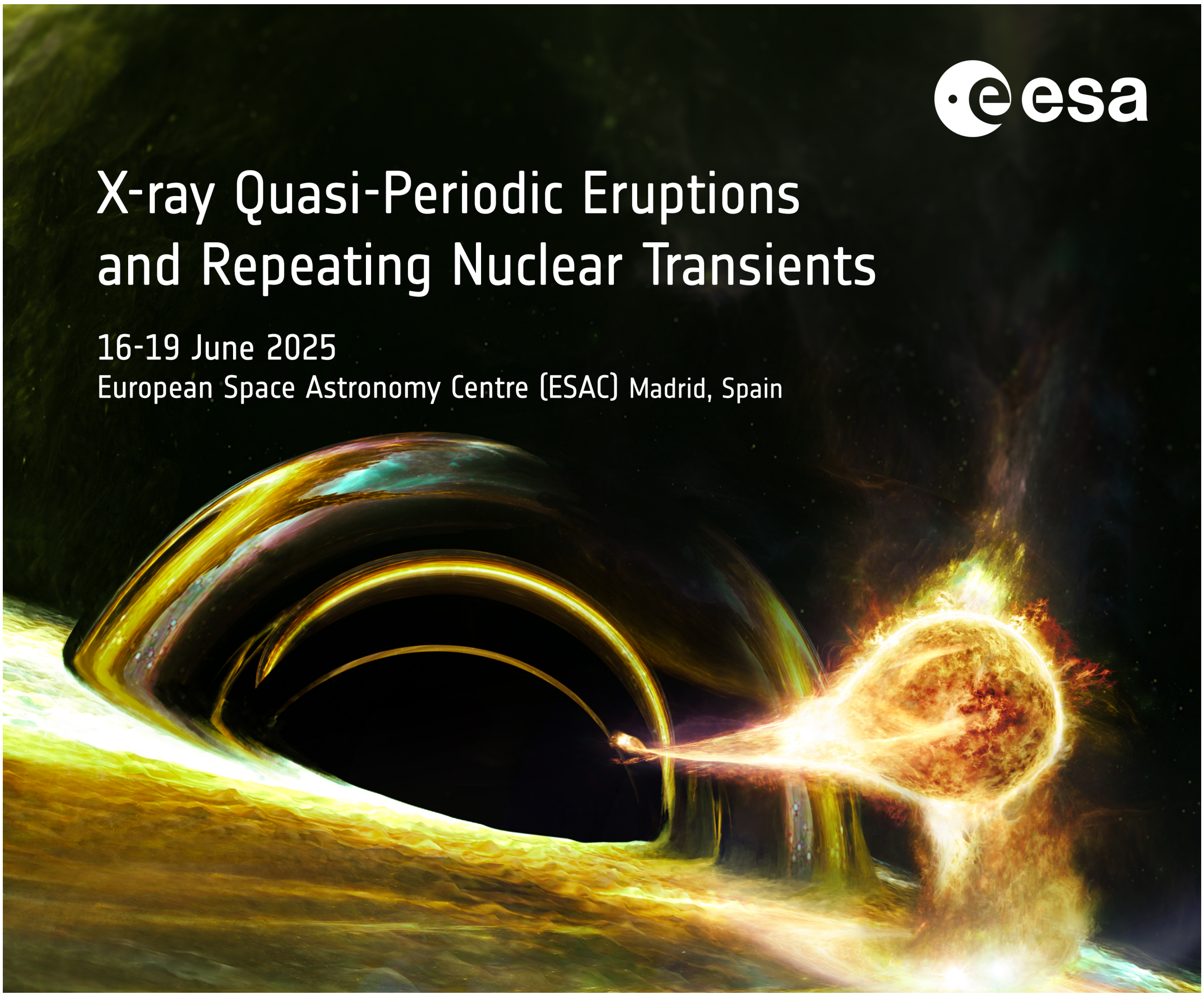

Scientific Programme and Abstracts

➡️ Monday 16 June
- 10:00 - 18:00

➡️ Tuesday 17 June
- 09:30 - 18:00
- 18:15 - 19:45 cocktail

➡️ Wednesday 18 June
- 09:30 - 18:00

➡️ Thursday 19 June
- 09:30 - 18:00

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Monday 16 June

09:15-09:45	Badge pick-up and coffee	
09:45-10:00	LOC announcements	
10:00-11:00	**Chair: TBD**	
10:00-10:30	**Iair Arcavi** - An observational Overview of TDEs, repeating TDEs, and Other Nuclear Transients	➡️
10:30-11:00	**Eric Coughlin** - TDEs, Partial TDEs, and Repeating Partial TDEs – Current Understanding, Open Questions, and Relation to QPEs	➡️
11:00-11:30	Coffee break	
11:30-13:00	**Chair: TBD**	
11:30-12:00	**Zhu Liu** - Exploring accretion physics and inner disk region with the repeating partial TDE: eRASSt J045650-203751	➡️
12:00-12:15	**Ananya Bandopadhyay** - Repeating nuclear transients from repeating partial tidal disruption events: reproducing ASASSN-14ko and AT2020vdq	➡️
12:15-12:30	**Jingbo Sun** - AT2021aeuk: A Repeating Partial Tidal Disruption Event Candidate in a Narrow-line Seyfert 1 galaxy	➡️
12:30-12:45	**Zheyu Lin** - AT2022dbl - A Spectroscopically Confirmed Repeated Partial Tidal Disruption Event	➡️
12:45-13:00	**Lydia Makrygianni** - The Double TDE AT 2022dbl Implies That at Least Some “Standard” Optical TDEs are Partial Disruptions	➡️
13:00-14:30	Lunch break	
14:30-16:00	**Chair: TBD**	
14:30-15:00	**Taeho Ryu** - Tidal Disruption Events and Their Link to Repeating Nuclear Transients	➡️
15:00-15:30	**Andrew Mummery** - Accretion disks in Tidal Disruption Events	➡️
15:30-16:00	**Poster session**	
16:00-16:30	Coffee break	
16:30-18:00	**Chair: TBD**	
16:30-16:45	**Yael Alush** - Late-Time Evolution of Magnetized Disks in Tidal Disruption Events	➡️
16:45-17:15	**Benny Trakhtenbrot** - Changing Look AGN: Drastic Changes in Accretion Flows Feeding Supermassive Black Holes	➡️
17:15-17:30	**Biswaraj Palit** - The Changing Face of Markarian 590: Soft Excess and Inner Accretion Flow	➡️
17:30-17:45	**Xinwu Cao** - An accretion disk with magnetic outflows triggered by a TDE in CLAGN 1ES 1927+654	➡️
17:45-18:00	**Marzena Sniegowska** - Recurring flares in Active Galactic Nuclei and peculiar optical emission lines	➡️
18:30	Shuttle bus to Madrid	

