Poster Abstracts for

Black Holes and Transient Phenomena

Parallel Session

Scott F. Anderson (University of Washington)

A. Merloni (Max-Planck Inst. fur Ext. Physik), Y. Shen (Univ. of Illinois), & BHM Team

Topic: Black Holes and Transient Phenomena

The Black Hole Mapper in Sloan Digital Sky Survey V

The Black Hole Mapper is among the main science programs of the next generation Sloan Digital Sky Survey (SDSS-V), actively being developed for dual-hemisphere, wide-area, multi-epoch and multi-object spectroscopy (MOS), starting about 2020. Black Hole Mapper (BHM) exploits two hallmark characteristics of accreting supermassive black holes (SMBHs) in quasars to assess their fundamental parameters, astrophysics, and evolution: optical spectral variability on a range of timescales from days to decades, and prodigious luminosities extending even up to X-ray energies. In the time-domain, $\sim 10^{4.5}$ quasars will be (re)observed with MOS at a range of cadences, with the bulk having a few to a dozen epochs added in SDSS-V, e.g., suitable for exploring accretion astrophysics and transitions such as changing look quasars; and BHM time-domain efforts will more-intensively study $>10^{3}$ quasars, each with hundreds of spectral epochs for reverberation measures of masses of SMBHs across a broad range of redshift and luminosity. BHM additionally will reveal the identifications and natures (redshift, spectral subclass etc.) of the optical counterparts to $\sim 10^{5.5}$ X-ray sources (mainly AGN) discovered in initial years of the upcoming eROSITA surveys of the X-ray sky; the eROSITA/SDSS-V combination will yield an obscuration unbiased probe of SMBH demographics and evolution, again with orders of magnitude advances. [BHM optical IDs of eROSITA sources will also yield X-ray emitting clusters of galaxies, compact binaries and CVs, and active late-type stars]. An overview is provided of the status of BHM planning, as we continue to expand our international collaboration. Funding for The Sloan Digital Sky Survey V has been provided by the Alfred P. Sloan Foundation, and the Participating Institutions. www.sdss.org/future/ .

Sabrina Berger (UC Berkeley)

Ran Duan, Jin Fan, Chengjin Jin, Di Li, Rendong Nan, Chenhui Niu, Xiangwei Shi, Jinyou Song, Jinglong Yu, Youling Yue, Weiwei Zhu, Yan Zhu (National Astronomical Observatory of China)

Jeff Cobb, Vishal Gajjar, Eric Korpela, Dan Werthimer (UC Berkeley)

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Shi-Yu Li, Tong-Jie Zhang (Beijing Normal University)

Mark Bowen, Paul Doherty, Alex Dunning, Douglas Hayman, Kanapathippillai Jeganathan, Peter Roush, Tasso Tzioumis (Australia Telescope National Facility, Commonwealth Scientific and Industrial Research Organisation)

Topic: Black Holes & Transient Phenomena

The Fast Radio Burst Search Pipeline at FAST

FAST (Five hundred meter Aperture Spherical Telescope) is the newest and largest radio telescope ever built. It is situated in the Guizhou province of China. Berkeley SETI Research Center is developing a real time search pipeline to analyze all incoming data for possible fast radio bursts (FRBs). FRBs are extremely high energy transient radio bursts that have been observed with no confirmed origin. Recently, by scrutinizing polarization properties of an FRB (i.e. FRB 121102), it is speculated that some FRBs may come from a source embedded in a very powerful magnetic field.

The development of the FRB search pipeline, *fastburst*, has been an intensive process involving narrowing down the best and most efficient transient search algorithm available and developing the hardware and software to go alongside this. With real-time multibeam commensal observations using FAST, we expect many new fast radio transient discoveries. Increasing our sample size of FRBs could help us improve our understanding of their origins. Fast radio transients also play an important role in detecting missing baryonic matter in the interstellar medium as well as testing general relativity. Discoveries at FAST may play a key role in answering some of the most fundamental questions in astrophysics.

