Transient Phenomena and Physical Processes Around Supermassive Black Holes

Tuesday, 15 October 2024 - Friday, 18 October 2024

Tsung-Dao Lee Institute

Book of Abstracts

Contents

Session / 2

EM counterparts to extreme mass ratio inspirals: quasi-periodic eruptions

Author: Zhen Pan[1]

[1] *TDLI*

Corresponding Author: zhpan@sjtu.edu.cn

Quasi-periodic eruptions (QPEs) are intense repeating soft X-ray bursts with recurrence times about a few hours to a few weeks from galactic nuclei. Though the debates on the origin of QPEs have not completely settled down, more and more analyses favor the interpretation that QPEs are the result of collisions between a stellar mass object (a stellar mass black hole or a main sequence star) and an accretion disk around a supermassive black hole (SMBH) in galactic nuclei. If this interpretation is correct, QPEs will be invaluable in probing the orbits of stellar mass objects in the vicinity of SMBHs, and further inferring the formation of extreme mass ratio inspirals (EMRIs), one of the major targets of spaceborne gravitational wave missions. In this work, we extended the EMRI orbital analysis in Paper I arXiv:2401.11190 to all the known QPE sources with more than flares observed. Among all the analyzed 5 QPE sources, two distinct EMRI populations are identified: 4 EMRIs are of low orbital eccentricity (consistent with 0) which should be born in the wet EMRI formation channel, and 1 mildly eccentric EMRI is consistent with the predictions of both the dry loss-cone formation channel and the Hills mechanism.

3

AT2018fyk: Candidate Tidal Disruption Event by a (Super)Massive Black Hole Binary

Authors: A. I. ZabludoffN[one]; A.J. LevanN[one]; C. LewinN[one]; D. LiN[one]; D.R. PashamN[one]; E. KaraN[one]; N. C. StoneN[one]; Peter JonkerN[one]; T. WeversN[one]; Z. CaoN[one]; sixiang WenN[one]

Corresponding Author: wensx@bao.ac.cn

The tidal disruption event (TDE) AT2018fyk has unusual X-ray, UV, and optical light curves that decay over the first $\sim$600d, rebrighten, and decay again around 1200d. We explain this behavior as a one-off TDE associated with a massive black hole (BH) \emph{binary}. The sharp drop-offs from $t^{-5/3}$ power laws at around 600d naturally arise when one BH interrupts the debris fallback onto the other BH. The BH mass $M_\bullet$ derived from fitting X-ray spectra with a slim disk accretion model and, independently, from fitting the early UV/optical light curves, is smaller by two orders of magnitude than predicted from the $M_\bullet$–σ_* host galaxy relation, suggesting that the debris is accreted onto the \emph{secondary}, with fallback cut off by the primary. Furthermore, if the rebrightening were associated with the primary, it should occur around 5000d, not the observed 1200d.
The secondary's mass and dimensionless spin is $M_{\bullet,\rm s} = 2.7^{+0.5}_{-1.5} \times 10^5 M_\odot$ and $a_{\bullet,\rm s} > 0.3$ (X-ray spectral fitting), while the primary's mass is $M_{\bullet,\rm p} = 10^{7.7\pm0.4} M_\odot$ ($M_\bullet$-σ_* relation). An intermediate mass BH secondary is consistent with the observed UV/optical light curve decay, i.e., the secondary's outer accretion disk is too faint to produce a detectable emission floor. The time of the first accretion cutoff constrains the binary separation to be $(6.7 \pm 1.2) \times 10^{-3}$ pc. X-ray spectral fitting and timing analysis indicate that the hard X-rays arise from a corona above the secondary's disk. The early UV/optical emission, suggesting a super-Eddington phase for the secondary, possibly originates from shocks arising from debris circularization.

Session / 4

Changing-look AGN in the Dark Energy Spectroscopic Instrument

Author: 威坚郭 [1]

[1] 中国科学院国家天文台

Corresponding Author: guowj@bao.ac.cn

Changing-look active galactic nuclei (AGNs), which transition between quasar-like and quiescent states, have become a critical focus in astrophysical research. The Dark Energy Spectroscopic Instrument (DESI) offers an unprecedented opportunity to detect and study these phenomena on a large scale. Utilizing DESI's high-precision spectroscopic data, we have recently identified and analyzed several hundreds changing-look AGNs, offering new insights into their frequency, underlying mechanisms, and connections to their host galaxy environments. I will present the latest findings from DESI on changing-look AGNs and outlines the ongoing follow-up research plans aimed at further understanding these dynamic processes and their broader implications for AGN evolution.

Session / 5

The Double Tidal Disruption Event

Author: Iair Arcavi[1]

[1] *Tel Aviv University*

Corresponding Author: arcavi@gmail.com

AT 2022dbl was a typical optical-UV tidal disruption event (TDE) in a typical TDE host galaxy. Then, 700 days after the first flare, a second, almost identical, flare occurred at the same position. Ruling out lensing and two unrelated events, we conclude that the first flare of AT 2022dbl was a partial disruption. The question remains whether the second flare was a full disruption or another partial one. We will know for sure if we see a third flare in early 2026. However, both options have far reaching implications for our understanding of optical TDEs: Given how typical of the class both flares are, either all optical TDEs are partial disruptions, or some are partial and some are full disruptions, with very little difference in flare characteristics. Either case will require that we re-visit our most basic optical TDE model assumptions.

6

Overlooked supersoft X-ray nuclear transients in the X-ray catalogue

Author: Andrea Sacchi[1]

[1] *Center for Astrophysics | Harvard & Smithsonian*

Corresponding Author: andrea.sacchi@cfa.harvard.edu

Supersoft hyperluminous X-ray sources offer a unique opportunity to study accretion onto supermassive black holes in extreme conditions. Typical supersoft hyperluminous sources are tidal disruption events, quasi-periodic eruptions, changing-look AGN, and other anomalous nuclear transients.
Although these objects are rare phenomena amongst the population of X-ray sources, we developed an efficient algorithm to identify promising candidates exploiting archival observations.
In my talk, I will present the results of a search for supersoft X-ray nuclear transients on the XMM-Newton and recently released Chandra archive of serendipitous X-ray sources. I will also show the potential of a machine-learning-based archival search.

Session / 7

Probing orbits of stellar mass objects deep in galactic nuclei with quasi-periodic eruption

Authors: Cong Zhou[1]; Yuhe Zeng[2]; Zhen Pan[2]

[1] *University of Science and Technology of China*

[2] *TDLI*

Corresponding Author: dysania@mail.ustc.edu.cn

Quasi-periodic eruptions (QPEs) are intense repeating soft X-ray bursts with recurrence times about a few hours to a few weeks from galactic nuclei. Though the origin of QPEs is still an open question, more and more analyses favor the interpretation that QPEs are the result of collisions between a stellar mass object (SMO, a stellar mass black hole or a main sequence star) and an accretion disk around a supermassive black hole (SMBH) in galactic nuclei. If this interpretation is correct, QPEs will be invaluable in probing the orbits of stellar mass objects in the vicinity of SMBHs, and further inferring the formation of extreme mass ratio inspirals (EMRIs). In the previous two papers \cite{Zhou2024a,Zhou2024b}, we adopted assumptions that SMO moves along a geodesic and the accretion disk lies on the equator, and noticed that these assumptions might be violated in the long run. In this paper, we extend the previous works by including secular effects, e.g., the disk alignment of an initially misaligned disk and the SMO orbital decay due to collisions with the disk. We find clear Bayes evidences for these secular effects in several QPE sources, and the detection of these secular effects provides informative clues about the SMO nature, the SMBH spin, the disk structure and evolution.