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Tuesday 17 June

09:30-11:00	**Chair: TBD**	
09:30-10:00	**Margherita Giustini** - An observational overview of X-ray quasi-periodic eruptions	➡️
10:00-10:30	**Itai Linial** - EMRI+TDE=QPE: Star-Disc Interaction and Quasi-Periodic Eruptions	➡️
10:30-10:45	**Riccardo Arcodia** - Testing star-disk EMRI models in QPE sources with eRO-QPE2	➡️
10:45-11:00	**Hiromichi Tagawa** - Breakout emissions from stars crossing accretion disks and light curves of quasi-periodic eruptions	➡️
11:00-11:30	Coffee break	
11:30-13:00	**Chair: TBD**	
11:30-11:45	**Paula Sanchez Saez** - How can optical surveys and machine learning help identify novel activity in SMBHs?	➡️
11:45-12:15	**Lorena Hernández-García** - Exploring AGN behavior in real time: AT2021hdr and Ansky	➡️
12:15-12:30	**Indrek Vurm** - Radiation Transport Simulations of Quasi-Periodic Eruptions from Star-Disk Collisions	➡️
12:30-12:45	**Joheen Chakraborty** - Recent observational progress in QPEs	➡️
12:45-13:00	**Taj Jankovič** - Radiation-hydrodynamics of star-disc collisions	➡️
13:00-14:30	Lunch break	
14:30-16:00	**Chair: TBD**	
14:30-15:00	**Muryel Guolo** - Stress-testing models for QPE sources through physical and multiwavelength modeling of their disk emission	➡️
15:00-15:15	**Cong Zhou** - Dynamical measurement of supermassive black hole masses with quasi-periodic eruptions	➡️
15:15-15:30	**Amedeo Motta** - Constraining the impact model of QPEs by fitting multi-epoch light curves	➡️
15:30-15:45	**Markos Polkas** - Tidal Disruption Event streams intersecting accretion disks	➡️
15:45-16:00	**Philippe Yao** - Stellar Debris Stream - Accretion Disk Interactions: Implications for QPEs and Other Transients Near SMBHs	➡️
16:00-16:30	Coffee break	
16:30-18:00	**Chair: TBD**	
16:30-17:00	**Andrew King** - Angular Momentum Transfer in QPE Systems	➡️
17:00-17:15	**Xin Pan** - A disk instability model for the quasi-periodic eruptions	➡️
17:15-17:30	**Peter Kosec** - Detection of a highly ionized outflow in the quasi-periodically erupting source GSN 069	➡️
17:30-17:45	**Tomoya Suzuguchi** - Early Evolution of Quasi-Periodic Eruptions after Tidal Disruption Events	➡️
17:45-18:00	**Chiara Maria Allievi** - Constraints on extreme mass ratio inspirals from quasi periodic eruptions	➡️
18:15-19:45	Cocktail	
20:00	Shuttle bus to Madrid	

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Wednesday 18 June

09:30-11:00	**Chair: TBD**	
09:30-10:00	**Thomas Wevers** - Overview of the X-ray properties of tidal disruption events and repeating nuclear transients	➡️
10:00-10:30	**Dheeraj Pasham** - A Potential Unification Model for Repeating Nuclear Transients and a Novel Method to Identify QPE Populations	➡️
10:30-10:45	**Chichuan Jin** - Early Discoveries of TDE Candidates by the Einstein Probe Mission	➡️
10:45-11:00	**Dongyue Li** - Probing Late-time X-ray Behaviors of TDEs: Early Results from the Einstein Probe (EP) Mission	➡️
11:00-11:30	Coffee break	
11:30-13:00	**Chair: TBD**	
11:30-11:45	**Wei Chen** - The Evolution of the X-ray Spectra in Tidal Disruption Events	➡️
11:45-12:15	**Jane Dai** - Simulating the Unseen: Outflow Dynamics and Energy Release in TDEs	➡️
12:15-12:30	**Clément Bonnerot** - First light from tidal disruption events	➡️
12:30-12:45	**Nicholas Earl** - Elliptical Accretion Disk Modeling: Distinguishing AGN and TDE Disk Structures	➡️
12:45-13:00	**Minghao Zhang** - Tidal Disruption of Stars in Active Galactic Nuclei: The Role of Orbital Inclination and Schwarzschild Precession	➡️
13:00-14:30	Lunch break	
14:30-16:00	**Chair: TBD**	
14:30-14:45	**Jinhong Chen** - Precessing disk in a tidal disruption event candidate J0456-20	➡️
14:45-15:00	**Jialai Wang -** A Tidal Disruption Event from an Intermediate-Mass Black Hole Revealed by Comprehensive Multi-wavelength Observations	➡️
15:00-15:15	**Sara Faris** - Are AT 2019ehz and AT 2024doo TDEs Around SMBH Binaries?	➡️
15:15-15:45	**Wenbin Lu** - Origin of stellar orbits in QPEs and repeating partial TDEs	➡️
15:45-16:00	**Luca Broggi** - Repeating partial disruptions and two-body relaxation	➡️
16:00-16:30	Coffee break	
16:30-18:00	**Chair: TBD**	
16:30-17:00	**Kate Alexander** - New Surprises from Radio Observations of TDE Outflows	➡️
17:00-17:15	**Adelle Goodwin** - The radio properties of 22 eROSITA X-ray selected tidal disruption event candidates	➡️
17:15-17:30	**Tatsuya Matsumoto** - Origins of late time radio flares in tidal disruption events	➡️
17:30-17:45	**Itai Sfaradi** - Radio beasts and where (and when) to find them - a study of the first radio-bright off-nuclear TDE	➡️
17:45-18:00	**Magdalena Kunert-Bajraszewska** - Study of the radio transient population	➡️
18:30	Shuttle bus to Madrid	

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Thursday 19 June

09:30-11:00	**Chair: TBD**	
09:30-10:00	**Brenna Mockler** - Exploring galactic nuclei with tidal disruption events	➡️
10:00-10:15	**Jason Hinkle** - The Utility of Coronal Line Emitters as Probes of Tidal Disruption Events Physics	➡️
10:15-10:30	**Margaret Shepherd** - The Observed Delay Time Distribution of TDEs	➡️
10:30-10:45	**Hannah Wichern** - Peering into the photospheres of tidal disruption events: what causes their multi-wavelength emission?	➡️
10:45-11:00	**Beatriz Agís González** - The clockwork outbursts of ASASSN-14ko: polarimetry of a repeating partial disruption event	➡️
11:00-11:30	Coffee break	
11:30-13:00	**Chair: TBD**	
11:30-12:00	**Sjoert van Velzen** - Nuclear Transients in the Next Decade(s)	➡️
12:00-12:15	**Natalie Webb** - Discovering periodic and repeating nuclear transients in the XMM-Newton archives	➡️
12:15-12:30	**Erwan Quintin** - Needle in a Poissonian haystack - An X-ray astronomer's guide for QPE fishing	➡️
12:30-12:45	**Dimitrios Alkinoos Langis** - Repeating Flares, X-ray Outbursts and Delayed Infrared Emission: A Comprehensive Compilation of Tidal Disruption Events	➡️
12:45-13:00	**Etienne Russeil** - Early identification of optical tidal disruption events with the Fink broker	➡️
13:00-14:30	Lunch break	
14:30-16:00	**Chair: TBD**	
14:30-15:00	**Elena Maria Rossi** - Massive Black Hole's be-messenger Science with LISA	➡️
15:00-15:15	**Alberto Sesana** - Extreme Mass Ratio Inspirals with LISA	➡️
15:15-15:30	**Nicholas Stone** - Cliffhanger EMRIs	➡️
15:30-15:45	**Aleksandra Olejak** - Supermassive black hole with a stripped subgiant companion as a gravitational wave source detectable by LISA	➡️
15:45-16:00	**Santiago Rios** - Searching for Binary Supermassive Black Hole candidates in ZTF optical Light Curves	➡️
16:00-16:30	Coffee break	
16:30-18:00	**Chair: TBD**	
16:30-16:45	**Vincent Foustoul** - A sample of good miliparsec separation massive black hole binaries	➡️
16:45-17:15	**Megan Masterson** - Quasi-Periodic Oscillations around Supermassive Black Holes	➡️
17:15-17:30	**Ruisong Xia** - An Interconnected Evolution of X-ray QPO and its modulation in RE J1034+396	➡️
17:30-17:45	**Pietro Baldini** - A new X-ray variable Bowen Fluorescence Flare and Extreme Coronal Line Emitter discovered by SRG/eROSITA	➡️
17:45-18:00	**Patrik Milan Veres** - Back from the dead: The Neutrino Source AT2019aalc as a Candidate Repeating TDE in an AGN	➡️
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Posters

Margaret Verrico - The Star Formation Histories of CL-AGN Host Galaxies Revealed with Prospector	➡️
Srijan Srivastava - Improving transient identification with Swift-XRT	➡️
Diego Calderón - The effect of relativistic precession on light curves of tidal disruption events	➡️
Alok C. Gupta - X-ray Quasi Periodic Oscillations in AGNs with XMM-Newton	➡️
Tianying Lian - A Systematic Search for X-ray Eclipse Events in Active Galactic Nuclei Observed by Swift	➡️
Andrea Sacchi - A new 'old' TDE discovered in the Chandra archive	➡️
Chen Qin - AGN Pairs in CDFs	➡️
Athena Engholm - Probing Hidden Emission in Tidal Disruption Events: Insights from the Coronal Line Emitter ATLAS22kjn (AT2022fpx)	➡️

