 Hz. While gravitational wave observations using a network of detectors permits a direct and independent measurement of the sky position, polarization and distance to the source, we analyze here the capabilities of the Einstein Telescope as a standalone instrument. The redshift and the system chirp mass are degenerate in gravitational wave observations with a single detector so it is usually assumed that the source redshift is obtained from the electromagnetic counterparts. We analyze the current design of the Einstein Telescope , consisting of three overlapping interferometers, arranged in an equilateral configuration with arm-opening angles of 60 degrees, and perform a joint analysis of coalescing binaries detection with three ET-D interferometers in the triangular configuration and show that such analysis to constrain their luminosity distances and chirp masses with the accuracy down to 20%.

Daniele Sorini
Institute for Astronomy, University of Edinburgh, United Kingdom
The effect of feedback on the circumgalactic medium of z~2-3 quasars
Galaxy formation depends critically on the physical state of gas in the circumgalactic medium (CGM) and its interface with the intergalactic medium (IGM), determined by the complex interplay between inflow from the IGM and outflows from supernovae and/or AGN feedback. The average Lyman-alpha (Ly-a) absorption profile around galactic halos represents a powerful tool to probe their gaseous environments. We compare predictions from hydrodynamic simulations (Illustris, Nyx, Simba) with the observed absorption around foreground QSOs at z~2-3. Significant differences between the simulations are present on scales <100 kpc, highlighting the constraining power of the Ly-a absorption profile. We also analyse the results of four Simba runs incorporating different feedback prescriptions, and find that the average properties of the CGM surrounding QSOs seem to be almost insensitive to any sort of AGN feedback (winds, jets, or X-ray heating). Instead, stellar feedback may play a key role in shaping the CGM of QSOs and the corresponding Ly-a profile.

Thaisa Storchi Bergmann
Instituto de Fisica, Universidade Federal do Rio Grande do Sul (IF-UFRGS), Brazil
Review Talk
Feeding and Feedback of Active Galactic Nuclei
Supermassive black holes grow at the centre of galaxies in consonance with them. In this talk, I will first discuss observational signatures of the mass-feeding mechanisms that lead to this growth in active galactic nuclei (AGNs), from extragalactic down to galactic and nuclear scales. Once triggered, the nuclear activity produces feedback in the form of radiation, mass outflows

and jets associated with the accretion flow to the SMBH. I will then concentrate on results from resolved Integral Field Spectroscopic studies, including those of my research group AGNIFS. Most observational signatures of feeding and feedback processes in such studies are detected via the isolation of non-circular gas motions -- inflows and outflows that can be used to gauge the mass budget of the AGN feeding and the power and impact of gas outflows on the host galaxy. I will also discuss the uncertainties that plague the determination of this impact, that include uncertainties on the geometry and extent of the outflows as well as of the gas density in the outflows.

Mariusz Tarnopolski
Jagiellonian University, Poland

A comprehensive power spectral density analysis of astronomical time series: the gamma-ray light curves of selected Fermi blazars

I present the results of our Fermi-Large Area Telescope (LAT) light curve (LC) modelling of selected Fermi blazars: flat spectrum radio quasars (FSRQs) and BL Lacertea type objects (BL Lacs). All objects possess densely sampled and long-term LCs. For each blazar we generated three LCs with 7, 10, and 14 days binning, using the latest 4FGL catalogue and binned analysis provided within the fermipy package.
The LCs were modelled with several tools: the Fourier transform, the Lomb-Scargle periodogram (LSP), the autoregressive moving average (ARMA), the fractional autoregressive integrated moving average (FARIMA), the continuous-time autoregressive moving average (CARMA) processes, the Hurst exponents (H), the A−T plane, and the wavelet scalogram.
The power law PSD is indicative of a self-affine stochastic process characterised by H, underlying the observed variability. An estimation of H was performed with a wavelet lifting transform. We find that all blazars exhibit H > 0.5, indicating long-term memory. The power law spectral indices calculated from the Fourier and the LSP modelling are consistent with each other. The PSDs modelled with the LSP are slightly softer. Using the wavelet scalograms, we detect no statistically significant quasi-periodic oscillations (QPOs). The ARMA and CARMA results are consistent with each other, reaching higher orders for 7 days binned LCs and lower orders for 10 and 14 days binned LCs for the majority of selected blazars. The higher-order ARMA/CARMA fits suggest that additional variations in the blazar jets and/or accretion discs need to be taken into account to constrain the shape of the PSD. Finally, the FSRQ and BL Lac subclasses are clearly separated in the A-T plane. This separation is done entirely based on the LCs, with no spectroscopic measurements.