Session / 8

Sgr A Lobes as a Tidal Disruption Event from the Galactic Center

Author: Fulai Guo[1]

[1] *Shanghai Astronomical Observatory, Chinese Academy of Sciences*

Corresponding Author: fulai@shao.ac.cn

I will present our new work on modeling the 15-parsec-sized Sgr A lobes observed at the Galactic center as the relic of a tidal disruption event occurring about 3500 years ago by the supermassive black hole Sgr A* in our Galaxy. While an increasing number of extragalactic TDEs have been identified in recent years, TDE flares have never been detected from the Galactic center. A TDE flare typically lasts for months or years, but the predicted TDE outflow evolves much longer. Here we perform hydrodynamic simulations to investigate the evolution of TDE outflows in the GC environment, finding that opposing TDE outflows naturally produce bipolar hot lobes with sharp shock-enclosed edges. We show that a pair of TDE jets naturally reproduce the morphology, density, temperature, and X-ray surface brightness distribution of Sgr A lobes observed in X-rays at the GC. The lobe age is derived to be about 3500 yr, consistent with the theoretically-estimated TDE occurrence rate.

Session / 9

New physics out of the shadow

Author: Luca Visinelli[1]

[1] *Shanghai Jiao Tong University*

Corresponding Author: luca.visinelli@sjtu.edu.cn

Horizon-scale images of black holes (BHs) and their shadows have opened an unprecedented window onto tests of gravity and fundamental physics in the strong-field regime. I discuss the prospects for witnessing the presence of new physics out BH imaging, using an array of observables such as the time evolution of the shadow and the photon ring autocorrelation. I focus on the properties of new light scalar and vector fields, which can affect the dynamics of spinning BHs via superradiant instability. This talk is based on 2205.06238 and 2205.07787.

Session / 10

3D GRMHD Simulations of Tilted Disks: Magnetically Driven Retrograde Precession

Authors: Hongxuan Jiang[1]; Yosuke Mizuno[2]; Dong Lai[3]

[1] *Tsung-Dao Lee Institute, Shanghai JiaoTong University*

[2] *TDLI / Shanghai Jiao Tong University*

[3] *TDLI*

Corresponding Author: hongxuan_jiang@sjtu.edu.cn

Accretion disks around black holes are typically thought to be misaligned with the black hole's spin axis due to the random angular momentum of infalling gas. Using 3D general relativistic magnetohydrodynamic (GRMHD) simulations, we investigate the accretion process of tilted disks. Contrary to the conventional understanding that prograde precession is driven by the Lense-Thirring effect, we report, for the first time, magnetically-driven retrograde precession in self-consistent simulations. Our results show that the black hole's rotation aligns the magnetic field configuration with the spin axis, generating a significant vertical magnetic field. We estimate that the vertical magnetic field exerts a stronger torque than the Lense-Thirring torque, leading to retrograde precession. This work provides new insights into the dynamics of magnetized accretion disks around rotating black holes.

11

Testing General Relativity using Binary Black Hole Orbital Frequency Evolution on Time-Frequency plane

Authors: Debtroy Das[1]; Soumen Roy[2]

[1] *Fudan University, Shanghai*

[2] *Nikhef*

Corresponding Author: debtroyd@gmail.com

The orbital evolution of binary black hole (BBH) systems is determined by the component masses and spins of the black holes and the governing gravity theory. General relativity (GR) is the simplest theory of gravity that lays the foundation for successfully explaining the current gravitational wave (GW) observations. We present a method of **stacking up the time-frequency pixel energies through the orbital frequency (OF)** evolution with the flexibility of gradually shifting the OF curve along the frequency axis. The time-frequency spectrogram is obtained using a high-resolution **Synchroextraction method**. We observe a distinct energy peak corresponding to the GW signal's quadrupole mode. If an alternative theory of gravity is considered and the analysis of the BBH orbital evolution is executed following GR, the energy distribution on the time-frequency plane will be significantly different. We propose a **new consistency test** to check whether GR explains the BBH orbital evolution. Finally, through the numerical simulation of beyond-GR theory of gravity

and utilizing the framework of second-generation interferometers, we demonstrate the efficiency of this new method in detecting any possible departure from GR.

Session / **12**

Electromagnetic Flares Associated with Compact Object Mergers in Disks of Active Galactic Nuclei

Author: Hiromichi Tagawa[1]

[1] *Shanghai Astronomical Observatory*

Corresponding Author: htagawa@astr.tohoku.ac.jp

In the disks of active galactic nuclei (AGN), compact objects and stars are thought to be embedded and densely populated. These compact objects are predicted to merge with each other, representing one of the promising channels for stellar-mass black hole (BH) mergers discovered through gravitational waves (GWs). Due to the uncertainties of these processes, it is of great interest to identify signatures of these processes using GWs and/or electromagnetic observations. As a potential signature, we have focused on emissions from post-merger objects. We estimated the properties of breakout and shock cooling emissions from shocks that develop around jets and explosions generated by the merging remnants. We demonstrated that these emissions are typically bright in the optical to gamma-ray bands. We predict that the shock cooling emissions related to jets and explosions are detectable by observing thousands of AGNs with luminosities on the order of ˜10ˆ44-10ˆ45 erg/s and ˜10ˆ42-10ˆ43 erg/s, respectively. We then applied this model to interpret gamma-ray and optical flares that may be associated with GW events. I will present the current understanding and findings on this topic.

Session / **13**

Extreme Resonant Eccentricity Excitation of Stars around Merging Black-Hole Binary

Author: Bin Liu[1]

[1] *Zhejiang University*

Corresponding Author: liubin23@zju.edu.cn

We study the dynamics of a star orbiting a merging black-hole binary (BHB) in a coplanar triple configuration. During the BHB ’ s orbital decay, the system can be driven across the apsidal precession resonance, where the apsidal precession rate of the stellar orbit matches that of the inner BHB. As a result, the system gets captured into a state of resonance advection until the merger of the BHB, leading to extreme eccentricity growth of the stellar orbit. This resonance advection occurs when the inner binary has a nonzero eccentricity and unequal masses. The resonant driving of the stellar eccentricity can significantly alter the hardening rate of the inner BHB and produce observational signatures to uncover the presence of nearby merging or merged BHBs.

Session / **14**

Nuclear Transients from Star-Disk Interactions Near Black Holes

Author: Xiaoshan Huang[1]

[1] *California Institute of Technology*

Corresponding Author: xshuang@caltech.edu

Recently, multiple detections of repeating soft X-ray emissions from quiescent galaxies have suggested a potential new category of nuclear transient events: quasi-periodic eruptions (QPEs). These events are characterized by quasi-regular, large-amplitude X-ray flares detected at around ~100 eV, with typical recurrence times ranging from hours to days, a connection to previous tidal disruption events (TDEs), and a lack of optical/UV counterparts. Several models have been proposed to explain their origin, including a class of models involving a star orbiting near a black hole and interacting with the relic accretion disk.
In this work, we perform two-dimensional multigroup radiation hydrodynamics simulations of a star colliding with an existing disk. We find that the collision is able to produce two plumes of ejecta from both sides of the disk, consistent with theoretical expectations. However, the ejecta are not symmetric in mass and velocity. As the ejecta expand and cool, the quasi-adiabatic cooling emission can potentially be connected to transient flares. The emission, however, is not always thermalized, which is essential to producing the emission in the soft X-ray band. We discuss the importance of capturing the multi-band radiation transfer physics in this problem

15

The Evolution of the X-ray Spectra in Tidal Disruption Events

Author: Wei Chen[1]

[1] 中国科学院国家天文台

Corresponding Author: chenwei@bao.ac.cn

The evolution of the energy spectrum during black hole tidal disruption events (TDEs) is an important approach to studying their physical processes. Many observational sources exhibit a soft X-ray spectrum during the peak of outbursts, which gradually becomes harder over the course of several years. We have developed a model for the coexistence of the disk and corona in an super-Eddington accretion state, explaining the observed radiation of hard X-rays in late-stage TDEs through the inverse Compton scattering of low-energy particles in the corona. In our model, we replace the standard disk in the region dominated by radiation pressure with a slim disk, while the outer region dominated by gas pressure continues to use the standard disk plus strong corona model. As the accretion rate decreases, the corona gradually moves inward, resulting in the observed transition of the X-ray spectrum from soft to hard in TDEs. This behavior is compared with data from sources such as ASASSN-14li, showing good agreement with observations.