➡️ links to the abstract

Title: An observational Overview of TDEs, repeating TDEs, and Other Nuclear Transients

Author: Iair Arcavi[1]

[1]Tel Aviv University

Abstract: Since the discovery of optical-UV TDEs a decade ago, which joined X-ray and Gamma-ray TDEs, a plethora of nuclear transients has been discovered across all wavelengths. I will give an overview of the current nuclear transient zoo, including broad-line H/He events, narrow-line Bowen flares, ambiguous nuclear transients, extreme nuclear transients, flares associated with changing-look AGN, extreme coronal line emitters, and more, as well as their possible connections. In addition, I will review recent evidence for repeating flares, and their implications as partial TDEs. Finally, I will discuss prospects for increasing our sample of observed nuclear transients with new facilities, such as the Rubin Observatory and ULTRASAT

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Title: TDEs, Partial TDEs, and Repeating Partial TDEs – Current Understanding, Open Questions, and Relation to QPEs

Author: Eric Coughlin[1]

[1]Syracuse University

Abstract: The TDE detection rate has increased immensely over the past decade, and accompanying this larger sample has been the discovery of TDE "oddities" that do not conform to the standard TDE picture. Within this odd-TDE subset are 5-10 events that repeat, such that the first TDE flare is followed by a second – months to years later – that is comparable in brightness to the first. I will review our current theoretical understanding of TDEs, and how such recurring systems could be explained by the repeated partial stripping of a star on a bound orbit about a supermassive black hole (SMBH), i.e., a repeating partial tidal disruption event (rpTDE). I will describe recent quantitative analyses of the repeated (and strong) tidal interaction between a star and an SMBH, with emphasis on the difficulties associated with reproducing some observed features of rpTDEs. I will also highlight the similarities and differences between rpTDEs and quasi-periodic eruptions, and discuss challenges associated with the possible unification of these phenomena within the framework of an object orbiting and interacting with a black hole.

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Title: Exploring accretion physics and inner disk region with the repeating partial TDE: eRASSt J045650-203751

Author: Zhu Liu[1]

Co-authors: Arne Rau[2], Iuliia Grotova[2], Andrea Merloni[2], Mirko Krumpe[3], David Homan[3]

[1]University of Hertfordshire
[2]Max Planck Institute for Extraterrestrial Physics
[3]Leibniz-Institut fuer Astrophysik Potsdam

Abstract: eRASSt J045650-203751 (hereafter J0456), initially discovered by SRG/eROSITA, is one of the best-studied repeating partial tidal disruption event (TDE). Extensive monitoring with XMM-Newton, Swift, NICER, and EP/FXT has revealed eight repeating X-ray flares, along with intermittent radio emission. A detailed analysis of the data shows that the characteristic X-ray variability for each flare can be best explained by the accretion state transitioning between the thermal and the steep power-law states, accompanied by the formation and destruction of the coronae. This indicates that similar accretion processes are at work across a wide range of black hole (BH) masses and accretion rates, and that the corona can be formed and destroyed over periods of weeks to months. Additionally, I will present findings that indicate a fairly stable inner accretion structure in J0456, despite significant changes in the Eddington ratio, suggesting that a thermal disk can exist across a broad range of accretion rates. Our results highlight repeating partial TDEs as the ideal objects for deepening our understanding of accretion physics and exploring the circumnuclear region around supermassive BHs.

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Title: Repeating nuclear transients from repeating partial tidal disruption events: reproducing ASASSN-14ko and AT2020vdq

Author: Ananya Bandopadhyay[1]

Co-authors: Eric Coughlin[1], Chris Nixon[2], Dheeraj Pasham[3]

[1]Syracuse University
[2]University of Leeds
[3]Massachusetts Institute of Technology

Abstract: Some electromagnetic outbursts from the nuclei of distant galaxies have been found to repeat on months-to-years timescales, and each of these sources can putatively arise from the accretion flares generated through the repeated tidal stripping of a star on a bound orbit about a supermassive black hole (SMBH), i.e., a repeating partial tidal disruption event (rpTDE). We test the rpTDE model through analytical estimates and hydrodynamical simulations of the interaction between a range of stars, which differ from one another in mass and age, and an SMBH. We show that higher-mass ($\gtrsim 1M_\odot$), evolved stars can survive many ($\gtrsim 10$– 100) encounters with an SMBH while simultaneously losing few$\times0.01M_\odot$, resulting in accretion flares that are approximately evenly spaced in time with nearly the same amplitude, quantitatively reproducing the transient ASASSN-14ko. Contrarily, lower-mass and less-evolved stars lose progressively more mass and produce brighter accretion flares on subsequent encounters for the same pericenter distances, leading to the rapid destruction of the star and cessation of flares. Such systems cannot reproduce ASASSN-14ko-like transients, but are promising candidates for recreating events such as AT2020vdq, which displayed a second and much brighter outburst compared to the first. Our results imply that the lightcurves of repeating transients are tightly coupled with stellar type. We use this model to show that the energy imparted to an evolved star via tides can lead to a decay in its orbital period that is comparable to the observed decay in the recurrence time of ASASSN-14ko's flares, $\dot{P} \simeq -0.0026$.

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Title: AT2021aeuk: A Repeating Partial Tidal Disruption Event Candidate in a Narrow-line Seyfert 1 galaxy

Author: Jingbo Sun[1]

Co-authors: Hengxiao Guo[1], Minfeng Gu[1], Yaping Li[1], Yongjun Chen[1], D. Gonzalez-Buitrago[2], Jianguo Wang[3]

[1]Shanghai Astronomical Observatory
[2]Universidad Autonoma de Mexico
[3]Yunnan Astronomical Observatory

Abstract: The advent of time-domain astronomy has led to the detection of an increasing variety of nuclear transients. In this talk, I present the discovery of AT 2021aeuk, a transient exhibiting dual flares within three years in a narrow-line Seyfert 1 galaxy (NLS1). Multi-wavelength observations during the second flare reveal an exceptional V-shaped X-ray evolution, which is nearly the inverse of the optical light curve. This behavior challenges the pure active galactic nucleus (AGN) origin. We propose that the dual flares may be linked to a repeating partial tidal disruption event (TDE) within an AGN, where the optical flares arise from the interaction between the TDE fallback stream and the pre-existing AGN accretion disk, while the X-ray evolution during the second flare suggests the destruction and subsequent reconstruction of the corona. Additionally, several unusual features - a steady plateau phase, a late-time UV dip, and a precursor flare - indicate a series of changes in the accretion disk, which could be distinctive features of TDEs in AGN. An alternative explanation is the stellar-mass black hole merger within the accretion disk, which could also account for similar phenomena, and we cannot fully exclude this possibility. Upcoming large-field sky surveys will provide a powerful tool for further probing the underlying physics of such events in the future.

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Title: AT2022dbl - A Spectroscopically Confirmed Repeated Partial Tidal Disruption Event

Author: Zheyu Lin[1]

Co-authors: Ning Jiang, Tinggui Wang, Xu Kong, Dongyue Li, Han He, Jiazheng Zhu, Wentao Li, Ji-an Jiang, Avinash Singh, Rishabh Singh Teja, Chichuan Jin, Keiichi Maeda, and Shifeng Huang

[1]University of Science and Technology of China

Abstract: 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 mainly 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 in 1 yr can judge the correctness of this identification. I will also briefly discuss the broader impact of pTDEs, such as distinguishing the emission mechanism.