Mariusz Tarnopolski -- 2nd contribution

How many classes of gamma-ray bursts are there? Modelling with skewed distributions

Two classes of gamma-ray bursts (GRBs), short and long, have been confidently identified thus far and are prescribed to different physical scenarios. A third class, intermediate in duration, was suggested to be present in various catalogues based on a mixture-modelling with two or three Gaussian distributions of the log-durations, log(T90). This might not be an adequate model. An analysis of log(T90) from CGRO/BATSE, Swift/BAT, and Fermi/GBM revealed that mixtures of

skewed distributions with only two components are a better description than a three-component Gaussian mixture. The same results were obtained by analysing a duration-hardness ratio plane, log(T90)-log(H32), for BATSE and Fermi GRBs. Similar results were obtained for Swift, Konus-Wind, RHESSI, and Suzaku/WAM. This implies that the presumed intermediate class of GRBs is unnecessary to explain the observations.
A comprehensive, multivariate analysis, performed on various sets of BATSE parameters, including several three-dimensional spaces, and reaching up to a four-dimensional space of T90-H32-Ftot-P256, gave inconclusive results of 2-4 components, depending on the parameter set. A similar investigation of the Fermi data in the 3D and 5D spaces of T90-Ftot-P256 and T90-Ftot-Epeak-alpha-beta (with the Band parameters) lead to 3 and 2 components, respectively. This outcome is in a sense undesired, since for the same set of GRBs one would expect to get consistent results. A Monte Carlo testing suggests that additional components might be artifacts owing to the finiteness of the data and be a result of examining a particular realisation of the data as a random sample, resulting in spurious identifications. All-in-all, the presumed third class of GRBs appears to be non-existent.

Justine Tarrant
University of the Witwatersrand, South Africa
The Fate of LIGO Accretion Disks
Binary black hole systems of $\sim\mathcal{O}(10)$$M_{\odot}$, i.e. those in the LIGO mass range, are expected to have possessed, at some point, a circumbinary accretion disk. Accretion-related electromagnetic emissions are expected to accompany the binary merger. However, only one LIGO black hole binary event, GW150914, reported a candidate electromagnetic counterpart. In this work we explore the fate of the accretion disk in the LIGO scenario and try to ascertain whether an electromagnetic signature may be detected, heralding the start of the merger.

Alexander Tchekhovskoy
Review Talk
Accretion-disk evolution in NS-NS mergers (after merging)
tbd

Alexandra Tetarenko
East Asian Observatory, United States
Multi-wavelength fast timing in X-ray binaries
Time-domain observations now offer a promising new way to study accretion and jet physics in X-ray binaries. Through detecting and characterizing rapid flux variability in these systems across a wide range of frequency/energy bands (probing emission from different regions of the accretion flow and jet), we can measure properties that are difficult, if not impossible, to measure by traditional spectral and imaging methods (e.g., size scales, geometry, jet speeds, the sequence of events leading to jet launching). While variability studies in the X-ray bands are a staple in the X-ray binary community, there are many challenges that accompany such studies

at longer wavelengths. However, with recent advances to observing techniques/instrumentation, the availability of new computational tools, and today's improved coordination capabilities, we are no longer limited by these challenges. In this talk, I will discuss new results from fast timing observations of Cygnus X-1 and MAXI J1820+070 in the sub-mm and radio bands, highlighting how we can directly connect variability properties to internal jet physics. Additionally, I will discuss future prospects for obtaining more of these invaluable data sets, and the key role that next-generation instruments will play in driving new discoveries through this science.