Session / 16

Plasmoid merger and shock wave during the magnetic reconnection on the accretion disk of the Sgr A*

Author: TianLe Zhao[1]

[1] *Guangzhou University*

Corresponding Author: tlzhao@gzhu.edu.cn

SgrA* often shows bright, episodic flares observationally, the mechanism of the flares intermittent brightening is not very clear. Many people believe the flares may formed by the non-thermal particles, which can be a consequence of the magnetic reconnection and shock waves. In this work, we use MHD simulation to study the magnetic reconnection process which is on the accretion disk, and show the plasmoid merger and the shock wave during the magnetic reconnection. In our simulations, there are many plasmoids formed due to the magnetic reconnection, and these plasmoids consequently merge many times. It is found that the temperature-dependent diffusivity will cause more frequent merger of the plasmoids. The simulation results also show that the reconnection of magnetic field lines passes through a current sheet, which bifurcates into two pairs of slow shocks. The shock wave heating effect by the magnetic reconnection is confirmed by the simulation results, and thus the process of instantaneous brightening of the flares on the accretion disk can be explained.

Session / **17**

Existence of effectively optically thin accretion flow around black holes

Author: Mingjun Liu[1]

[1] *National Astronomical Observatories, Chinese Academy of Sciences*

Corresponding Author: mjliu@bao.ac.cn

At high accretion rates, the high temperature and low density in the standard thin disk (SSD) suppress the absorption of the radiation, making the innermost region effectively optically thin. In this work, we systematically investigate the effectively optically thin accretion flow through the generalized self-similar solution of the steady axisymmetric, non-relativistic accretion flow. Our results show the existence of the effectively optically thin accretion flow in the range of accretion rates between the SSD regime and the slim disk regime. Due to the inefficient bremsstrahlung by low density, the effectively optically thin accretion flow is heated to a high temperature and cooled by inverse-Compton scattering. Despite being supported by radiation pressure, the advection and the saturated self-Compton scattering help this accretion flow to be thermally stable, whereas the viscosity instability still exists. The feature of the effectively optically thin accretion flow is a Wien bump in the X-ray band. Its intensity and cut-off energy are sensitive to the viscosity parameter, which provides an alternative way to constrain the viscosity parameter via spectral analysis. The effectively optically thin accretion flow would give the natural explanations for the soft X-ray excess in AGNs and the very high state of XRBs. Besides, the radial cooling, bound-free process, and inner boundary conditions are also discussed.

Session / **18**

Binary Stars Approaching Supermassive Black Holes: Tidal Break-up, Double Stellar Disruptions and Stellar Collision

Author: Fangyuan YuN[one]

Co-author: Dong Lai [1]

[1] *TDLI*

Corresponding Author: yufangyuan@sjtu.edu.cn

In galactic centers, stars and binaries can be injected into low-angular-momentum orbits, resulting in close encounters with the central supermassive black hole (SMBH). We use simulations to study such encounters under a wide range of conditions. Depending on the system parameters (such as β_b, the ratio of binary tidal radius to pericenter distance r_p to the SMBH, and the compactness of the binary), such close encounters can lead to the break-up of the binary, disruptions of both stars and collision between the stars. Binary break-up produces a hyper-velocity star and a bound star around the SMBH; the peak value of the orbital binding energy depends weakly on β_b. When

r_p is comparable to the stellar tidal radius, sequential disruptions of the stars occur within a time interval much shorter than the initial binary orbital period. Stellar collisions occur for a range of β_b's, with a few to 10's percent probabilities (depending on the compactness of the binary). The merger remnants are either ejected or bound to the SMBH. We suggest that stellar collisions induced by binary-SMBH encounters may produce exotic stars in galactic centers, trigger accretion flares onto the SMBH due to the mass loss, and result in bound merger remnants causing repeated partial TDEs. We also carried out hydrodynamical simulations on double stellar disruptions and stellar collisions. We explored the mass loss during the collision and calculated the fallback rate onto the SMBH, which could potentially result in light curves distinct from TDE flares.

19

Accretion Disk Formation in Tidal Disruption Event

Author: Xiaoshan Huang[1]

[1] *California Institute of Technology*

Corresponding Author: xshuang@caltech.edu

The tidal disruption of a star by a nearby black hole can trigger transient electromagnetic signals in multiple wavebands, making it a well-recognized class of transient events. Understanding the origin of detected emissions from such tidal disruption events (TDEs) is particularly interesting.

In this work, we discuss the potential radiative emissions from TDEs during the formation of the accretion disk. We follow the dynamic process before the peak fallback rate with 3D radiation-hydrodynamic simulations. We found that for higher mass black holes, the stream-stream collision can drive strong, optically thick outflows, creating a reprocessing layer in the pre-peak time. When the outflow subsides, dissipation initiates gas circularization and accretion disk formation. The photosphere of such pre-peak TDE systems is likely to be anisotropic, either assembled by the optically thick outflow or early circularization gas.

Session / 20

Late-time radio emission of tidal disruption events

Author: Tatsuya MatsumotoN[one]

Corresponding Author: tm@kusastro.kyoto-u.ac.jp

Recent radio observations discovered that a significant fraction of TDEs are accompanied by late-time radio flare ~1000 days after the discovery. One possible origin of the flares is a relativistic jet. By applying a generalized formalizm to analyze radio emissions, I will discuss the possibility that if viewed from off-axis, a powerful jet (as observed in AT2022cmc) can power the late time flares in particular for the rapidly brightening event, AT2018hyz. However, this off-axis model may have a difficulty to explain more slowly evolving and less luminous flares, and other possibilities have been considered such as delayed outflows. I will propose an alternative scenario and discuss its implications.

21

A repeating partial TDE candidate in an narrow-line seyfert 1 galaxy

Author: Jingbo Sun[1]

Co-authors: Hengxiao Guo [1]; Minfeng Gu [1]

[1] *Shanghai Astronomical observatory*

Corresponding Author: jingbogogogo@gmail.com

Thanks to modern time-domain surveys, the process of identifying a tidal disruption event (TDE) gradually develops in the quiescent galaxy and several repeating partial TDEs have been studied. Meanwhile, the TDE in AGN is theoretically predicted to exhibit different observable features from the identified TDEs in quiescent galaxies. To date, a dozen of TDE in AGN candidates and the ambiguous nuclear transients (ANTs) have been well-studied, but it is still challenging to identify the population of TDE in AGN. We report the discovery of a repeating partial TDE candidate in a super-Eddington AGN, AT2021aeuk, which exhibits two similar flares separate with 3 years in a radio-loud narrow-line Seyfert 1 galaxies. After the onset of the second flare, we conducted multi-wavelength and spectral observations, revealing multiple features similar to the TDE in quiescent galaxies, and an extraordinary X-ray evolution which has never occurred in AGN but is similar to the other TDE candidates in AGN, potentially as a distinguishing feature for TDE in AGN. In contrast with the other TDE in AGN candidates and the ANTs, AT2021aeuk is unlikely from the AGN flares as: 1) the accretion rate is already super-Eddington before the outburst, resulting in the small variability from a nearly saturated accretion disk; 2) the light curve of two flares are similar and both are comparable to the TDEs in quiescent galaxies. We also found the relations in the light curve properties of the quiescent TDEs still hold for the TDE in AGN candidates and ANTs. Finally, we put a simple scenario for the potential emission mechanism for the TDE in AGN, which can account for the features observed in AT2021aeuk.