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Laura Chomiuk (Michigan State)

Tom Maccarone (Texas Tech)

Topic: Black Holes & Transient Phenomena

Revealing the Galactic Population of Black Holes with the ngVLA

As part of our ngVLA community study, we present a plan to discover and characterize a substantial, unbiased sample of accreting stellar-mass black holes in our Milky Way. A deep Galactic radio survey with the ngVLA, obtained with high resolution, will be able to distinguish Galactic point sources from extragalactic objects by their proper motions---revealing a diversity of interesting stellar radio-emitters. Accreting black holes can then be distinguished using their flat radio spectra and multi-wavelength follow-up, while their kicks can be measured from their proper motions. A better understanding of black holes in our Galaxy, including the overall size of the population, their environments, mass distribution, and velocity distribution, will have important implications for may of the most pressing questions in stellar astrophysics, like supernova explosion physics, the formation of LIGO merging binaries, and common envelope physics.

Anh Doan (Pennsylvania State University)

Michael Eracleous, Jessie C. Runnoe, Jules P. Halpern, Jia Liu, Gavin Mathes, Helene M. L. G. Flohic

Topic: Black Holes and Transient Phenomena

A New, Sophisticated Test of the Binary Black Hole Hypothesis for Quasars with Double-peaked Broad Balmer Lines.

Displaced peaks in the Balmer lines of quasars could serve as indirect evidence for the existence of close, bound supermassive black hole binaries (SBHBs) at sub-parsec separations. In this work, we test the SBHB hypothesis for 14 quasars with double-peaked emission lines using their long-term radial velocity curves. We make use of a Markov Chain Monte Carlo method to explore the parameter space efficiently. Compared to previous works, we have relaxed the assumption of circular orbits, adding two parameters (eccentricity and argument of periapsis) to the parameter space. We also account for jitter, i.e., short-term fluctuations in the radial velocity curves due to processes that are intrinsic to an individual broad-line region. We have found that the distribution of jitter about a smooth radial velocity curve resembles a Gaussian. Thus, jitter is equivalent to increasing measurement uncertainty in individual measurements. The resulting posterior distributions show the lower mass limit of the SBHBs to be in the range of 10^8- 10^{11} solar masses. For several objects, the mass limit drops by a few orders of magnitude compared to previous results by Liu et. al. However, we note that solutions corresponding to minimum masses often require very high orbital eccentricity (> 0.9). We also calculate the orbital decay timescale of the binaries due to gravitational radiation, finding values in the range 10^6 – 10^{11} years; these values correspond to the minimum-mass solutions. For one third of our targets, we can confidently disfavor the SBHB hypothesis on the basis that the minimum mass exceeds even the most massive black holes measured so far (2 x 10^{10} solar masses). For the remaining objects, we must take into account the plausibility of a variety of parameters (e.g. eccentricity, lifetime, etc.) in our evaluation.

Richard Dodson & Maria Rioja (ICRAR, Uni. Western Australia)

Topic: Black Holes and Transients

New Developments in Radio Astrometry, with the Next Generation of Instruments

The arrival of ALMA at mm and SKA at meter wavelengths and ngVLA for all frequencies in-between means that the facilities are outstripping the limitations inherent for conventional VLBI astrometry. We will summarise the new methods we have been developing for extremely low and extremely high frequencies for the next generation radio arrays, that are delivering the astrometric accuracies that match or exceed that of current day state of the art. These methods, primarily Source/Frequency Phase Referencing at 2mm and MultiView at 20cm have been demonstrated on VLBA, KVN and other VLBI arrays and are allowing new fields of research to be explored.

A. Miguel Holgado (University of Illinois at Urbana-Champaign)

Paul Ricker (University of Illinois at Urbana-Champaign)
Eliu Huerta (University of Illinois at Urbana-Champaign)

Topic: Black Holes and Transient Phenomena

Gravitational Waves from Accreting Neutron Stars in the Common-Envelope Phase

The common-envelope phase is a likely formation channel for close binary systems containing compact objects. Neutron stars in common envelopes accrete at a fraction of the Bondi–Hoyle–Lyttleton accretion rate, since the stellar envelope is inhomogeneous, but they may still be able to accrete at hypercritical rates (though not enough to become black holes). We show that common-envelope systems consisting of a neutron star with a massive primary may be gravitational-wave (GW) sources detectable in the Advanced LIGO band as far away as the Magellanic Clouds. From the range of possible accretion rates relevant to common-envelope evolution, we find that these systems may be louder GW sources than low-mass X-ray binaries like Sco X-1, which are currently the target of directed searches for continuous GWs. We also find that their strain amplitude signal may allow for novel constraints on the orbital separation and inspiral timescale in common envelopes when combined with pre-common-envelope electromagnetic observations.