Bailey Tetarenko
University of Michigan, USA

Thermally-Driven Disc Winds as a Mechanism for X-ray Irradiation Heating in Black Hole X-ray Binaries: The Case Study of GX339-4

Observed signatures for accretion disc winds in black hole X-ray binaries (BHXBs) are broadly consistent with thermal winds, driven by X-ray irradiation of the outer disc. These winds are known to produce mass outflow rates that can exceed the accretion rate in the disc and have long been postulated as an effective medium to scatter X-rays back onto the disc itself. We study the impact a thermal-radiative wind has on the outburst cycles in BHXBs. By modifying the standard disc-instability picture to include wind mass loss and a scattering source of irradiation, our simulations suggest thermal-radiative wind mass loss is not a major driver for outburst dynamics in BHXBs. The more important role these winds appear to play is as a mechanism for irradiation heating. We apply this idea to 15 yrs of outburst activity in Galactic BHXB GX339-4. Using simultaneous X-ray and optical/IR observations, along with analytic thermal-radiative wind models, we are able to relate the time-series evolution of wind properties, source spectrum, and luminosity, to changes in the optical/IR emission that traces the irradiated outer disc. While our findings suggest the observations require a scattering source of irradiation to play a prominent role, they cannot be fully explained via scattering in a thermal-radiative wind, even when combined with direct illumination. This is highly suggestive of additional scattering mechanisms at work here, such as magnetically-driven outflows, acting to increase the optical/IR flux. Overall, this wind-driven irradiation is likely a common feature among long-period BHXBs, however, the driving mechanism(s) behind the wind are currently unclear and may be source dependent.

Christina Thöne
IAA – CSIC, Spain

VHE emission from GRBs, only from peculiar host environments?

GRB 190114C was the first gamma-ray burst (GRB) for which a secure detection of very high-energy (VHE) photons has been reported. By now, at least another two GRBs have confirmed VHE detections. One of the still unsolved questions is whether all GRBs show VHE emission and we were just lucky to observe it or whether they actually require special conditions for the VHE emission to occur at sufficient strength to be observable. In the case of GRB 190114C, optical spectroscopy from X-shooter a few hours after the burst hints at a peculiar environment: We detect excited lines of Titanium never seen before in any GRB (nor in any other astrophysical object) and we have further evidence for a very dense environment in the data. At

least one of the other VHE detected GRBs, 190829A, share some of these properties and both GRBs show a high extinction. The location of GRB 190114C in its host was also peculiar: It occurred in the central region of its host, which itself shows a high molecular gas content, as seen in ALMA CO imaging, and is part of an closely interacting galaxy pair. All these observations support our claim of a particularly dense environment, not commonly observed in GRBs. We therefore believe that a dense environment is key to produce the VHE emission, similar to the dense central star clusters where VHE emission in low redshift starburst galaxies has been observed (without hosting a GRB).

Victoria Toptun
Sternberg Astronomical Institute, M. V. Lomonosov Moscow State University, Russia
Expanding a bona fide sample of intermediate-mass black holes in active galactic nuclei: X-ray confirmation of four candidates with XMM-Newton
Intermediate mass black holes play a key role in our understanding of SMBH formation and growth. But the current bona-fide sample of IMBH candidate comprises only 10 objects, where the AGN nature was confirmed by direct X-Ray observations. Here we present a confirmation of additional four IMBHs from a sample of 305 optically selected candidates by Chilingarian et al. (2018). Two of them were confirmed with our own XMM-Newton EPIC observations. Another two were identified in the recent release of the XMM source catalog 4XMM DR9. With the expanded sample of bona fide IMBHs we probe BH accretion rates in low-mass AGN and identify two galaxies close to the Eddington limit.

Michele Trenti
University of Melbourne, Australia
Spotting and studying black holes with tiny satellites
Astronomical observations from space, at wavelengths unobstructed by Earth's atmosphere, are becoming critically needed to advance a large array of diverse fields, in particular in the area of high-energy astrophysics events related to black hole formation and mergers, and multi-wavelength follow-up of their afterglows. Orbiting telescopes, large or small, have been so far mainly confined to complex missions run by government agencies. However, thanks to dramatic technological improvements, CubeSats (micro-satellites based on standardised dimensions) represent a new opportunity to break the price and performance curve of traditional space missions, while retaining attractiveness as cutting-edge research platforms. In this talk I will introduce the status of astrophysics CubeSat missions, focusing in particular on those associated to search and characterisation of Gamma Ray Bursts.