Session / **22**

Particle Acceleration and Multi Messengers from Accreting Black Holes

Author: Jieshuang Wang[1]

[1] *Max Planck Institute for Plasma Physics*

Corresponding Author: jiesh.wang@gmail.com

Accreting black holes are highly dynamic systems, where particles are efficiently accelerated during the complex inflow/outflow processes, producing multi-messenger emissions. In this talk, I will focus on particle acceleration in jets and their corresponding multi-wavelength emissions, while also touching on the potential roles of inner accretion flows and the possible origin of neutrinos. The discussion will center on Fermi-type acceleration mechanisms, such as stochastic shear acceleration and shock acceleration, and their relevance to the jets of radio galaxies like M87 and Centaurus A. Our simulations, using relativistic magnetohydrodynamics and test-particle approaches, demonstrate that jets from supermassive black holes are capable of accelerating ultra-high-energy cosmic rays.

Session / **23**

Unveiling the Cosmic Dance of Repeated Tidal Disruption Event ASASSN-14ko: Insights from Multiwavelength Observations

Author: 石锋黄 [1]

[1] 中国科学技术大学

Corresponding Author: sfhuang999@ustc.edu.cn

ASASSN-14ko is a nuclear transient resulting from the repeated partial tidal disruption event (rpTDE). We conducted high-cadence, multiwavelength observations of this source, revealing several recurrent early bumps and rebrightenings in its UV/optical light curves. The energy released during these bumps and rebrightenings shows a decreasing trend in recent UV/optical outbursts and we monitored the whole process through multiwavelength observations. This unique structure may be attributed to the interaction between stream debris and the expanded disk in the rpTDE. The X-ray light curve exhibits an evolution opposite to that of the UV/optical bands, with periodicities of approximately 54 days and 105 days, respectively. Furthermore, our high-cadence, multiwavelength observations demonstrate that the UV/optical luminosity in each outburst increases with the blackbody temperature and radius, and such evolution resembles that observed in quasi-periodic eruptions, distinguishing it from typical TDEs.

Session / 24

An X-ray view of the ambiguous nuclear transient AT2019pev

Author: Zhefu Yu[1]

Co-authors: Christopher Kochanek [2]; Smita Mathur [2]; Katie Auchettl [3]; Dirk Grupe [4]

[1] *Stanford University*

[2] *The Ohio State University*

[3] *The University of Melbourne*

[4] *Northern Kentucky University*

Corresponding Author: yzfkieran@gmail.com

Active galactic nuclei (AGN) can exhibit drastic changes that differ significantly from the normal stochastic variability, such as changing-look AGN and rapid-turn on events. Transients also occur in quiescent supermassive black hole (SMBH). When it tidally disrupts a passing star, about half of the debris can be accreted to produce a luminous flare in a tidal disruption event (TDE). It is non-trivial to observationally distinguish TDEs from AGN transients. In particular, transient surveys have discovered "ambiguous nuclear transients (ANTs)" that can be classified as neither TDEs nor AGN. Unveiling the nature of these ANTs is critical for understanding of the extreme accretion episodes in SMBHs. I will present an extensive X-ray study with Swift, Chandra and NICER over 173 days for the ambiguous nuclear transient AT2019pev that showed features of both TDEs and AGN. Most X-ray properties of this transient more closely resemble an AGN. However, the X-ray spectra show a "harder-when-brighter" trend before the X-ray lightcurve peak, while the trend is inverted after the peak. This change could indicate a transition of accretion state, which is not commonly observed for both TDEs and AGN.

Session / 25

AT 2022dbl: A spectroscopically confirmed repeated partial TDE

Author: Zheyu LinN[one]

Corresponding Author: linzheyu@mail.ustc.edu.cn

Partial TDE (pTDE) complements the classical full TDE (fTDE) picture, predicted to have higher occurrence rate than fTDE. Although it is still hard to distinguish a pTDE from a fTDE through a single flare, a repeated pTDE can provide multiple flares for a robust identification. In this talk, I will introduce the discovery and follow-up observations of a highly-confident repeated pTDE, AT 2022dbl. Two separate optical/UV flares have been observed in 2022 and early 2024, with no bright X-ray, radio or mid-infrared counterparts. To identify a repeated pTDE, one needs to prove both "TDE

origin" and "only one star is involved." In this event, the TDE origin for both flares is supported by the quiescent galaxy background (SDSS spectrum), the typical TDE photometric features (similar blackbody temperature of ~26,000 K, declining radii after peak, similar rise and decline phases as ZTF TDEs, etc.), as well as the typical TDE-H+He/Bowen features (Broad Balmer, Bowen and possible He II emission lines). To support that only one star is involved in both flares, the similar emission lines in the spectra provide the strongest evidence by now. Given the short orbital period of ˜2 yrs, the rise or absence of the third flare can judge the correctness of this identification. ("The unluckiest star: A spectroscopically confirmed repeated partial tidal disruption event AT 2022dbl" , Lin, Jiang, Wang et al., 2024, ApJL, 971, L26.)

Session / **26**

EMRI+TDE=QPE: Star-Disc Interaction and Quasi-Periodic Eruptions

Author: Itai Linial[1]

[1] *Columbia University/Institute for Advanced Study*

Corresponding Author: itailin@gmail.com

Quasi-periodic eruptions (QPEs) are an emerging class of high amplitude bursts of X-ray radiation, repeating on a hours-day timescale, recently discovered near the central supermassive black holes (SMBHs) of a few low-mass galaxies. I will briefly review our current theoretical understanding of QPEs, and the different classes of proposed theoretical interpretations. I will focus on a scenario involving a main-sequence star repeatedly colliding with an accretion flow onto the SMBH, twice per orbit. I will show how this model naturally reproduces the observed period, luminosity, emission temperature, duration, occurrence rate of QPEs, as well as the possible association between TDEs and QPEs. I will also discuss the implications of the observations and of our model for probing the accretion physics around SMBHs, the rate of extreme mass ratio inspirals (EMRIs) for future space-based gravitational wave detectors, and the discovery prospects of related repeating nuclear transients in light of upcoming UV surveys such as ULTRASAT and UVEX.

Session / **27**

Understanding AGN UV/Optical Variability through Quasi-periodic Large-scale Magnetic Dynamos

Author: Hongzhe Zhou[1]

Co-author: Dong Lai [2]

[1] *Tsung-Dao Lee Institute, Shanghai Jiao Tong University*

[2] *TDLI*

Corresponding Author: hongzhe.zhou@sjtu.edu.cn

The UV/optical light curves observed in active galactic nuclei (AGNs) are well-characterized by damped random walk (DRW) processes, where the damping timescale $\tau_{\rm d}$ shows correlations with both black hole mass ($M_{\rm BH}$) and photon wavelength (λ). However, the underlying physical mechanisms behind these scaling laws remain uncertain. We aim to understand the variability induced by a quasi-periodic large-scale dynamo in an accretion disk, and examine whether it reproduces the observed variability features in AGN UV/optical light curves. Using a one-dimensional, optically thick, geometrically thin disk model, we introduce variability into the viscosity parameter α by incorporating quasi-periodic large-scale magnetic fields. We calculate the power spectral densities (PSDs) of the accretion rates and disk thermal emission, and fit for their damping time scales.

The disk and dynamo parameters are adjusted to explore how $\tau_{\rm d}$ scales with them. With reasonable dynamo parameters, our model successfully reproduces both the linear rms-flux relation and the log-normal distribution of flux variability. The PSDs of accretion rates and fluxes align well with DRW models, and yield consistent values for $\tau_{\rm d}$ at 2500 angstrom with observations. Analytical arguments, supported by numerical evidence, suggest that the flattening of flux PSDs at low frequencies is governed by the timescale at the inner boundary of the emission region for a fixed wavelength. For $M_{\rm BH} > 10^6 M_{\odot}$, variations in the Eddington ratio $\eta_{\rm Edd}$ flatten the $\tau_{\rm d}$-$M_{\rm BH}$ scaling, resulting in $\tau_{\rm d} \propto M_{\rm BH}^{0.5-1}$. For smaller black hole masses ($M_{\rm BH} < 10^6 M_{\odot}$), we find a steeper scaling, $\tau_{\rm d} \propto M_{\rm BH}$. Including further refinements, such as the dependence of dynamo properties on $M_{\rm BH}$ and AGN luminosity, and accounting for X-ray reprocessing, would further enhance the accuracy of the model.