A. Miguel Holgado (University of Illinois at Urbana-Champaign)

Alberto Sesana (University of Birmingham)
Angela Sandrinelli (Universito dell'Insubri, Istituto Nazionale di Astrofisica)
Stefano Covino (Istituto Nazionale di Astrofisica)
Aldo Treves (Universito dell'Insubri, Istituto Nazionale di Astrofisica)
Xin Liu (University of Illinois at Urbana-Champaign)
Paul Ricker (University of Illinois at Urbana-Champaign)

Topic: Black Holes and Transient Phenomena

Pulsar-Timing Constraints on the Fermi Massive Black-Hole Binary Blazar Population

Blazars are thought to be active galactic nuclei whose jets are almost aligned with our line-of-sight. Electromagnetic observations of blazars have found quasi-periodic behavior in their light curves on timescales of order years. One interpretation of such behavior is that the quasi-periodicity is due to the presence of a massive black-hole binary. We test the binary hypothesis of the cosmic blazar population as discovered by the Fermi Gamma-Ray Space Telescope with recent pulsar-timing array upper limits on the stochastic nanohertz gravitational-wave background. We find that the binary interpretation is inconsistent with pulsar-timing upper limits; thus, binarity alone cannot fully explain quasi-periodicity in the cosmic blazar population.

Yasaman Homayouni (University of Connecticut)

Jonathan Trump (University of Connecticut)
Catherine Grier (Penn State University)
Yue Shen (University of Illinois at Urbana-Champaign)
Patrick Hall (York University)
Neil Brandt (Penn State University)
Keith Horne (University of St. Andrews)

Topic: Black Holes and Transient Phenomena

Mapping the Growth of Supermassive Black Holes

I will present my most recent results on the physics of black hole accretion using direct accretion-disk size and structure measurements as a part of the pioneering Sloan Digital Sky Survey Reverberation Mapping (SDSS-RM) campaign. Supermassive black holes are now known to be ubiquitous, with a critical role in galaxy evolution implied by the tight connections between black hole mass and galaxy properties. But we still lack a basic understanding of how supermassive black holes grow. SDSS-RM simultaneously monitors 850 quasars, spanning a broad range of well-measured masses that are representative in quasar orientation and accretion rate. I will focus on how continuum reverberation mapping technique can expand our understanding of the physics of accretion by observationally connecting accretion-flow structure to black hole mass and accretion rate.

Kojiro Kawana (University of Tokyo)

Ataru Tanikawa (University of Tokyo)
Naoki Yoshida (University of Tokyo)

Topic: Black Holes & Transient Phenomena

Tidal Disruption Events of a White Dwarf by a Black Hole

In tidal disruption events (TDEs) of a white dwarf (WD) by a black hole (BH), the WD is tidally compressed and possibly ignites nuclear burning with the help of shock heating, leaving a transient similar to Type Ia SNe. We study a variety of the WD-BH TDEs performing a suite of smoothed particle hydrodynamic simulations coupled with nuclear reactions. We derive boundaries in a parameter space on whether the nuclear reactions ignite, and also nucleosynthetic yields for various cases. We show that helium WD–BH TDEs cannot be an origin of so-called calcium-rich gap transients because the amounts of ^{56}Ni synthesized in our simulations are much larger than the observed ones. Tanikawa et al. (2017) find that simulations of WD–BH TDEs with low resolution suffer from spurious heating and inaccurate nuclear reaction results. In order to examine the validity of our calculations, we compare the amounts of the synthesized elements with the upper limits of them derived in a way where we can avoid uncertainties due to low resolution. The results are largely consistent, and thus support our findings.

Adam Kawash (Michigan State University)

Laura Chomiuk (MSU)
Tommy Nelson (UPitt)
Koji Mukai (GSFC/UMBC)
Justin Linford (GWU)
Michael Rupen (NRC)
Jeno Sokoloski (Columbia)
Amy Mioduszewski (NRAO)
Jennifer Weston (AAAS)

Topic: Black Holes & Transient Phenomena

Multi-Wavelength Radio Light Curves of Novae in the E-Nova project

The E-Nova Project is a collaboration dedicated to observing novae from radio through gamma-ray regimes. Our central goal is to understand the shocks that occur internal to nova ejecta. These internal shocks are currently poorly characterized, and it is not clear why some novae show large shock-powered luminosities and substantial relativistic particle acceleration, while others do not. Radio light curves provide direct tracers of these shocks via synchrotron emission, while allowing us to measure the total mass, velocity, and energetics of the ejected material through thermal free-free radiation. Multi-wavelength radio observations with Karl G. Jansky Very Large Array (VLA) show how the radio emission from novae evolves over time, and allow us to measure critical nova properties. Here, we present the radio light curves of eight novae monitored in the E-Nova Project since 2013. These novae were observed with the VLA at four frequency bands (L, C, Ku, Ka) covering 1.3 GHz to 35 GHz. Four of these novae have gamma-ray detections with the Fermi Space Telescope while the other four do not.