Eleonora Troja
NASA/GSFC, USA
Review Talk
Electromagnetic follow-ups of GW sources
The discovery of the gravitational wave transient GW170817 and its electromagnetic counterparts ushered in a new era of multi-messenger. astrophysics, in which both gravitational

waves and light provide complementary views of the same source. In this talk, I will present the long-term evolution of GW170817 across the electromagnetic spectrum, and discuss its similarities with the sample of short GRBs at cosmological distances. Finally, I will summarize current challenges and strategies for follow-up observations of GW events during O3.

Audrey Trova
Zarm, University of Bremen, Germany
Thick accretion disk in an external gravitational and electromagnetic field
We present an analytical model of a thick accretion disk modeled by a charged fluid encircling a charge or noncharge black hole and endowed in an axisymmetric and stationary magnetic field. Both electric and magnetic fields are known to influence the accretion flow as well as the gravitational field. Our study is based on the Polish doughnut and provides an extension of this well-known model. The vertical and radial structure of the torus is influenced by the balance between these forces. Here our interest is to know how each of the interactions involved in the equilibrium process as the gravity, the electric and the magnetic force are influencing the shape and the density distribution of the fluid. We focus on orbiting structures in the equatorial plane, as single or double tori, on the polar axis, and structures above the equatorial plane as a levitating torus. Moreover, as one of the aims of analytical models is to be used as initial conditions of simulation, we are testing their stability and how the external force is playing a role in that area.

Devendra Raj Upadhyay
Amrit Campus, Tribhuvan University, Kathmandu, Nepal
Astrophysics in Nepal
Research activities in astronomy and astrophysics in Nepal will be presented.

Alexander Wagner
University of Tsukuba, Japan
Review Talk
Jet-ISM interactions: Simulations
Active galactic nuclei jets launched from the environs of supermassive black holes are powerful, relativistic plasma streams that can interact strongly with the interstellar medium (ISM) on galactic scales. The interactions are effective because the light jet plasma is easily deflected and confined by ISM homogeneities. Simulations of jets propagating through the ISM of galaxies show that jet streams percolate through the porous ISM and blow an energy bubble that shocks, engulfs, compresses, and disperses star-forming clouds. In the process, star-formation may either be enhanced or inhibited, but the conditions determining how star-formation is affected are as yet unclear.

Grzegorz Wiktorowicz
National Astronomical Observatories, Chinese Academy of Sciences, China
Populations of Stellar-mass Black Holes from Binary Systems

In large and complicated stellar systems like galaxies, it is difficult to predict the number and characteristics of a black hole (BH) population. Such populations may be modeled as an aggregation of homogeneous (i.e. having uniform star formation history and the same initial chemical composition) stellar populations. Using realistic evolutionary models, abundances and properties of BHs formed from binaries in these environments can be predicted. I am going to show that the BH population is dominated by single BHs originating from binary disruptions and stellar mergers and discuss how BH populations are influenced by such factors as initial parameters, metallicity, initial mass function, and natal kick models. The prediction for OGLE, Gaia, and LAMOST will be provided. Finally, a publicly available database with the raw data from our simulations to be used for more in-depth studies will be introduced.

Anna Wojtowicz
Astronomical Observatory of the Jagiellonian University, Poland
Jet production efficiency in a sample of the youngest radio galaxies
We discuss the sample of the confirmed young radio galaxies with measured kinematic ages, black hole masses, and accretion rates. We investigate the distribution of our sample in the three-dimensional space of the Eddington ratio, the nuclear X-ray luminosity, considered as a proxy for the emission of the accretion disk coronae, and the jet total kinetic power.
We find that (i) the Eddington ratio is distributed within a narrow range from \sim 1\% up to \sim 20\%; (ii) the jet power normalized to the accretion luminosity correlates with the accretion rate; (iii) the jet production efficiency is below the level expected for magnetically arrested disks around maximally spinning black holes; and (iv)there is an interesting diversification in the normalized jet power on the accretion disk hardness–intensity diagram, with the jets being produced the most efficiently during the high/hard states, and suppressed during the soft states. The latter finding could be analogous to the dependance that was established for Galactic X-ray binaries.