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Title: The Double TDE AT 2022dbl Implies That at Least Some “Standard” Optical TDEs are Partial Disruptions

Author: Lydia Makrygianni[1]

[1]Lancaster University

Abstract: Flares produced following the tidal disruption of stars by supermassive black holes can reveal the properties of the otherwise dormant majority of black holes and the physics of accretion. In the past decade, a class of optical-ultraviolet tidal disruption flares has been discovered whose emission properties do not match theoretical predictions. This has led to extensive efforts to model the dynamics and emission mechanisms of optical-ultraviolet tidal disruptions in order to establish them as probes of supermassive black holes. We present the optical-ultraviolet tidal disruption event AT 2022dbl, which showed a nearly identical repetition 700 days after the first flare. Ruling out gravitational lensing and two chance unrelated disruptions, we conclude that at least the first flare represents the partial disruption of a star, possibly captured through the Hills mechanism. With this study, however, a riddle on these events arises. Since both flares are typical of the optical-ultraviolet class of tidal disruptions in terms of their radiated energy, temperature, luminosity, and spectral features, it follows that either the entire class are partial rather than full stellar disruptions, contrary to the prevalent assumption, or that some members of the class are partial

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Title: Tidal Disruption Events and Their Link to Repeating Nuclear Transients

Author: Taeho Ryu[1]

[1]Max Planck Institute for Astrophysics

Abstract: Tidal disruption events (TDEs) are among the most dramatic nuclear transients, occurring when a star is destroyed by the immense tidal forces of a supermassive black hole within hours. This process generates a luminous flare capable of outshining the entire host galaxy. The number of detected TDEs have been steadily growing thanks to ongoing surveys and telescopes, such as Pan-STARRS, ATLAS, ASAS-SN, and ZTF, reaching over one hundred. The number is expected to rise significantly with future transient surveys like LSST and ULTRASAT. Initially, most TDE candidates were characterized by a single peak in luminosity. However, as more events have been observed, unexpected phenomena have emerged. One particularly intriguing discovery is the presence of repeated nuclear transients with varying peak-to-peak timescales, including quasi-periodic eruptions. While the origins of these events remain uncertain, some may be closely linked to TDEs. In this talk, I will review the theoretical framework of TDEs both in both gas-free and gas-rich environments, with a focus on those capable of producing recurring flares.

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Title: Accretion disks in Tidal Disruption Events

Author: Andrew Mummery[1]

[1]University of Oxford

Abstract: The tidal disruption of a star by a supermassive black hole leads to the formation of an accretion flow which can be (and is in the majority of sources) observed from Optical to X-ray energies. These disks differ in important ways from classical AGN systems: they are much more compact, evolve much more quickly, and have much lower mass contents. These disk systems also act as the site in which more novel phenomena, like QPEs, etc. occur, and a robust understanding of their properties is essential before we can make progress in these fields. In this talk I will discuss the progress we have made in understanding TDE accretion disks, and summarise the implications this understanding has for QPE science.

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Title: Late-Time Evolution of Magnetized Disks in Tidal Disruption Events

Author: Yael Alush[1]

Co-authors: Nicholas C. Stone[1,2]

[1]The Hebrew University of Jerusalem
[2]University of Wisconsin

Abstract: In classic time-dependent, 1D accretion disk models, the inner region, dominated by radiation pressure, is thermally and viscously unstable. While this radiation pressure instability has been theorized to be responsible for QPEs, XRB variability and other observed phenomena, late-time observations of tidal disruption event (TDE) disks exhibit no evidence for it. These late- time disks have recently attracted much attention because of their relative simplicity (compared to early-time TDE hydrodynamics), offering the potential for accurate parameter estimation if their time evolution can be modeled. A common theoretical approach to stabilize the disk and to model TDE-like systems is to modify the viscosity parameterization, but, the typical change is usually ad hoc and lacks physical motivation. In this study, we take a different approach, and investigate a time-dependent 1D alpha-disk model in which (following recent MHD simulations) the pressure is dominated by magnetic fields rather than photons. In my talk, I will (1) compare the time evolution of thermally stable, strongly magnetized TDE disks to more simplified 1D viscosity models, (2) predict a new category of 'TDE fossils,' slowly evolving disks detectable decades post-disruption even absent any early time emission, and (3) discuss the connection between TDE disks and QPEs in star-disk collision models.

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Title: Changing Look AGN: Drastic Changes in Accretion Flows Feeding Supermassive Black Holes

Author: Benny Trakhtenbrot[1]

[1]Tel Aviv University

Abstract: Some active galactic nuclei (AGN) present dramatic transitions between seemingly distinct spectral states, on timescales as short as several months. Such events of changing look AGN (CL-AGN) have been observed in both the X-ray and the UV-optical regime for decades, but the ongoing revolution in time domain astronomy allows us to identify them in greater numbers and study their nature in great detail. I will review the basic characteristics of CL-AGN as observed in the various spectral regimes, and discuss how these can reveal the physical mechanisms that drive these transitions. Focusing on UV-optical CL-AGN, I will describe the evidence that links them to dramatic changes in the accretion flow that power them, rather than in the circumnuclear (dusty) gas, and stress why such changes challenge classical, mostly-stable accretion disk models. In line with the main topics of the meeting, I will highlight a few cases of recurring CL-AGN and the models put forward to explain them. and will raise the question of whether some CLAGN are intrinsically driven by other SMBH-related transients, such as tidal disruption of stars. These and other examples will demonstrate how new survey data, combined with responsive follow-up observations, are advancing our understanding of CL-AGN and other related phenomena.

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Title: The Changing Face of Markarian 590: Soft Excess and Inner Accretion Flow

Author: Biswaraj Palit[1]

Co-authors: Marzena Sniegowska[2], Alex Markowitz[3], Agata Rozanska[3], Joseph Farah[4], D. Andrew Howell[4]

[1]Nicolaus Copernicus Astronomical Center
[2]Tel Aviv University
[3]Nicolaus Copernicus Astronomical Center
[4]Las Cumbres Observatory, University of California

Abstract: Changing-Look (CL) behaviour in Active Galactic Nuclei (AGNs) are characterized by dramatic changes in overall brightness of sources connected to restructuring of the circumnuclear environment such as: the accretion disk, broad line region (BLR), and dusty torus. In this talk, I will present the results of multi-wavelength studies conducted on the well known CL AGN- Markarian 590 and discuss the implications in the context of (1) inner accretion flow, (2) Warm Corona and (3) Effects of CL events on surrounding gas. From Swift-XRT and UVOT monitoring, we caught the source undergoing more than an order of magnitude amplification in ionizing radiation in near-UV and X-rays since July 2024. This event was followed by the enhancement of soft X-ray excess and BLR gas emission, resembling Seyfert 1 activity state from the mid-1990s. We also detected a pivoting of spectral energy distribution (SED) associated with this event, acting as a strong indicator of changes in inner-accretion flow. An extensive multi-mission (XMM-Newton, NuSTAR, Chandra and Suzaku) X-ray spectroscopy spanning 25 years revealed the dissipative nature and dynamics of warm corona, and consequently demonstrating the ideal conditions required to generate strong soft X-ray excess. Our initial reverberation mapping results locate the Fe Kalpha emitting gas a few parsecs from the central black hole. Finally, I will comment on modeling the effects of CL-like nuclear transient events on circumnuclear environments of supermassive black holes using the CLOUDY photoionization code.

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

Author: Xinwu Cao[1]

[1]Institute for Astronomy, Zhejiang University

Abstract: 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.

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Title: Recurring flares in Active Galactic Nuclei and peculiar optical emission lines

Author: Marzena Sniegowska[1]

Co-authors: Benny Trakhtenbrot[1], Lydia Makrygianni[2], Claudio Ricci[3], Iair Arcavi[1], Sara Faris[1], Biswaraj Palit[4]

[1]Tel Aviv University
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Abstract: Active galaxies are known for their stochastic variability across all observed wavelength bands. However, sudden and drastic flux changes over surprisingly short timescales of years or even months, accompanied by (dis-)appearance of certain spectral features, are challenging canonical models and suggest more abrupt changes to the accretion flow should be further investigated. With the growth of astronomical surveys, we start to get flooded with more and more transient events in Active Galactic Nuclei and we are currently in need of understanding the physical mechanism(s) behind the various at extreme variability phenomena. I will discuss recent findings related to recurring flares in already-accreting AGN, from both theoretical and observational perspectives. First, I will present several mechanisms in AGN accretion disks that may give rise to recurring flares over a wide range of timescales, involving radiation pressure instabilities, and compare them to other recent suggestions (shocks driven by magnetic fields and ionization instabilities). I will then present a peculiar nuclear transient, recently identified to exhibit recurring optical flares, in a previously known AGN, over timescales of months-years. I will present photometrical observations of the event (SWIFT, ZTF and ATLAS) and spectral monitoring from Las Cumbres Observatory showing the peculiar evolution of the emission lines. This source shows strong broad Bowen fluorescence emission features, which seem to vary in tandem with the (recurring) continuum flares. This is the first case where we were able to track the common rebrightening of such Bowen features and the continuum. These rare spectral features offer the unique opportunity to gain insight into the most extreme UV emission, and thus the innermost parts of the accretion flow, and confront model predictions for (recurring) instabilities, partial tidal stripping of stars, as well as the line emitting region(s).