Session / 28

Early Discovery of TDE Candidates by the Einstein Probe Mission

Author: Chichuan Jin[1]

[1] *National Astronomical Observatories, Chinese Academy of Sciences*

Corresponding Author: ccjin@bao.ac.cn

The Einstein Probe (EP) is a newly launched space mission dedicated to the X-ray all-sky survey and characterization of all kinds of high-energy transients. During the first few months of in-orbit operation, EP has discovered dozens of new X-ray transients with intriguing properties. In this talk, I will present a few typical examples of TDE candidates discovered by EP since its launch, including the first case of TDE spectroscopically confirmed to be located in the outskirts of a galaxy. Its rising, peak, plateau and decay phases have all been observed, supporting it in hosting an IMBH of tens of thousands of solar masses. Then I will introduce some puzzling TDE candidates discovered by EP, which are still being monitored and under investigation. Finally, I will provide some prospects for future discoveries and joint observations of EP with other facilities on TDE sciences.

Session / 29

Optical and Infrared Hunt for Tidal Disruption Events

Author: Ning Jiang[1]

[1] *USTC*

Corresponding Author: jnac@ustc.edu.cn

The discovery of tidal disruption events (TDEs) has experienced great progresses in the past decade thanks to modern wide-field time-domain surveys. I will first review the current search of TDEs in the optical band. Then I will present our systematic search for TDEs using the novel dust infrared echoes (MIRONG project), which have revealed a large sample of dusty TDE candidates missed by optical (and also X-ray) surveys. Then I will briefly introduce a new TDE hunter 2.5-meter Wide Field Survey Telescope, its prospects for TDE science and our recent progresses.

Session / 30

The Einstein Probe mission: status and preliminary detection results

Author: Weimin Yuan[1]

[1] *National Astronomical Observatories, CAS*

Corresponding Author: wmy@nao.cas.cn

The Einstein Probe (EP) is a space X-ray observatory designed to detect mainly high-energy transient and variable sources in the universe. It features a lobster-eye wide-field X-ray monitor with unprecedented sensitivity and spatial resolution in the soft X-ray band, and a conventional X-ray telescope to perform quick onboard follow-up observations. The Einstein Probe is a project led by the Chinese Academy of Sciences in collaboration with ESA, MPE and CNES. EP was launched on January 9, 2024. Till July, the satellite has completed the commissioning and in-orbit calibrations. Since then, EP has started the nominal science operations. This talk will present the mission, the instrument performance and some preliminary science results of the transient and variable sources detected. The scientific potential of EP in the context of time-domain astrophysics will be briefly discussed.

Session / **31**

Dynamical Formation of BH Binaries in AGN Accretion Disks

Author: Jiaru Li[1]

Co-authors: Adam Dempsey [2]; Dong Lai [3]; Hui Li [2]; Kecheng Qian [4]; Laetitia Rodet [4]; Shengtai Li [2]

[1] *CIERA - Northwestern University*

[2] *Los Alamos National Laboratory*

[3] *TDLI*

[4] *Cornell University*

Corresponding Author: jiaru.li@northwestern.edu

Mergers of black hole (BH) binaries embedded in the active galactic nucleus (AGN) accretion disks have recently received significant attention as an interesting type of gravitational wave (GW) source. Studying the formation processes of these binaries allows us to better understand the rate and the observational properties of their mergers. In this talk, I will present our work on the mechanisms of forming tightly bound BH binaries in AGN disks via close encounters between two single BHs. In particular, using a series of high-resolution 2D global hydrodynamical simulations, we demonstrate that binaries can be formed by the collisions of the BHs' gaseous minidisks. The majority of the binaries assembled in this scenario have retrograde rotations (i.e., the relative angular momentum of BHs in a binary is anti-aligned to the angular momentum of the AGN disk). Several recent studies have shown that, after formation, these retrograde binaries are expected to shrink a few times faster than their prograde counterparts and may undergo eccentricity excitation. Our results can be combined with these studies to illustrate a pathway to form high-mass, eccentric, and possibly negative-effective-spin GW events.

Session / **32**

Stellar Black Holes Can "Stretch" Supermassive Black Hole Accretion Disks

Author: Shuying Zhou[1]

[1] *Xiamen University*

Corresponding Author: zhoushuying@stu.xmu.edu.cn

Stellar black holes (sBHs) are widely believed to exist in the accretion disks of active galactic nuclei (AGNs). Previous studies often focus on the transient emission produced by embedded sBHs. Here, we explore the possible observational consequences of an AGN accretion disk that contains a population of accreting sBHs. Embedded accreting sBHs change the effective temperature distribution of the AGN accretion disk by heating gas in the outer regions. Two possible observational consequences are presented. First, the spectral energy distribution has a turnover feature at ~4700 Å when the supermassive black hole mass is ~108 Me, which can help explain the observed shallow spectral shape at wavelengths >5000 Å for the Sloan Digital Sky Survey quasar composite spectrum. Second, the half-light radius of a given relatively long wavelength is significantly larger than for an AGN disk without sBHs, which can be tested by microlensing observations. With appropriate sBH distributions, the model can be reconciled with quasar microlensing disk sizes. We propose that the half-light radius–wavelength relation can be utilized to investigate the distributions of embedded sBHs in AGN accretion disks.

Session / 33

Electromagnetic Signatures from Irradiated Circumbinary Disks in Binary Black Hole Systems

Author: Kimitake Hayasaki[1]

[1] *Chungbuk National University*

Corresponding Author: kimi.hayasaki@gmail.com

Recent gravitational wave observations have detected several tens of mergers between stellar mass and likely intermediate-mass black holes (BHs). However, no clear observational evidence has yet been found for electromagnetic (EM) signals associated with such BH mergers or binary BHs. If a dense gas surrounds binary BHs, a circumbinary disk (CBD) can be formed. In such a case, the system consists of two mini-accretion disks around the secondary and primary BHs, respectively, with a CBD surrounding them, which serves as an EM emitter. In particular, the two mini-disks act as point-like UV/X-ray sources, irradiating the surface of the CBD. In this talk, we demonstrate how this irradiation affects the CBD spectrum and how the resulting irradiated CBD spectrum differs from the case of a single black hole. We also discuss the observational implications and the potential application of our model to supermassive BH binary systems.

Session / 34

Unveiling accretion flows around our galaxy's supermassive black hole

Author: Indu Kalpa Dihingia[1]

[1] *TDLI-SJTU*

Corresponding Author: ikd4638@sjtu.edu.cn

There are ample ambiguities in the theoretical modeling of accretion flow around Sgr A.*The theory and observations can not confirm the nature of the accretion flow around the central supermassive black hole. In this talk, we investigate the possible application of low-angular momentum flow for the same. We focus on the role of angular momentum in determining the properties of accretion flows around Kerr black holes. Utilizing numerical simulations employing general relativistic magnetohydrodynamics (GRMHD), we explore how different angular momentum profiles influence the flow dynamics. Finally, we propose that intermediate angular momentum flows offer some insights into the complexities observed* *in the supermassive black hole Sgr A*, which requires more study. We also discuss other accretion possibilities around Sgr A* and compare them together.