Xue-Bing Wu
Peking University, China
Review Talk
SMBH growth at high redshift
The discovery of 10 billion solar mass black holes at redshift beyond 6 provides a serious challenge to the models of SMBH growth in the first billion years of our Universe. I will review the current progress in finding high redshift quasars and estimating their central BH masses, and discuss how to grow the SMBHs at high redshift by several different ways including direct collapse, super-Eddington accretion and BH mergers.

Satoshi Yamada
Kyoto University, Japan
Structures of AGN Tori in Ultra-/luminous Infrared Galaxies Revealed with Mid-infrared and X-ray Spectroscopy

Mergers of gas-rich galaxies, which are often observed as ultra-/luminous infrared galaxies (U/LIRGs), play a key role for supermassive black hole growth and star formation. Understanding the nature of their active galactic nuclei (AGNs) is important to establish the strategy to completely survey them. First, we propose new diagnostics that utilize the [O IV] 25.89 um and subarcsecond-scale 12 um luminosity ratio for identifying deeply "buried" AGNs (i.e., obscured by tori with large covering factors; Yamada et al. 2019, ApJ, 876, 96). Second, we perform a systematic X-ray spectroscopic survey of local U/LIRGs in various merger stages, utilizing the best-quality broadband data obtained with NuSTAR, Suzaku, XMM-Newton, and/or Chandra. Applying the state-of-art X-ray clumpy torus model (XCLUMPY), we are able to constrain the covering factor of the obscurer for each object (Yamada et al. submitted to ApJ). Both results suggest that AGNs in late-stage mergers are deeply "buried", whereas those in non-mergers or early-stage mergers are not. On the basis of these findings, we discuss the structures of the AGN tori in U/LIRGs and their relations to the Eddington ratios.

Silvia Zane
Mullard Space Science Laboratory, University College London
United Kingdom
Review Talk
Future perspectives on X-ray Polarimetry with IXPE and eXTP
Future missions on Xray polarimetry are now at the horizon. IXPE is an approved NASA small mission, completely devoted to X-ray polarimetry. With a launch in ~2021, is expected to open a discovery space in the field and revolutionize our understanding of the X-ray sky. On a slightly longer timescale, we expect the realization of the enhanced X-ray Timing and Polarimetry (eXTP) mission, a mission concept developed by an international Consortium led by the Institute of High Energy Physics of the Chinese Academy of Science, and expected to be launched in the mid 2020s. The mission is devoted to high resolution X-ray timing and spectroscopy, in addition to X-ray polarimetry. In this talk, I will present the mission concept and the science potential of these two observatories.

Andrzej Zdziarski
N. Copernicus Astronomical Center, Poland
Transfer of magnetic field and jet formation in black-hole X-ray binaries
We have discovered long-term lags of soft radio emission with respect to X-rays andstrong correlations at no lag of hard X-rays and radio across all spectral states in two high-mass X-ray binaries, Cyg X-1 and Cyg X-3. Those are modelled by transfer of large scale magnetic field from the donors via the stellar winds, and jet formation related to the hot coronal plasma.

Shuang-Nan Zhang
Institute of High Energy Physics/CAS/China
Review Talk
Highlights of Insight-HXMT X-ray Astronomy Satellites

Insight-HXMT is China's first X-ray astronomy satellite and was successfully launched on June 15th, 2017. It carries three sets of collimated X-ray instruments with large effective areas, covering energy ranges of 1-15 keV, 5-30 keV, and 20-250 keV, respectively. In addition, it can also serve as a nearly all-sky monitor for high energy sources between 0.2 to 3 MeV, such as bright pulsars and gamma-ray bursts. I will review some highlights of the scientific results of Insight-HXMT, on accreting X-ray binaries harboring black holes or neutron stars, isolated pulsars, gamma-ray bursts and scanning survey of the Galactic Plane.