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Title: An observational overview of X-ray quasi-periodic eruptions

Author: Margherita Giustini[1]

[1]Centro de Astrobiologia (CAB), CSIC-INTA

Abstract: X-ray quasi-periodic eruptions (QPEs) have recently joined the family of extragalactic repeating nuclear transients. Six years after their serendipitous discovery in the galaxy GSN 069, QPEs have now been observed in about ten galaxies. While the QPE duration and the time separation between them have a large observed scatter in the various galaxies (of 0.5-30 hours and 1-100 hours, respectively), the fundamental general QPE properties are similar for all the sources. I will present an overview of the observational status of the QPE science, highlighting state-of-the-art observations that include advanced timing analysis of the shortest-period QPE sources and time-resolved spectroscopy of the longest-duration QPEs. I will then discuss how observations of QPEs can be improved in the near and distant future and how they can constrain theoretical models that can provide precious information about the nuclear environment of the QPE-hosting galaxies.

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

Author: Itai Linial[1]

[1]Columbia University

Abstract: 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), and the discovery prospects of related repeating nuclear transients in light of upcoming UV surveys such as ULTRASAT and UVEX.

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Title: Testing star-disk EMRI models in QPE sources with eRO-QPE2

Author: Riccardo Arcodia[1]

[1]Massachusetts Institute of Technology

Abstract: Several models recently proposed that quasi-periodic eruptions (QPEs) are the electromagnetic counterpart of the gravitational wave emitters called extreme-mass ratio inspirals. While this explanation is tantalizing in relation to the recently-adopted LISA mission, a conclusive and model-independent test is still pending. We designed a multi-mission X-ray campaign on the well-behaved source eRO-QPE2 to test models proposing QPEs to be star-disk interactions by measuring the orbital decay driven by hydrodynamic drag experienced by the star as it collides with the accretion disk surrounding the central massive black hole, or the lack thereof. The latter would imply that either the secondary is a stellar-mass BH (which would imprint a much smaller orbital decay), or that current orbital models for QPEs are incomplete or incorrect.

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Title: Breakout emissions from stars crossing accretion disks and light curves of quasi-periodic eruptions

Author: Hiromichi Tagawa[1]

[1]Shanghai Astronomical Observatory

Abstract: The origin of the recently discovered new class of transients, X-ray quasi-periodic eruptions (QPEs), remains a puzzle. Due to their periodicity and association with tidal disruption events and active galactic nuclei (AGN), it is natural to associate these eruptions with stars and/or gaseous disks in tight orbits around supermassive black holes. In our research, we have predicted the properties of breakout emission from bow shocks produced by stars as they cross AGN disks and then compared these predictions to the observed properties of QPEs. Our findings suggest that when a star's orbit is retrograde, possesses a low inclination with respect to the AGN disk, and the star itself is of substantial mass, the breakout emissions from the bow shock can account for the observed duration and X-ray luminosity of QPEs. This model further allows for the explanation of a variety of light curves, which have not been explained by past studies. Asymmetric and symmetric light curves are caused by planar and spherical phases, respectively, and the evolution timescales help constrain intrinsic parameters. We also suggest that in Swift J0230+28, the accretion disk originates from the inflow of gas from large radii, and the star is very slightly inclined with respect to the disk, differing from other events.

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Title: How can optical surveys and machine learning help identify novel activity in SMBHs?

Author: Paula Sanchez Saez[1]

Co-authors: Lorena Hernandez Garcia[2], Patricia Arevalo[2], Santiago Bernal[2], Paulina Lira[3], Claudio Ricci[4]

[1]European Southern Observatory
[2]Universidad de Valparaiso
[3]Universidad de Chile
[4]Universidad Diego Portales

Abstract: In recent years, the ALeRCE broker, one of the seven official brokers for the Rubin Observatory's Legacy Survey of Space and Time (LSST), has developed machine learning models to identify various classes of transients, persistently variable, and non-variable sources from different Zwicky Transient Facility (ZTF) data products. These models are particularly adept at detecting supermassive black hole (SMBH) activity, including active galactic nuclei (AGNs) and tidal disruption events (TDEs). In this talk, I will introduce the ALeRCE broker's light curve classifiers available for the community and demonstrate how our collaboration has utilized these models to identify changing-look AGNs (CLAGNs) transitioning from type 2 to type 1, low-mass AGNs, as well as candidates for newborn AGNs (black holes igniting for the first time). I will particularly focus on the discovery of optical nuclear activity in the galaxy SDSS1335+0728 (also known as Ansky). This galaxy exhibited no optical or infrared variations for two decades until December 2019, when it began showing significant optical stochastic variability. Remarkably, since February 2024, Ansky has exhibited X-ray quasi-periodic eruptions (QPEs). Its unprecedented behavior suggests that Ansky could either be a low-mass AGN igniting for the first time or an exotic TDE, potentially representing the longest and faintest SMBH transient ever observed. With this talk, I aim to underscore the efficacy of the ALeRCE broker models in identifying rare SMBH activity, which may contribute valuable insights into the dynamic processes governing galactic nuclei.

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Title: Exploring AGN behavior in real time: AT2021hdr and Ansky

Author: Lorena Hernández-García[1]

[1]Universidad de Valparaiso

Abstract: Recent advancements in observational techniques have led to the discovery of extreme-variability events associated with active galactic nuclei (AGN). These rare phenomena offer an unprecedented opportunity to study AGN in real time. In this presentation, I will focus on two remarkable events detected using tools developed by the ALeRCE broker: AT2021hdr and Ansky. Thanks to ALeRCE's rapid processing of large data volumes and timely alerts, these objects were identified in their early stages, enabling prompt multiwavelength follow-up observations. AT2021hdr displays oscillations with timescales of 90 days in its light curves across X-ray, UV, and optical bands, and its unusual behavior may be linked to the tidal disruption of a gas cloud by a binary supermassive black hole (SMBH). Ansky, on the other hand, exhibits some of the most extreme quasi-periodic eruptions (QPEs) observed to date, with burst durations of 1.5 days, a 4.5-day peak-to-peak recurrence time, and an average integrated energy output about 10 times higher than other QPEs. Ansky appears to be entering an active phase, challenging current theoretical models. These findings provide valuable insights into the dynamic environments around SMBHs, including tidal disruption events, episodic mass transfer, and the potential existence of SMBH binaries.

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Title: Radiation Transport Simulations of Quasi-Periodic Eruptions from Star-Disk Collisions

Author: Indrek Vurm[1]

Co-authors: Brian D. Metzger[2]

[1]University of Tartu
[2]Columbia University

Abstract: Periodic collisions between a star on an inclined orbit around a supermassive black hole and its accretion disk offers a promising explanation for X-ray quasi-periodic eruptions (QPEs). Each passage through the disk midplane shocks and compresses gas ahead of the star, which subsequently re-expands above the disk as a quasi-spherical cloud. We present spherically symmetric Monte Carlo radiation transport simulation which follow the production of photons behind the radiation-mediated shock, Comptonization by hot electrons, and the eventual escape of the radiation through the expanding debris. Such one-dimension calculations are approximately justified for thin disks (scale-height $h \lesssim$ few $\times R_{\star}$), through which the star of radius $R_{\star}$ passes faster than the shocked gas can flow around the star. For collision speeds $v \gtrsim 0.15c$ and disk surface densities $\Sigma \sim 103$ g cm^{-2} characteristic of those encountered by stellar orbits consistent with QPE recurrence times, the predicted transient light curves exhibit peak luminosities $\gtrsim 10^{42}$erg s^{-1} and Comptonized quasi-thermal (Wien-like) spectra which peak at energies $h\nu \sim 100$ eV, broadly consistent with QPE properties. For these conditions, gas and radiation are out of equilibrium, rendering the emission temperature harder than the blackbody value due to inefficient photon production behind the radiation-mediated shock. The predicted eruptions execute counterclockwise loops in hardness-luminosity space, qualitatively similar to QPE observations. Reproducing the observed eruption properties (duration, luminosity, temperature) requires a large radius $R_{\star} \gtrsim 10R_{\odot}$, which may point to inflation of the star's atmosphere from repeated collisions.