Joseph Lazio (Jet Propulsion Laboratory, California Institute of Technology)

Topic: Black Holes & Transient Phenomena

The North American Nanohertz Observatory for Gravitational Waves

The North American Nanohertz Observatory for Gravitational Waves (NANOGrav) aims to open the next window of the gravitational wave spectrum, at nanohertz frequencies. At these frequencies, the Universe should be awash in gravitational waves from the ensemble of inspiraling supermassive black holes binaries, potentially including nearby loud binaries; cosmic strings or other exotic sources might also contribute. NANOGrav is steadily improving the limits on the nanohertz gravitational wave spectrum, with an 11 Year Data Release just announced and 12.5 Year and 14 Year Data Releases being developed. I summarize the current status of the NANOGrav Collaboration and projections into the next decade. The NANOGrav project receives support from NSF Physics Frontier Center award number 1430284. Part of this research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

Jennifer I. Li (University of Illinois at Urbana-Champaign)

Yue Shen (University of Illinois at Urbana-Champaign)
Catherine J. Grier (Pennsylvania State University)
William N. Brandt (Pennsylvania State University)
And the SDSS-RM collaboration

Topic: Black Holes & Transient Phenomena

The Sloan Digital Sky Survey Reverberation Mapping Project: Composite and Individual Lag Measurements from First-year Observations

The Sloan Digital Sky Survey Reverberation Mapping project (SDSS-RM) is one of the first surveys to perform reverberation mapping observations on a large, uniform sample of quasars. We present the composite and individual lag measurements of ~200, $z<1$ SDSS-RM quasars using data from first-year observations. We compute the composite lags for broad Hα, Hβ, HeII and MgII lines by coadding the individual cross correlation functions using spectroscopic-only light curves from the first season observations. At similar redshift and luminosity, the averaged lag decreases in the order of Mg II, Hα, Hβ, and He II, which is roughly consistent with the virialized motion for BLR gas in photoionization equilibrium. In addition, we measure time lags for individual sources using the broad Hβ (44 sources detected) and Hα (18 sources detected) emission lines. The median redshift of our sample is >0.5 and these measurements are the first large sample of reverberation mapping observations beyond the local Universe ($z<0.3$).

Jessica Maldonado (Michigan State University)

Laura Chomiuk (Michigan State University), Carles Badenes (University of Pittsburgh), Sumit Sarbadhicary (University of Pittsburgh)

Topic: Black Holes & Transient Phenomena

Next Generation VLA: A Tool For Supernova Remnant Population Studies

For decades an important unsolved problem in astrophysics has been the progenitors of Type-Ia supernovae. Measuring the supernova rate as a function of stellar age (the Delay Time Distribution) has revealed hints as to the nature of these progenitor systems. We have established a new way to measure the Delay Time Distribution using high resolution surveys of supernova remnants in radio continuum images of Local Group galaxies like M31. Although we are currently optimistic about the order of magnitude increase in detection of supernova remnants in our deep Jansky VLA survey of M31, we foresee that ngVLA could push this substantially further and provide the long-needed sensitivity and resolution for next-generation supernova remnant studies.

AleksandraOlejak(Astronomical Observatory, University of Warsaw)

Krzysztof Belczynski (Nicolaus Copernicus Astronomical Center of the Polish Academy of Sciences)

Topic: Black Holes & Transient Phenomena

Synthetic Catalog of Black Holes in the Milky Way

We present an open-access database that includes a synthetic catalog of black holes in Milky Way. As it is an ongoing project, at the moment we have included data of black holes in the Galactic disk, and in the next steps we will add black hole populations of the Galactic bulge and halo. To calculate evolution of single and binary stars in Milky Way disk we have used updated population synthesis method (StarTrack code). Resulting black holes are in all various configurations. We find that at the current moment, Galactic disk should contain about 112,381,940 single black holes and 3,779,720 black holes in binary systems. We obtained that single black holes mostly form from single stars evolution or as a product of merger of: two main sequence stars, main sequence and helium star or two compact objects.