Session / **35**

An accretion disk with magnetic outflows triggered by a TDE in CLAGN 1ES 1927+654

Author: Xinwu Cao[1]

[1] *Zhejiang University*

Corresponding Author: xwcao@zju.edu.cn

The CLAGN 1ES 1927+654 was known as a type 2 Seyfert galaxy, which exhibited drastic variability recently in ultraviolet (UV)/optical and X-ray bands. An UV/optical outburst was observed in the end of 2017, and it reached the peak luminosity ~50 d later. The high-cadence observations showed a rapid X-ray flux decline with complete disappearance of the power-law hard X-ray component when the soft X-ray thermal emission reached its lowest level about 150 d after the UV/optical peak. The power-law X-ray component reappeared with thermal X-ray emission brightening from its lowest flux within next ~100 d. We propose a magnetic disk-outflow model to explain the observational features of this source. We assume an episodic accretion event taking place in the outer region of the disk surrounding a central black hole (BH), which is probably due to a red giant star tidally disrupted by the BH. The inner thin disk with corona is completely swept by the TDE disk when the gas reaches the innermost circular stable orbit. The field threading the disrupted star is dragged inwards by the TDE disk, which accelerates outflows from the disk. The disk dimmed since a large fraction of the energy released in the disk is tapped into the outflows. The accretion rate of the TDE disk declines with time, and ultimately, it turns out to be a thin disc, which is inefficient for field advection, and the outflows are switched off. A thin disc with corona reappears later several hundred days after the outburst.

Session / **36**

Probing AGN Inner Structures Near and Far: Insights from Infrared Interferometry

Author: Jinyi Shangguan[1]

[1] *Peking University*

Corresponding Author: shangguan@pku.edu.cn

The inner structures of active galactic nuclei (AGNs) are essential for probing the fundamental parameters of the central supermassive black hole (BH), understanding accretion physics, and investigating the physical connection between the BH and its host galaxy. The reverberation mapping (RM) technique has been widely used to study the broad-line region (BLR), the dust torus, the accretion disk, and the corona in AGNs through coordinated campaigns. These observations have confirmed our basic understanding of AGN inner regions. Recent IR interferometry has enabled spatially resolved observations of the BLR and surrounding hot dust emission. The GRAVITY instrument on the Very Large Telescope Interferometer, combining four 8-meter Unit Telescopes, provides two-dimensional spatial resolution, which is highly effective for inferring BLR structure and dynamics, as well as efficiently measuring BH masses. The combination of RM and interferometry offers a powerful diagnostic tool for detailed investigations of the BLR structure and for determining the geometric distance to the BLR. Mid- and near-IR observations of AGN continua offer new insights into the structure and composition of hot dust, which are closely linked to the BLR. In this talk, I will provide an overview of AGN nuclear structures, focusing on recent results from IR interferometry and its synergy with RM observations. I will conclude with new high-redshift quasar observations made

possible by the ongoing GRAVITY+ instrument upgrade, and discuss the potential for addressing key questions about BH accretion and coevolution in the future.

Session / 37

Modeling the light curve of rebrightening tidal disruption event

Author: Shiyan Zhong[1]

[1] *South-Western Institute For Astronomy Research, Yunnan University*

Corresponding Author: zhongsy@ynu.edu.cn

In recent years, a class of tidal disruption events (TDEs) with special light curves has been observed: during the luminosity decline phase, they will brighten again and produce a second peak. The interval between the two peaks is only a few hundred days, and the flux of the second peak may become higher or lower than the first peak. There are many models for this phenomenon in the literature, one of which is that it is due to the same star experiencing two partial disruptions (partial TDE). If we simply apply the existing fitting software to this type of light curve, the following problems will arise: (1) Both peaks need to be fitted separately, and it is not possible to process the contribution of the first peak's decline phase to the second peak; (2) The star is on a parabolic orbit, and even if it is not completely destroyed, a second TDE will not occur. We try to address these two issues and construct a new light curve model, as well as develop corresponding fitting code. We have applied this fitting code to a few TDEs with re-brightening features. Finally, we will briefly discuss other applications of our model.

Session / 38

Probing Astrophysical Environments of Massive Black Holes with Extreme Mass-Ratio Inspirals

Author: Huan Yang[1]

[1] *Tsinghua University*

Corresponding Author: hyangdoa@tsinghua.edu.cn

In this talk, I will discuss the unprecedented science opportunities to probe astrophysical environments of galactic-centre massive black holes by observing extreme mass-ratio insprirals with gravitational waves and electromagnetic counterparts. Possible measurements target both direct modification of the gravitational waveform due to the environment and indirect change of system parameters (mass, spin, eccentricity) through environmental couplings. I will discuss a few examples that have been studied in recent years and highlight future promises.

Session / 39

Origin of TDE and evolution of QPEs in GSN 069

Author: Di WangNone

Corresponding Author: wangdi@nju.edu.cn

The tidal disruption event(TDE) in GSN 069 is associated with X-ray quasi-periodic eruptions(QPEs) and re-brightened about 10 years after the first flare. The QPEs is probably produced by the mass transfer of a star in a high eccentric orbit around a central supermassive black hole(SMBH), which is captured by SMBH from a binary by the Hills mechanism. In this scenario, the TDE cannot be explained by the disruption of a single star because the timescales of the QPEs are much smaller than the characteristic timescales of the TDE. I will talk about that the tidal disruption of a common envelope can naturally explain the timescale issue, and it also explains the second flare. And I will also talk about the possibility that drag of the disk can stabilise mass transfer to explain the contradiction between the unstable mass transfer predicted by previous theories and observations.

Session / 40

Physical processes around a black hole driven by magnetic reconnection

Author: 峰袁 [1]

[1] 复旦大学

Corresponding Author: fyuan@fudan.edu.cn

In this talk, I will introduce our two recent works. One is the formation and radiation of jet, another is the flares of black holes. The common key physical processe behind them is magnetic reconnection. In the first work, taking the M87 jet as an example, we shown that the well-known BZ model of jet formation, which is a purely dynamical model, can explain various observations of jet, especially the morphology of the jet such as the elongated structure, the limb-brightening feature, and teh jet width as a function of distance, if we assume that the nonthermal elecrons in the jet are accelerated by magnetic reconnection. In the second work, we try to explain the flares of Sgr A* observed by GRAVITY. We find from GRMHD numerical simulation of accretion flow that flux ropes can be formed above the accretion flow due to magnetic reconnection and the formed flux ropes will be further ejected. Electrons will be accelerated by the reconnection and produce flares. The predicted light curve of the flare and the trajectory of the hope spot are found to be well consistent with those observed by GRAVITY.

Session / 41

Flares in Sgr A* from GRMHD simulations

Author: Yosuke Mizuno[1]

Co-authors: Hongxuan Jiang [2]; Indu Kalpa Dihingia [3]

[1] *TDLI / Shanghai Jiao Tong University*

[2] *Tsung-Dao Lee Institute, Shanghai JiaoTong University*

[3] *TDLI-SJTU*

Corresponding Author: mizuno@sjtu.edu.cn

Sgr A* exhibits flares at various wavelengths, but their origin remains unclear. Magnetic flux rope eruption from the black hole is one of the possible candidates for explaining the observed Sgr A* flares. Based on new 3D GRMHD simulations of magnetized accretion flows, we investigate the dynamics of magnetic flux ropes ejected from the vicinity of the black hole. We found the formation of magnetic flux ropes strongly depends on the size of the magnetic loops. We also calculate the emissions from the magnetic flux ropes. From the non-thermal emission models, we can reproduce the observation of near-infrared flares and time delay.

Session / 42

Modeling the inner part of the jet in M87: Confronting jet morphology with theory

Author: Hai Yang[1]

[1] *TDLI*

Corresponding Author: hai-yang@sjtu.edu.cn

The formation of jets in black hole accretion systems is a long-standing problem. It has been proposed that a jet can be formed by extracting the rotation energy of the black hole ("BZ-jet") or the accretion flow ("disk-jet"). While both models can produce collimated relativistic outflows, neither has successfully explained the observed jet morphology. By using general relativistic magnetohydrodynamic simulations and considering nonthermal electrons accelerated by magnetic reconnection that is likely driven by magnetic eruption in the underlying accretion flow, we obtain images by radiative transfer calculations and compared them to millimeter observations of the jet in M87. We find that the BZ-jet originating from a magnetically arrested disk around a high-spin black hole can well reproduce the jet morphology, including its width and limb-brightening feature.