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Title: Recent observational progress in QPEs

Author: Joheen Chakraborty[1]

[1]Massachusetts Institute of Technology

Abstract: In order to understand the origin of QPEs, we need to (1) find more sources and (2) rigorously test theoretical models. I will present two recent results toward this end, and discuss how our deepening understanding of QPE observables is allowing us to probe physical models in new ways. First, I will present the detection of rapidly evolving emission and absorption lines in the bright, long-duration QPEs of ZTF19acnskyy/Ansky; modeling the time-variation of the spectra with a P-Cygni profile akin to expanding supernova atmospheres has the potential to constrain the properties of the emitting material. Then, I will highlight the recent discovery of QPEs in AT2022upj, which is suggestively the second QPE found in an extreme coronal-line emitter; I will discuss preliminary constraints on the rate of optical TDEs resulting in QPEs, and follow-up efforts to further probe the emerging connection with CLEs.

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Title: Radiation-hydrodynamics of star-disc collisions

Author: Taj Jankovič[1]

Co-authors: Clément Bonnerot[2], Sergey Karpov[1], Aleksej Jurca[3]

[1]Institute of Physics of the Czech Academy of Sciences
[2]School of Physics and Astronomy & Institute for GW Astronomy, University of Birmingham
[3]Center for Astrophysics and Cosmology, University of Nova Gorica

Abstract: Quasi-periodic eruptions (QPEs) are newly discovered transients of unknown nature occurring near supermassive black holes, which feature bright X-ray bursts separated by approximately 10 hours. A promising model for QPEs is the star-disc model, where a star interacts periodically with a black hole's pre-existing accretion disc, creating shocks that expel dense gas clouds from which radiation emerges.

We performed the first 3D radiation-hydrodynamics simulations to investigate the dynamics of the star-disc collisions, the properties of the ejected gas clouds, and the resulting radiation signatures. The star was modeled as a solid, spherical body, and the interaction was simulated for a small, local section of the accretion disc.

We found that star-disc collisions generate a nearly paraboloidal bow shock. The heating of gas is not confined to the column of gas directly ahead of the star but also extends laterally as the shock front expands sideways while traveling with the star. The collision drives an outflow of gas both in the forward and backward directions relative to the star's motion. These outflows are asymmetric, with the forward outflow carrying more mass and producing a brighter luminosity than the backward component. We found that variations in stellar size, velocity, and disc density systematically influence this asymmetry, suggesting that specific parameter combinations could naturally reproduce the strong-weak brightness pattern observed in some QPEs.

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Title: Stress-testing models for QPE sources through physical and multi-wavelength modeling of their disk emission

Author: Muryel Guolo[1]

Co-authors: Andrew Mummery[2]

[1]Johns Hopkins
[2]University of Oxford

Abstract: The presence of 'quiescent' X-ray disk emission between eruptions, similar to that seen in tidal disruption events (TDEs), appears to be a ubiquitous feature of all confirmed quasi-periodic eruption (QPE) sources, with a UV/optical counterpart already detected in a few cases. In most leading models of QPE mechanisms, the properties of the eruptions are intrinsically linked to the properties of the disk itself. Thus, a physical understanding of the disk emission provides an alternative approach - complementary to, for example, timing analysis - for investigating these sources. In this talk, we present new methods for analyzing these TDE-like disks, including simultaneous fitting of UV/optical and X-ray data, as well as multi-epoch modeling using fully time-dependent disk evolution equations, both of which incorporate relativistic effects. We demonstrate that simultaneous X-ray/UV/optical fitting constrains disk sizes and refines estimates of other key parameters of the disk-black hole system. Additionally, fully time-dependent modeling allows us to constrain parameters such as the disk's viscous timescale and the evolution of its surface density - constraints that are not possible with typical time-independent approaches. We will present results from the application of these methods to GSN 069, which exhibited no QPEs in 2014 but showed strong QPE activity in 2018. We will argue that the simple versions of all major QPE models, including proposed disk instabilities and orbiter/disk collision scenarios, fail to explain the absence (presence) of QPEs in 2014 (2018) given the observed evolution of the disk properties.

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Title: Dynamical measurement of supermassive black hole masses with quasi-periodic eruptions

Author: Cong Zhou[1]

Co-authors: Zhen Pan[2], Ning Jiang[1]

[1]University of Science and Technology of China
[2]Tsung-Dao Lee Institute

Abstract: 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. More and more analyses show 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. With QPE timing data, one can reconstruct the trajectory of a single SMO around a SMBH. Specifically, the orbital period and the apsidal precession period of the SMO can be well measured from long-term monitoring of the QPEs. The SMBH mass and the SMO orbital size are consequently tightly constrained by these two periods. We compile a number of SMBH mass measurements using this QPE timing method and show that they are consistent with and of lower uncertainty than those inferred from the $M_\bullet - \sigma_*$ relations. Therefore the QPE timing method is of great potential in precise measurement of SMBH masses, especially in the lower mass end ($\lesssim 10^6 M_\odot$), where QPEs prevail while no other well-calibrated method is available.

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Title: Constraining the impact model of QPEs by fitting multi-epoch light curves

Author: Amedeo Motta

Co-authors: Alberto Sesana[1]

[1]University of Milano-Bicocca

Abstract: Recent observations suggest a connection between quasi-periodic eruptions (QPEs) and tidal disruption events (TDE), highlighting the need for further analysis of the impact model. In particular, as shown in Miniutti et al. (2024) and Franchini et al. (2023), the recurrent X-ray emissions could be produced by a compact object orbiting around a massive black hole that impacts a precessing accretion disk produced by a TDE. In my Master's thesis, I implement the semi-analytical model developed in Franchini et al. (2023) to reproduce the evolution of such a system and to fit the crossing times with multi-epoch observations of QPEs. By fitting the light curve with multiple datasets spanning a long time, we can account for the variations in the dynamics of the system, providing more robust constraints on the parameters of the binary system and validating the hypothesis of the impact model.

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Title: Tidal Disruption Event streams intersecting accretion disks

Author: Markos Polkas[1]

Co-authors: Clément Bonnerot[2]

[1]Donostia International Physics Center
[2]University of Birmingham

Abstract: Quasi-Periodic Eruptions (QPE) are possibly linked to Tidal Disruption Events (TDE), as has been demonstrated by recent observations. At the same time, the theoretical understanding of the two classes of transient phenomena is still improving, with key aspects of the driving engine and energy dissipation being pinned down only during the last year. In my talk I will analyze the results of the TDE-stream/disk interaction, probed with 2D and 3D hydrodynamical simulations performed with the high-performance adaptive-mesh code Athena++. With simple simulations (the TDE stream and the disk are two interacting flows), we explore a vast parameter space relevant to TDEs and QPEs, especially regarding the survivability of the stream and the fate of the fragments in the presence of an Active Galactic Nucleus or a TDE stream. Analytical estimates and formulas are derived and are applied to estimate the effect on a massive black hole population level.

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Title: Stellar Debris Stream - Accretion Disk Interactions: Implications for QPEs and Other Transients Near SMBHs

Author: Philippe Yao[1]

Co-authors: Eliot Quataert[1], Yan-Fei Jiang[2]

[1]Princeton University
[2]Center for Computational Astrophysics, Flatiron Institute

Abstract: Hydrodynamic simulations of star-disk collisions reveal significant mass stripping from stars, with the liberated stellar debris potentially circularizing and re-colliding with the disk. This process is more likely to power the observed quasi-periodic eruption (QPE) flares than star-disk collisions alone. Using Athena++, we perform 3D hydrodynamic simulations to investigate the interactions between stellar debris streams and accretion disks in the tidal potential of a supermassive black hole (SMBH). SMBH tidal gravity elongates stellar debris streams, prolonging their interaction timescales with the disk. The dynamics of these interactions vary with the star's distance from the SMBH, influencing the surface density of stellar debris, collision cross-sections, and relative velocities of the debris and disk. These factors play a crucial role in determining the amplitude and duration of the resulting flares. Our findings demonstrate significant contributions of shocked mass from both the stellar debris and the accretion disk, with the dominant source depending on initial conditions. This framework provides a basis for understanding the diverse timing behaviors observed in QPE light curves.