Mean mass of single black hole is estimated as 8.4 $M_{\odot}$ while for black hole in binary systems this value is 8.9 $M_{\odot}$. We find that most of binary systems which contain black holes are black hole – black hole systems. We have also calculated merger frequency rate for compact objects.

Charee Peters (University of Wisconsin - Madison)

Alexander van der Horst (George Washington University), Laura Chomiuk (Michigan State University), Rodolfo Barniol Duran (California State University, Sacramento), Adithan Kathirgamaraju (Purdue University), Dimitrios Giannios (Purdue University), Raffaella Margutti (Northwestern University), Eric Wilcots (University of Wisconsin – Madison)

Topic: Black Holes & Transient Phenomena

Early Sedov Phase in Gamma-Ray Bursts with Associated Supernova

Gamma-ray burst (GRB) radio afterglows are well-studied transient jet phenomena, some of which also have associated and unusually energetic supernovae (SNe). The SNe have been proposed to produce their own peak of radio emission after the afterglows fade away as the SN ejecta sweeps up and interacts with surrounding material (within a couple of decades of the initial explosion). In this project, we conducted multi-band radio observations (6 and 2 GHz) to observe this late-time radio re-brightening with three relatively old, nearby GRBs with associated SNe (GRBs 980425, 030329, and 060218). Although we were unable to detect any emission, we place deep limits on the GRB/SN luminosity 10-18 years after the initial explosion, and thereby constrain the density of the external medium, the SN energy, the fraction of energy in the electrons and magnetic field of the shocked region. With the increased sensitivity and resolution of the ngVLA, we will be able to monitor the evolution from SN to supernova remnant for nearby GRB/ SNe.

Sascha Schediwy (International Centre for Radio Astronomy Research)

Topic: Black Holes & Transient Phenomena

Phase Synchronization of the ngVLA

I present a detailed conceptual design of a phase synchronization system for the next-generation Very Large Array (ngVLA). The design will be optimized for the ngVLA by combining the best elements of the synchronization systems of the Mid-Frequency Square Kilometre Array and Atacama Large Millimeter Array telescopes, as well as any novel synchronization technologies that have been developed by the international frequency metrology community.

Interferometric radio telescope arrays, such as the ngVLA, require that astronomical observations be synchronized with reference signals that are phase-coherent across the array's extent. The reference signals can transmitted to each antenna using the array's optical fiber network; however, environmental perturbations affect the optical path length of the fiber. This acts to degrade the phase stability of the reference signals received at the antennas, which has the ultimate effect of reducing the fidelity and dynamic range of the data.

I review existing synchronization technologies; derive suggested ngVLA coherence requirements, justified with respect to impacts on astronomical performance; present the technical details of a proposed ngVLA phase synchronization system; determine a cost estimate of this system; provide an estimate of the expected phase coherence performance; and discuss potential design variations and trade-offs, highlighting how technology breakpoints might limit ngVLA other design choices.

Aarran Shaw (University of Alberta)

Bailey Tetarenko (University of Alberta), John Tomsick (SSL, UC Berkeley), Poshak Gandhi (University of Southampton), Tolga Dinçer (Yale University), and Dave Russell (NYU Abu Dhabi)

Topic: Black Holes and Transient Phenomena

Unravelling the Mysteries of Swift J1753.5-0127: The Black Hole That Just Wouldn't Stay Quiet