Session / 43

The near-pericenter self-intersection of the debris stream in TDEs by a misaligned Kerr black hole

Author: Rong-Feng Shen[1]

Co-author: Yan Song [2]

[1] *Sun Yat-Sen University*

[2] *Sun Yat-sen University*

Corresponding Author: shenrf3@mail.sysu.edu.cn

In TDEs, the stream-stream collision is an important way to dissipate orbital energy in the process of circularizing the debris stream. For non-rotating black holes (BHs), due to the apsidal precession the stream intersects with itself near the its orbital apocenter after a single winding. However, for rotating BHs, the out-of-plane precession arising from the Lense-Thirring effect may prevent the above apocenter intersection, and the stream will instead continue to fall back to pericenter and may self intersect near the pericenter.

We perform local 3-D hydrodynamic simulations of the stream self-intersections near pericenter with Athena++, with the BH's gravity included. The stream components that intersect at the pericenter have a width difference and a vertical offset, thus a large fraction of the stream can avoid the collision. For a BH mass of $10^6 M_\odot$ and a orbital penetration factor of 3 and in the case of offset collision where only 14% of the stream collides, we find that 0.5% of the stream kinetic energy is dissipated. After the collision, the stream experiences a lateral expansion, which makes its width to increase with radius more quickly than the case without a pericenter intersection. Our results suggest that for Kerr-BH TDEs which people once thought to have a delayed circularization, the stream intersection at the pericenter is likely to promote collisions in subsequent orbits and accelerate the disc formation.

Session / 44

X-ray reflection from slim accretion disks

Author: Swarnim Shashank[1]

[1] *Fudan University*

Corresponding Author: swarrnim@gmail.com

With newer and more precise observations of super-Eddington systems, it has become increasingly important to model the spectral emissions from slim accretion disks. However, X-ray reflection from such sources has not been thoroughly explored. REFLUX is a newly developed relativistic disk reflection model specifically tailored for super-Eddington systems. The model incorporates a slim disk geometry, where the disk thickness varies with radius and accretion rate. This geometry alters the reflection spectrum, which could be seen from its effect on Fe K emission line profiles. REFLUX is designed to work within XSPEC, making it suitable for fitting relativistic reflection features from sources expected to have slim disk geometry, such as super-Eddington X-ray binaries, tidal disruption events, and active galactic nuclei.

Session / 45

Detecting and characterizing the X-ray quasi-periodicity from candidate IMBH TDEs

Author: Xinwen Shu[1]

Co-author: Wenjie Zhang [2]

[1] *Anhui Normal University*

[2] *NAOC*

Corresponding Author: xwshu@ahnu.edu.cn

It is still in dispute the existence of intermediate-mass black holes (IMBHs) with a mass of ˜10ˆ3-10ˆ5 solar masses (Msun) which are the missing link between stellar-mass black holes (5-50 Msun) and supermassive black holes (10ˆ6-10ˆ10Msun). Many candidates have been proposed including the black holes in dwarf galaxies, globular clusters, and hyperluminous off-nuclear X-ray sources. Until recently, the bright flares from tidal disruption events (TDEs) provide a new and direct way to probe IMBHs. In this talk, we will report our search for the X-ray quasi-periodicity oscillation signal from IMBH TDEs, and the discovery of a transient X-ray QPO with a period of ˜85 second (at a significance of >3.5 sigma). Combining with the results from X-ray continuum fittings, the detection of QPO allows for joint constraints on the black hole mass and dimensionless spin in the range [9.9*10ˆ3-1.6*10ˆ4Msun] and [0.26-0.36], respectively. This result supports the presence of an IMBH with a low spin, and may open up the possibility of studying IMBHs through X-ray timing of TDEs, such as EP.

Session / 46

Systematic search and monitoring of X-ray flares from galactic nuclei by Einstein Probe

Authors: Dongyue Li[1]; Weimin Yuan[2]; Chichuan JinN[one]

[1] *NAOC*

[2] *National Astronomical Observatories, CAS*

Corresponding Author: dyli@nao.cas.cn

Eintein Probe (EP) mission is a space X-ray observatory to monitor the soft X-ray sky with X-ray follow-up capability, and was lauched on January 9, 2024. It carried out a series of performance verification and calibration observation after launch and had begun scienfic observations since late July. Its main scientific objectives include monitoring of the known X-ray sources, like XRBs, AGNs, and discovering new or rare type of X-ray transients, particularly tidal disruption events (TDEs). By September, EP-WXT has detected more than 1000 known AGNs, of which about 10% of them show high variabilities. Besides, EP-WXT has discovered several TDE candidates in daily observations. Apart from searching the X-ray flares from galactic nucleus with EP-WXT, EP-FXT has carried out monitoring of some carefully selected changing-look AGNs and previously known TDEs. In this talk, we will brifely introduce the preliminary results of EP's systematic search and monitoring of AGNs and TDEs, and some preculiar long-term transients discovered by EP.

Session / 47

Quasi-periodic X-ray eruptions years after a nearby tidal disruption event

Author: Matt Nicholl[1]

[1] *Queen's University Belfast*

Corresponding Author: matt.nicholl@qub.ac.uk

Quasi-periodic Eruptions (QPEs) are luminous bursts of soft X-rays from the nuclei of galaxies, repeating on timescales of hours to weeks. The mechanism behind these rare systems is uncertain, but most theories involve accretion disks around supermassive black holes (SMBHs), undergoing instabilities or interacting with a stellar object in a close orbit. It has been suggested that this disk could be created when the SMBH disrupts a passing star, implying that many QPEs should be preceded by observable tidal disruption events (TDEs). Two known QPE sources show long-term decays in quiescent luminosity consistent with TDEs, and two observed TDEs have exhibited X-ray flares consistent with individual eruptions. TDEs and QPEs also occur preferentially in similar galaxies. However, no confirmed repeating QPEs have been associated with a spectroscopically confirmed TDE or an optical TDE observed at peak brightness. In this talk I will show the detection of nine X-ray QPEs with a mean recurrence time of approximately 48 hours from AT2019qiz, a nearby and extensively studied optically-selected TDE. We detect and model the X-ray, ultraviolet and optical emission from the accretion disk, and show that an orbiting body colliding with this disk provides a plausible explanation for the QPEs.

Session / 48

Triple Flares of AT 2021aeuk within Five Years from the Active Galaxy SDSS J161259.83+421940.3

Authors: Dong-Wei Bao[1]; Wei-Jian Guo[1]

[1] *National Astronomical Observatory, Chinese Academy of Sciences*

Corresponding Author: sgkmndks@gmail.com

We present a noteworthy transient AT 2021aeuk exhibiting three distinct optical flares between 2018 and 2023. It is hosted in a narrow-line Seyfert 1 galaxy. One of the flares exhibits rapid rises, and long-term decays over 1000 days. We applied quantitative analysis with light curve fitting and blackbody fitting, which cannot confidently clarify the origin of triple flares. The flares could potentially be attributed to tidal disruption events, superluminous supernovae-II, or enhanced accretion processes within the host galaxy. The unusually high occurrence of three flares within five years may also induced by the complex local environment.

Session / 49

Tidal Disruption Events in AGN

Author: Yihan Wang[1]

Co-authors: Bing Zhang [1]; Douglas Lin [2]; Zhaohuan Zhu [1]

[1] *University of Nevada, Las Vegas*

[2] *University of California, Santa Cruz*

Corresponding Author: yihan.wang@unlv.edu

Tidal Disruption Events (TDEs) in Active Galactic Nuclei (AGN) exhibit distinct observational signatures compared to those in quiescent galaxies, attributed to the denser disruption environments within the accretion disk. Additionally, detecting these events poses challenges due to the luminous background emissions from AGNs. Consequently, TDEs in AGNs have been historically overlooked, with AGNs often excluded from TDE surveys. In this talk, I will demonstrate that the rate of TDEs in AGNs can be orders of magnitude higher than in quiescent galaxies, driven by star-disk interactions. This increased frequency of TDEs in AGNs may significantly contribute to AGN activities. I will argue for the importance of including AGNs in future TDE surveys, emphasizing their potential to unveil critical insights into galactic dynamics and evolution.