Hao Zhang
Department of Physics, Purdue University, USA

Inverse Compton Signatures of High-Energy GRB Afterglow Emission: the case of GRB 190114C and prospects for CTA

The recent detection of sub-TeV radiation from GRB 190114C by MAGIC has revived the interest in the question of what powers the high-energy emission of gamma-ray burst (GRB) afterglows. Here, we explore the inverse Compton scattering as a potential candidate process and consider two sources of seed photons for scattering: synchrotron photons from the blast wave (synchrotron self-Compton or SSC) and isotropic photon fields external to the blast wave (external Compton or EC). For each case, we compute the multi-wavelength afterglow spectra and light curves by analytical means. We find that SSC will dominate particle cooling and the GeV emission, unless a dense ambient infrared photon field, typical of star-forming regions, is present. By applying our analytical method on GRB 190114C, we find that its afterglow emission in the Fermi-LAT band is synchrotron-dominated for $t<10^6$ s. The late-time Fermi-LAT measurement (at $t \sim 10^4$ s) and the MAGIC observation also set an upper limit on the energy density of a putative external infrared photon field (i.e., $\lesssim 2.5\times10^{-8}$ erg/cm^3), making the EC emission sub-dominant in both GeV and sub-TeV energies. Additionally, considering the extragalactic background light attenuation, we discuss the detectability of sub-TeV and TeV afterglows by existing and future gamma-ray instruments, like CTA, for a wide range of model parameters.

Janusz Ziolkowski
Copernicus Astronomical Center, Poland

News from Cyg X-1

New VLBI parallax for Cyg X-1 gives the distance d=2.18 ± 0.19 kpc. This value agrees with the result from GAIA as determined by Bailer-Jones et al., 2018 (d=2.22+0.18-0.15 kpc). The most recent determination of the effective temperature of the optical component (Shimanskii et al., 2012) gives Te=30 500±500 K which agrees with the earlier estimates. The same authors determined (for the first time) the value of the surface hydrogen content of this component as X=0.52±0.05 which indicates the stormy past of the binary. Using the values quoted above J. Orosz applied his numerical code described in Orosz et al. (2011) to determine the revised values of the parameters of the binary. Our results give for the mass of the optical component 40±8 Msun and for the mass of the black hole 20±2 Msun (which makes it the most massive X-ray binary black hole known). The comparison with the evolutionary stellar models suggests that

while hydrogen content X=0.52 is consistent with the models, the higher value would fit the models better.
The important evolutionary conclusion is the following one: The formation of such a massive black hole in a high-metallicity system implies that stellar winds in massive stars must be less efficient than previously believed.

Natalia Zywucka
North-West University, South Africa

Optical variability modelling of newly identified blazars and blazar candidates behind Magellanic Clouds

We present an optical variability study of 44 newly identified blazar candidates behind the Magellanic Clouds, including 27 flat spectrum radio quasars (FSRQs) and 17 BL Lacertae objects (BL Lacs), but only nine of them are recognized as blazars, while the classification of 35 objects is still uncertain. All objects possess high photometric accuracy and infrequently sampled optical light curves (LCs), spanning several (up to 17) years, delivered by the Optical Gravitational Lensing Experiment. We investigated the variability properties to look for blazar-like characteristics and to analyze the long-term behaviour.
The LCs were analysed with the Lomb-Scargle periodogram, and it was found that the power spectral densities (PSDs) exhibit breaks for several objects, which allowed us to constrain the black hole masses of 18 FSRQs. Having the bolometric luminosities, we have also applied the fundamental plane of AGN variability as an independent estimate of the black hole masses. Many sources have very steep PSDs, with high frequency spectral index in the range 3-7. An alternative attempt to classify the LCs was made using the Hurst exponents and the A-T plane. Some of the sources yielded $H > 0.5$, indicating the presence of a long-term memory in the underlying process governing the variability, while the A-T plane shows dichotomy between the FSRQ and BL Lac type of blazars.