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Title: Angular Momentum Transfer in QPE Systems

Author: Andrew King[1]

[1]Univeristy of Leicester

Abstract: In a recent paper I suggested that QPE systems might undergo cyclic behaviour on periods longer than those of the eruptions. This happens when the QPE binary is perturbed by a more distant orbiter, producing von Zeipel - Lidov - Kozai cycles. I will show that these cycles divide QPE behaviour into characteristic families, giving direct information about the mass donors and the long-term evolution of QPE systems.

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Title: A disk instability model for the quasi-periodic eruptions

Author: Xin Pan[1]

Co-authors: Shuang-Liang Li[2], Xinwu Cao[3], Minfeng Gu[2]

[1]National Astronomical Observatories, Chinese Academy of Science
[2]Shanghai Astronomical Observatory
[3]Zhejiang University

Abstract: Quasi-Periodic Eruptions (QPEs) represent a newly discovered class of repeating nuclear transients in massive black hole (MBH) systems, characterized by their exclusive variability in the X-ray band on timescales of hours. Key features of QPEs - such as their thermal-like spectra, alternating timing patterns observed in some sources, and the potential connection to tidal disruption events (TDEs) - offer fresh perspectives for investigating MBH accretion systems. However, the physical origin of QPEs remains a subject of ongoing debate, with two primary mechanisms proposed to explain this phenomenon: disk instability and orbital interaction. In this talk, I will present our disk instability model for QPEs and compare some results of our model with observations.

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Title: Detection of a highly ionized outflow in the quasi-periodically erupting source GSN 069

Author: Peter Kosec[1]

[1]Smithsonian Astrophysical Observatory

Abstract: Quasi-periodic eruptions (QPEs) are high-amplitude, recurring soft X-ray bursts associated with supermassive black holes. Many interpretations for QPEs were proposed since their recent discovery in 2019. The most plausible models include extreme mass ratio inspirals or accretion disk instabilities, but as of today, the QPE nature remains to be understood. In this talk I will present the results of the first high-resolution X-ray spectral study of a QPE source. We leverage the nearly 2 Ms of XMM-Newton RGS grating exposure on GSN 069 (the first discovered QPE system) and resolve several absorption and emission lines, among them a strong pair of lines near the N VII rest-frame energy which resemble a P-Cygni line profile (blueshifted absorption and redshifted emission). We apply photoionization spectral models and identify the features detected in absorption as an outflow with a projected velocity of 1700-2900 km/s. Conversely, the emission lines are redshifted by up to 2900 km/s and can be interpreted as originating from the same outflow that imprints the ionized absorption and covers the full 4π sky from the point of view of GSN 069. We find strong evidence that nitrogen is heavily over-abundant in the ionized outflow, consistent with a previous abundance study of GSN 069 using UV data. I will conclude by discussing these findings in the context of QPEs and other nuclear transients.

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Title: Early Evolution of Quasi-Periodic Eruptions after Tidal Disruption Events

Author: Tomoya Suzuguchi[1]

Co-authors: Tatsuya Matsumoto[1]

[1]Kyoto University

Abstract: Quasi-periodic eruptions (QPEs) are X-ray burst from the central regions of extragalactic galaxies, occurring at intervals of hours to days, with peak luminosities of 10^{42-43} erg s^{-1}. The leading hypothesis suggests these eruptions arise from a star orbiting a supermassive black hole (an extreme mass ratio inspiral, or EMRI) colliding with an accretion disk. Recent findings link QPEs to tidal disruption events (TDEs), implying that the accretion disk may form from TDE debris (Nicholl et al. 2024). This is consistent with what was proposed by Linial & Metzger (2023) and other authors as the 'TDE+EMRI=QPE' model (e.g., Franchini et al. 2023; Tagawa & Haiman 2023). A natural question arises regarding the early-time evolution of QPEs in this context: When do QPEs start after a TDE, and what are their properties, such as luminosity, duration, and temperature? Addressing these questions requires including the time evolution of the TDE disk, which was ignored in previous works.

We explore the time evolution of the QPE observables during the early stages of a TDE, focusing in particular on the super-Eddington phase. Since disk formation in TDEs is still under debate, we consider two disk models: one based on a steady solution for an advection-dominated disk, in which the accretion rate equals the time-dependent fallback rate (Strubbe & Quataert 2009), and the other based on a self-similar solution for a slim disk (e.g., Cannizzo & Gehrels 2009). As a result, we find that during the early stages of a TDE, the temperatures of QPEs are higher than those of the currently observed QPEs, falling within the hard X-ray range, regardless of the disk model. Although the disk luminosity of an early TDE is greater than the QPE luminosity, the hardness of early QPEs enables their detection. We also find that the QPE duration is shorter than that of currently observed QPEs, making observations more challenging. However, hard X-ray QPEs could still be detected with current X-ray observatories, such as NuSTAR. Detecting early QPE signals could confirm the 'TDE+EMRI=QPE' scenario and potentially constrain disk formation models in TDEs, which remains a long-standing puzzle in TDE studies.

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Title: Constraints on extreme mass ratio inspirals from quasi periodic eruptions

Author: Chiara Maria Allievi[1]

Co-authors: Alberto Sesana[1], Luca Broggi[1], Matteo Bonetti[1]

[1]Università degli Studi di Milano-Bicocca

Abstract: In our work we compute the expected QPE volumetric rates under the assumption that these events are due to the interaction between a stellar black hole (sBH) in a close orbit and the accretion disk, around the central supermassive black hole (SMBH), formed by a tidal disruption event (TDE). We evolve the public code Phaseflow, which simulates the collisional evolution of spherical isotropic stellar systems based on the one-dimensional Fokker–Planck equation. Based on the observed QPEs we decided to evolve 7 systems with a range of SMBH masses from $10^5 M_\odot$ to $10^8 M_\odot$, with three populations: one of stars of $1 M_\odot$, two of sBHs with masses of $10 M_\odot$ and $40 M_\odot$. According to the modeling of the light curves in the article Franchini et al. (2023), we restricted the orbits of the EMRIs, selecting those with eccentricity less than 0.5 and inclination less than 20°. After evolving our systems for 10^{10} yrs, we built a library in Julia, so that we could compute the TDE rates and the EMRI rates from the variables that Phaseflow gives us. The result of our work is that the QPE volumetric rates depend on the mass of the SMBH, the period of the orbit of the QPE, the eccentricity and the inclination and they vary from 10^{-11} Mpc^{-3} to 10^{-9} Mpc^{-3}. Confronting these rates with the ones estimated by Arcodia et al. (2024), we observe that they differ of at least 3 orders of magnitude. This is due to our constraints on eccentricity and inclination that lower the rates of at least 3 orders of magnitude.

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Title: Overview of the X-ray properties of tidal disruption events and repeating nuclear transients

Author: Thomas Wevers[1]

[1]Schmidt Sciences

Abstract: I will give an overview of the X-ray properties of TDEs, partial TDEs, and repeating nuclear transients, focusing on common properties between all these populations and highlighting unique behaviours and opportunities that each of these classes of objects can teach us in the future.

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Title: A Potential Unification Model for Repeating Nuclear Transients and a Novel Method to Identify QPE Populations

Author: Dheeraj Pasham[1]

Co-authors: Eric Coughlin[2], Petra Sukova[3], Michal Zajacek[4], Vladimir Kara[3], Jason Hinkle[5]

[1]Massachusetts Institute of Technology
[2]Syracuse University
[3]Astronomical Institute of the Czech Academy of Sciences
[4]Masaryk University
[5]University of Hawaii

Abstract: In addition to QPEs, two other types of repeating soft X-ray signals have been discovered from nuclei of galaxies: Quasi-Periodic Outflows (QPOuts) and Quasi-Periodic Oscillations (QPOs). I will present results to argue that these various repeating phenomena: QPEs, QPOuts and QPOs may be the same systems viewed at different geometric orientations. I will also discuss their connection to tidal disruption events. Separately, one of the pressing questions we face in this field is how do we find many more QPEs. I will present a new observational approach to identify QPE populations in the current/archival and future survey data.