Low-mass X-ray binaries (LMXBs) are binary systems consisting of a compact object (a black hole or neutron star) accreting matter from a low-mass main sequence companion. LMXBs often exhibit transient outbursts characterized by a large increase in flux, followed by an exponential decay to its pre-outburst quiescent state. LMXB outbursts can broadly be explained by the disc-instability model, in which matter slowly builds up in an accretion disc until it reaches a critical temperature, triggering an outburst. Once the matter in the disc is sufficiently depleted, then the disc returns to a cold, quiescent state and the process begins anew. The outburst-quiescence cycle typically happens on timescales of ~months and gives us an opportunity to probe the physics of accretion, one of the most fundamental astrophysical processes. However, the black hole LMXB Swift J1753.5-0127 (hereafter J1753) remains an unusual anomaly. Discovered in in 2005, it remained in outburst for ~12 years, before finally entering quiescence (after two short-lived 'mini-outbursts') in July 2017. The reason behind J1753's prolonged tenure in the X-ray sky has long been unknown, but sophisticated modelling of the spectral energy distribution (SED) of the source during its decay to (and re-emergence from) quiescence may hold the key. Encoded within the SEDs of LMXBs is information about X-ray irradiation in accretion discs, which is an important heating process in the outburst and subsequent decay of a transient system. We present here the results from a dedicated multi-wavelength monitoring programme of J1753, in which we obtained NIR/UV/optical and X-ray observations during the 2017 drop to quiescence. With our monitoring programme, we find evidence that X-ray irradiation has played a significant part in prolonging the outburst of J1753. Our results suggest that to understand X-ray heating we need the ability to probe multiple regions of the accretion disc over the course of an outburst decay to quiescence. Advances in spectroscopic techniques, combined with next-generation facilities, will allow us to probe the heating properties of accretion discs across all luminosity regimes, paving the way to finally understanding the detailed physics at work.

Gregory Sivakoff (University of Alberta)

Alexandra Tetarenko (University of Alberta), James Miller-Jones (ICRAR/Curtin University), and the JACPOT XRB Collaboration

Topic: Black Holes & Transient Phenomena

Supersizing (Accreting Black Hole) Science with Subarrays

In X-ray binaries material from a nearby companion star accretes onto a compact object (neutron star or black hole) through a disk. In some accretion states, there are jets of material that move away from the compact object at relativistic speeds. Many X-ray binaries undergo relatively brief periods of intense accretion, separated by longer periods of quiescent accretion. These transient systems vary on timescales of seconds to years, allowing for time-resolved studies of entire outbursts. Thus, X-ray binaries, especially Galactic sources, deeply probe the connected evolution of accretion disks and relativistic jets, and act as lower-mass (and highly accessible) analogues to Active Galactic Nuclei. Past X-ray binary observations across the electromagnetic spectrum could be separated by days before being combined to form a single spectral energy distribution; however, non-simultaneity affected interpretation. While more X-ray binary observations are being performed quasi-simultaneously, strictly simultaneous observations are becoming increasingly important for rapidly evolving transients — even our definition of "simultaneous" may be up for grabs. The recent upgrade to the Karl G. Jansky Very Large Array (VLA) has enabled sub-array observations, where the VLA can be broken up into 2 or 3 completely separate interferometric arrays. Although each sub-array is less sensitive than the full VLA, subarray observations provide critical opportunities to simultaneously measure the spectral index of jets over wide ranges of frequencies, as well as probe jet physics in new ways [e.g., adapting Van der Laan (1966) models to the case of an expanding, bi-symmetric, pair of relativistic bubbles with geometric time delays]. Combined with other advantages such as shorter scheduling blocks, shorter integration times, observations uninterrupted by calibrations concerns, and efficient mosaicking, sub-arrays will play an important role for future radio facilities like the ngVLA.

Chris Suberlak (University of Washington)

Topic: Black Holes & Transient Phenomena

Using Gaussian Processes to Classify and Characterize Quasar Light Curves

We analyze quasar light curves using Damped Random Walk model. Large volumes of data in the age of upcoming and ongoing sky surveys (PanSTARRS, ZTF, LSST) pose a new challenge of processing huge volumes of data. We show that adding new data (ZTF, LSST) to existing surveys (SDSS,CRTS, PS1, PTF) provides a sufficient baseline to provide an unbiased estimate of the DRW parameters, that have been linked to properties of the central quasar engine - a supermassive black hole. Using variability information also allows one to classify quasars, especially where color information from photometry is insufficient (eg. the intermediate redshift range). This provides a larger sample of quasars - a crucial component for studying the high-redshift universe, the intergalactic medium of the intervening galaxies, as well as the AGN-galaxy co-evolution.