Session / 50

The TDE/EMEI/stellar distribution by considering the interaction of stellar objects with AGN disk

Author: Qingwen Wu[1]

[1] *Huazhong University of Science and Technology*

Corresponding Author: qwwu@hust.edu.cn

Many stars and stellar compact objects exist in the nuclear region of galaxies. The stellar dynamics and related TDEs/EMRIs are strongly affected by the central SMBH activities (or appearance or disappearance of accretion disk). I will present the evolution of TDE rate considering the evolution from quiescent to active galaxies, which can roughly explain why the TDEs are preferred to be found in green Vally galaxies. I will also present the dynamic evolution of stars in the nuclear region of Milky Way by assuming Sgr A* may active a million years ago, which can well explain the spatial distribution of nuclear stars, the distribution of inclinations and eccentricities etc. The metallicity enrichments and EMRI GW background will also be discussed considering possible evolution of nuclear stars and stellar BHs.

Session / 51

New Surprises from Radio Observations of TDE Outflows

Author: Kate Alexander[1]

[1] *University of Arizona*

Corresponding Author: kdalexander@arizona.edu

Within the past decade, it has become clear that tidal disruption events (TDEs) can power a variety of jets and outflows, cementing their status as premier probes of accretion processes in supermassive

black holes (SMBHs). Radio observations have been central to characterizing the properties of outflowing material from TDEs, as they reveal synchrotron radiation produced in the shock formed between fast-moving outflows and the ambient interstellar medium. Sustained radio monitoring thus allows us to (1) determine the properties of outflowing material (energy, size, expansion velocity) and (2) trace the ambient density profile around previously-dormant SMBHs on scales of a few light years. In this talk, I will discuss exciting recent radio observations of TDEs. For the past three years, we have been carrying out a large observing program on the Very Large Array to characterize the full diversity of radio emission in TDEs in the local Universe. I will present an update on the status of the program and reveal some of the new surprises we have uncovered, including radio (re)brightenings that can occur years post-disruption. It is clear that TDEs display an even wider diversity of radio behaviors than previously realized, which may ultimately provide new insights into the complex physics governing these extreme transients. The increased sample size now being realized by new wide-field multi-wavelength (and multi-messenger) surveys will shed further light on the physical conditions required for jet and outflow formation in TDEs.

Session / 52

Infrared Observations of the Galactic Center Black Hole

Author: Frank Eisenhauer[1]

[1] *Max Planck Institute for extraterrestrial Physics*

Corresponding Author: eisenhau@mpe.mpg.de

The Galactic Center harbors the nearest massive black hole. With a distance of only 8 kpc, it is the closest laboratory to study the astrophysical processes at work in these extreme objects, and to probe Einstein's general theory of relativity in the regime of strong gravity. Our presentation gives an overview of adaptive optics and GRAVITY infrared interferometry observations of stellar orbits, the detection of the gravitational redshift and the Schwarzschild precession in the orbit of a star, and the observations of orbital motion of hot gas close to the innermost stable orbit. So far all observations are fully described by the laws of general relativity and the motion around a single black hole. We give upper limits on the deviation from general relativity, the extended mass, and the mass of potential intermediate mass black holes. The observed motion and polarization loops during a flare are explained by a magnetically dominated accretion and suggest that the accretion flow is fueled by the winds of nearby, young, massive stars. We end our presentation with an outlook on future measurements of the spin and quadrupole of the black hole by combining infrared interferometry and spectroscopy form extremely large telescopes, which will then also test the cosmic censorship and no hair theorem of black holes.

Session / 53

Accretion onto Supermassive Binary Black Holes

Author: Dong Lai[1]

[1] *TDLI*

Corresponding Author: donglai@sjtu.edu.cn

Circumbinary disks are expected to exist around supermassive black-hole binaries as a consequence of accretion from the interstellar medium following galaxy mergers. I will discuss recent works on numerical modeling of circumbinary accretion, focusing short-term and long-term variabilities, and angular momentum transfer between the disk and the binary – the result suggests that the long-standing notion of binary orbital decay driven by circumbinary

disk may not always hold. I will also discuss the dynamics of stellar-mass black-hole binaries embedded in AGN disks.

54

lunch

Session / 55

Multi-Scale Wind-Fed Accretion Onto Sagittarius A*

Author: Sean Ressler[1]

[1] *Canadian Institute for Theoretical Astrophysics*

Corresponding Author: seanmressler@gmail.com

Sagittarius A*(Sgr A*), the supermassive black hole in the Galactic Center is of significant interest to the astrophysical community as a natural laboratory due to its proximity and relatively high angular resolution in the sky. This is true now more than ever given the exciting recent results from the Event Horizon Telescope and the GRAVITY interferometer. Our understanding of Sgr A*has been greatly aided by the hundreds, if not thousands of general relativistic simulations with which it has been modeled. Yet there still remain many open questions. One way to make progress is to connect horizon-scale observations to Bondi-scale observations using nested, multi-scale simulations. These simulations take into account observationally-motivated feeding of Sgr A* from nearby stellar winds and extend over 6 orders of magnitude in radius. Despite having relatively few free parameters, the simulations that I will present can match reasonably well several independent observational probes. These new results can provide insight into tilted accretion disks/jets, jet propagation, the rotation measure of Sgr A*, and more.

Session / 56

TDEs and other variable phenomena in galactic nuclei

Author: Shaoming Hu[1]

[1] *Shandong University*

Corresponding Author: husm@sdu.edu.cn

How to seperate the variability by TDE from others is important? We need to understand the variability in the nuclie better. We investigate the underlying stochastic processes driving the multi-wavelength variability of the blazar BL Lacertae over the past two decades by comprehensive multi-band data set including Fermi-LAT (γ-ray), Swift-XRT (X-ray), Swift-UVOT (ultraviolet), and the MOJAVE program (radio), as well as optical data including observations from Weihai Observatory over 224 nights. The results reveal that the power spectral slopes of intra-night variability(INV) follow a Gaussian distribution, ranging from approximately 0.4 to 2.6, with an average trend consistent with the long-term variability (LTV) power spectrum. Using power spectral analysis methods, such as the classical periodogram and the Lomb-Scargle periodogram (LSP), in combination with modeling techniques like PSRESP, multiple fragments variance function (MFVF), and continuous-time autoregressive moving average (CARMA), we examine the multi-band power spectral density (PSD) characteristics across a wide range of timescales (~7 dex). The results demonstrate that, at lower frequencies, the PSD across different bands shows remarkable consistency, suggesting that these variations may be driven by a common stochastic process linked to the accretion disk. However,

significant discrepancies arise at higher frequencies, indicating the presence of multiple stochastic processes. We propose that the variability is governed by at least two distinct processes: one related to disk stochastic processes (DSP), dominating the long-term variability, and another associated with jet stochastic processes (JSP), which may result from turbulence, particle acceleration, and shock interactions within the jet, and drive the short-term, high-frequency variations. These findings provide unique insights into the complex mechanisms underlying blazar variability and suggest an intrinsic connection between the accretion disk and jet dynamics.

Session / 57

TDE theory

Session / 58

Satellite black holes around supermassive black hole of active galactic nuclei

Massive stars formed in the self-gravitating regions of accretion disks remain stellar-mass black holes in active galactic nuclei forming a special population of black holes as satellites. In this presentation, I would talk about the observational consequences of these black holes.

Session / 59

Enhenced TDE in post star-burst galaxies

Session / 60

Supermassive binary black holes and the astrophysical origin of the nHz gravitational-wave background

Corresponding Author: yuqj@pku.edu.cn

Session / 61

gravitational lensing of supermassive binary black holes and their gravitational wave radiation

Corresponding Author: luyj@nao.cas.cn

Session / 62

Dynamical processes in galactic nuclei