Samuel Swihart (Michigan State University)

Jay Strader (MSU), Laura Shishkovsky (MSU), Laura Chomiuk (MSU), Arash Bahramian (Curtin), Craig Heinke (Alberta), James Miller-Jones (Curtin), Phil Edwards (CSIRO), C. C. Cheung (NRL)

Topic: Black Holes & Transient Phenomena

Multi-wavelength Observations of a Progenitor to Canonical Millisecond Pulsars

Multi-wavelength follow-up observations of previously unassociated *Fermi*-LAT γ-ray sources have led to the discovery of numerous millisecond pulsar (MSP) binaries with non-degenerate companions. Here we present optical, radio, and X-ray observations of the *Fermi* source 1FGL J1417.7--4407 (J1417), a compact X-ray binary with a MSP primary and a stripped red giant companion in a ~5.4 day orbit. The persistent double-peaked Hα emission line shows variations that can be explained by the presence of a strong, magnetically driven stellar wind from the secondary and its interaction with the pulsar wind. Although radio continuum observations with the VLA and ATCA are broadly consistent with that expected from a MSP, a significant amount of material is likely in and around the system, which scatters and absorbs the radio emission. At our new optically-inferred distance of 3.1 kpc (confirmed by *Gaia* DR2 parallax), the X-ray luminosity of J1417 is $L_X \sim 10^{33}$ erg/s, which is more luminous than all known redback MSPs in the pulsar state, perhaps due to the giant companion. The unusual phenomenology of this system and its differing evolutionary state from redback MSPs points to a new subclass of compact objects that are the possible progenitors of normal field MSP binaries.

Evangelia Tremou (CEA-Saclay)

Topic: Black Holes & Transient Phenomena

The Maveric Survey: Accreting Intermediate-mass Black Holes in Globular Clusters

Dynamical measurements have been used to claim detections of intermediate-mass black holes (IMBHs) in the centers of some Milky Way globular clusters. Such IMBHs may also be detectable through X-ray or radio emission due to accretion of gas lost by the stellar winds of red giants in cluster cores.

Here we discuss the results of an ultra-deep, systematic Karl G. Jansky Very Large Array and Australia Telescope Compact Array continuum survey of 50 Galactic globular clusters and the resulting constraints on the presence of IMBHs in these clusters.

Andrea Vang (UW-Madison)

Marsha J. Wolf (UW-Madison), Eric Hooper (UW-Madison), Yi-Hao Chen (UW-Madison), Sebastian Heinz (UW-Madison), Erick Wilcolts (UW-Madison)

Topic: Black Holes

The Coevolutionary History of AGN and Galaxies through Age Estimates of Radio AGN

Feedback, a process by which gas is expelled or heated too much for new star formation to occur, is required in galaxy formation simulations to truncate star formation (SF) and form galaxies with properties that we observe today. Winds from active galactic nuclei (AGN) or supernovae after a burst of new SF can blow out circumnuclear gas, suppressing SF, supporting the idea that feedback is an important ingredient in galaxy evolution. AGN are a potential source of this feed! back, which would mean they are affecting the evolution of galaxies. Yet, the timing of star forming and AGN phases are not well known and as of today we do not have a complete understanding of the connection between AGN and SF. The goals of our project focus on the relationship between the supermassive black holes and their host galaxies through their active phases to understand the role of the AGN in the host galaxy's evolution, from the triggering of the AGN to its dormant quiescence phase. This analysis requires three elements: (1) the ability to trace an AGN's history through radio spectral age dating; (2) the ability to trace a galaxy's stellar population history via full spectrum synthesis fitting; and (3) a spatially resolved view of these systems, since not all relevant information about galaxies is contained in the central core. Fulfilling all three key elements can be achieved with the ongoing SDSS IV MaNGA integral field optical spectroscopic survey for spatially resolved properties of 10,000 galaxies and radio survey! s such a s TGSS (150 MHz), WENSS (330 MHz), and NVSS (1.4 GHz), plus ongoing targeted GMRT observations to fully sample the frequency range of 150-900 MHz. The spectra of radio synchrotron sources contain information about the age of the source. In the AGN active stage, the total spectra of the radio sources are usually well approximated by a power law over a wide range of frequencies. The spectral index, a, becomes steeper at higher frequencies because more energetic particles lose their energy quicker. The break frequency is then related to the age of the source since as the AGN ages, the break migrates to lower frequencies. This time-dependent spectral ageing process has become a common method for determining the age of AGNs radiating via the synchrotron process. To estimate the spectral age of the radio sources, three injection models are widely used to fit the break frequency in the radio spectra. The continuous injection model assumes a mixture of electron populations of various ages. The Kardashev-Pacholczyk model includes a single injection of power-law distributed electrons where the pitch angles of electrons are assumed to be constant with time. The Jaffe-Perola model incorporates a single injection, like KP, but assumes an isotropic pitch angle. We present and compare preliminary AGN age estimates for element (1) of MaNGA sources for these three models using BRATS, a software suite containing tools for radio spectral analysis. These conventional analytic modeling approaches do not inherently account for complicating factors, such as complex realistic magnetic field structures and internal energy losses in the radio emitting plasma due to adiabatic expansion of the lobes. To explore the impact of these effects we are conducting state-of-the-art 3D MHD simulations of radio lobes assuming conditions appropriate to the observed galaxies in the sample. After assuming an initial magnetic field strength and geometry at jet launch, the B-fields and plasma properties are allowed to evolve self-consistently in the simulation. With these simulations we will explore the systematic errors of the analytic conventional approach, possibly calibrate these errors, and potentially directly estimate ages with custom simulations in some cases.

Shu Wang (Peking University)

Yue Shen (University of Illinois Urbana-Champaign)

Topic: Black Holes and Transient Phenomena

The Sloan Digital Sky Survey Reverberation Mapping Project: A Study On Broad-Line Widths And Implications For Virial Black Hole Mass Estimation

We explore the mean and rms spectra line width of quasars in the Hα , H and Mg II broad emission lines using the Sloan Digital Sky Survey Reverberation Mapping project (SDSS-RM). This is the largest spectroscopic study of quasar variability to date: our study includes 32 spectroscopic epochs from SDSS-RM over 6 months, containing 222 quasars with Hβ , 58 quasars with H and 755 quasars with Mg II. We use multi-component fit method to decompose the quasar mean spectra and measure mean spectra line width. For rms spectra line width, we directly measure rms spectra width from prepspec generated emission line rms spectra using the variation of the emission line model in each epoch. We compare mean and rms FWHM, mean and rms of each line and find good 1:1 correlation in both H and Hβ . As for Mg II it shows more scatter but still agrees with 1:1 correlation. We also compare the line width between different lines. We find Balmer lines correlate with each other very well with the slope is very close to 1 while the correlation between Balmer lines and Mg II deviates from 1:1 correspondence that MgII increases slower with Balmer lines than what is expected from 1:1 correlation. We derive the correlation between MgII and Hα , H using 4 different definition of line width which could be used in later Mg II based SE mass estimators for high redshift objects.

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Topic: Black Holes and Transient Phenomena

Characterization of Silicon Photomultipliers for Use in Optical SETI

The Silicon Photomultiplier (SiPM), a recent innovation, consists in general of an array of reverse-biased Avalanche Photodiodes (APDs), which produce a cascading avalanche of electrons upon photon incidence. In practice, the SiPM returns an analog output signal with similar characteristics to that returned by a Photomultiplier Tube (PMT), but the SiPM holds several advantages over the PMT; notably, its low cost, low operating voltage, low volume, and higher quantum efficiency as compared to PMTs allow for the use of SiPMs in experimental applications which may otherwise be constrained by the limitations of PMTs. One such experimental application is in the field of optical SETI, and more generally in the search for optical transients; the PANO-SETI collaboration is attempting to use SiPMs as the primary detectors in an all-sky all-the-time search for optical transients, using 100 wide-field telescopes simultaneously observing different fractions of the sky. To that end, we characterize SiPM analog output both with no light incident (the “dark count rate”) and with ambient light incident, and design an analog pipeline to minimize erroneous multi-photon event detections (the “false alarm rate”) with respect to a Hamamatsu S13360-3050S single-pixel SiPM. Progressive improvements to this pipeline result in a decrease in the “false alarm rate” by a factor of an order of magnitude. We continue development of a digital pipeline for collation and analysis of SiPM waveforms and statistics garnered from the analog pipeline.

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Topic: Black Holes & Transient Phenomena

Intermediate-Mass Black Holes in Globular Cluster Systems

Using the Next Generation Very Large Array (ngVLA), we will make a breakthrough inventory of intermediate-mass black holes (IMBHs) in hundreds of globular cluster systems out to a distance of 25 Mpc. IMBHs have masses $M_{IMBH} \sim 100 - 100,000\ M_{\odot}$. Finding them in globular clusters would validate a formation channel for seed black holes in the early universe and inform event predictions for gravitational wave facilities. Our IMBH inventory is well suited for ngVLA Early Science.