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Title: Early Discoveries of TDE Candidates by the Einstein Probe Mission

Author: Chichuan Jin[1]

[1]National Astronomical Observatories (NAOC), China

Abstract: 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. In its early operation phase, EP has already uncovered dozens of new X-ray transients with diverse and intriguing properties. In this talk, I will present some notable examples of TDE candidates discovered by EP since its launch in 2024. These include a peculiar off-nuclear TDE candidate with spectroscopic follow-up, a jetted TDE candidate, and several puzzling TDE candidates still under investigation. Finally, I will discuss some future prospects of EP's operation, including observations of TDEs and joint observations with other facilities.

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Title: Probing Late-time X-ray Behaviors of TDEs: Early Results from the Einstein Probe (EP) Mission

Author: Dongyue Li[1]

Co-authors: S. Wen[1], X. Pan[1], C. Jin[1], W. Zhang[1], M. Liu[1], W. Chen[1], E. Qiao[1], W. Yuan[1]

[1]National Astronomical Observatories, Chinese Academy of Sciences

Abstract: The X-ray emissions from tidal disruption events (TDEs) are linked to the inner region of the accretion disk close to the event horizon of the supermassive black holes (SMBHs). Observations reveal instances where certain TDEs exhibit unusual late-time X-ray behaviors, including delayed X-ray emission, repeated rebrightening, and quasi-periodic eruptions (QPEs). These phenomena, attributed to different environments for TDEs, provide more information for understanding their late-time X-ray emission. To systematically investigate these behaviors, we are carrying out a monitoring campaign utilizing the Follow-up X-ray Telescope (FXT) onboard the Einstein Probe (EP) mission targeting a selected sample of known TDEs since 2024 July. In this talk, we will present some preliminary findings from this project, including (1) a TDE showing delayed X-ray brightening, occurring about 400 days after its optical flare. (2) evidence of spectral hardening in late-time X-ray detections of a TDE, indicative of potential accretion-state transitions. (3) independent detection of QPEs in a TDE and some further temporal and spectral analysis.

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

Author: Wei Chen[1]

Co-authors: Erlin Qiao[1]

[1]National Astronomical Observatories, Chinese Academy of Sciences

Abstract: The study of the evolution of X-ray spectra in tidal disruption events (TDEs) is an important approach for understanding the physical processes occurred near a supermassive black hole. Observations show that the X-ray spectra of TDEs are very soft at the peak after the outburst, followed by a spectral hardening on a timescale of years. Theoretically, TDEs are suggested to undergo super-Eddington accretion at the time around the outburst. In this paper, we constructed a new disk-corona model to explain the observed X-ray spectral hardening in TDEs. In our model, there is a transition radius r_{tr}. For $r < r_{tr}$, the accretion flow exists in the form of slim disk, the emission of which is dominated by soft X-rays. While for $r > r_{tr}$, the accretion flow exists in the form of traditionally sandwiched disk-corona, in which a harder X-ray spectrum is produced. Our calculations show that r_{tr} decreases with decreasing mass accretion rate $\dot{M}$, which intrinsically can predict the hardening of the X-ray spectra since the relative contribution of the outer disk-corona to the inner slim disk to the X-ray spectrum increases with decreasing $\dot{M}$. Our model has been applied to explain the observed X-ray spectral hardening in TDEs ASASSN-14li, AT2019dsg, ASASSN-19dj and AT2018fyk, in which $\dot{M}$ is assumed to decrease proportionally to $t^{-5/3}$. Potential applications of the model in interpreting X-ray spectral evolution in upcoming TDE observations with the Einstein Probe (EP) are also explored.

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Title: Simulating the Unseen: Outflow Dynamics and Energy Release in Tidal Disruption Events

Author: Jane Dai[1]

[1]The University of Hong Kong

Abstract: Tidal disruption events (TDEs) are cosmic laboratories for studying the interplay between massive black holes and their stellar environments. One of the most pressing questions in the study of TDEs is the discrepancy between the predicted energy release - driven by super-Eddington accretion - and the observed emissions. In this talk, we present new radiative transfer simulations that shed new light on the emission mechanisms of TDEs. For the first time, we reproduce the diverse spectroscopic classes of optical TDEs, including those dominated by strong Bowen fluorescence lines, and reveal the physical conditions that give rise to these distinct signatures. Our simulations not only reveal the origins of these spectral features but also establish a framework for constraining the properties of TDE outflows and their bolometric luminosities based on observable line signatures. These findings bridge the gap between theory and observation, offering a deeper understanding of the energetics, dynamics and observational diversity of TDEs.

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Title: First light from tidal disruption events

Author: Clément Bonnerot[1]

Co-authors: Wenbin Lu[2], Philip Hopkins[3], Martin Pessah[4], Simona Pacuraru[1], Louis Siebenaler[5]

[1]University of Birmingham
[2]University of California, Berkeley
[3]California Institute of Technology
[4]Niels Bohr Institute, University of Copenhagen
[5]Leiden Observatory

Abstract: I will present progress in our theoretical understanding of tidal disruption events, which relies on a suite of interlinked first-principles simulations to robustly study some of the most crucial phases of their evolution and the accompanying radiation. By simulating the evolution of a two-dimensional section of the returning debris stream during pericenter passage, we were able to resolve the strong compression of this gas and resulting nozzle shock, finding that it does not impart significant net stream expansion. Using local simulations, we show that the collision of the stream with itself causes a self-crossing shock that launches a large-scale outflow. Treating this outflow through gas injection inside a larger computational domain, we followed its subsequent evolution with radiation-hydrodynamics simulations. We find that multiple circularizing shocks take place that lead to the rapid formation of an accretion disc, while the generated radiation diffuses through the outflowing gas envelope. Emission from the disc likely results in the detectable X-ray radiation, and we propose that these photons are reprocessed by the surrounding envelope to eventually emerge at optical wavelengths. This work paves the way towards a full characterization of the electromagnetic signatures from tidal disruption events that can be used to optimally exploit the upcoming wealth of observations.

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Title: Elliptical Accretion Disk Modeling: Distinguishing AGN and TDE Disk Structures

Author: Nicholas Earl[1]

[1]University of Illinois Urbana-Champaign

Abstract: The interaction between active galactic nuclei (AGN) and tidal disruption events (TDEs) is crucial for understanding repeating nuclear transients (RNTs), including X-ray quasi-periodic eruptions and episodic mass transfer events. Accretion disk structure should differ significantly between AGN and TDEs, yet both can exhibit double-peaked broad emission line profiles, indicating disk-driven emission. While elliptical accretion disk models have been applied to individual TDEs, we now extend this approach to a larger sample using a new framework built on the probabilistic programming library NumPyro and the JAX framework, enabling efficient Bayesian inference and hardware-accelerated computation. Applying this framework to a broader population of AGN and TDEs, we search for differences in their accretion dynamics and disk structures that provide insight into the mechanisms driving variability in these systems. Understanding how AGN and TDEs interact is crucial, as their disk properties may influence RNT behavior, helping disentangle the physical processes underlying extreme nuclear transients.

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Title: Tidal Disruption of Stars in Active Galactic Nuclei: The Role of Orbital Inclination and Schwarzschild Precession

Author: Minghao Zhang[1]

Co-authors: Wenda Zhang[1]

[1]National Astronomical Observatories, Chinese Academy of Sciences

Abstract: Tidal disruption events (TDEs) occur when a star enters the tidal radius of a supermassive black hole (SMBH), producing a flare that lasts for months. Several TDE-like flares are observed in active galactic nuclei (AGN), indicating that TDEs can also take place in SMBHs with existing accretion disks where traditional TDE theories are limited for either comprehensive understanding of the dynamical processes or identification of these events. Using the meshless hydrodynamics code GIZMO, incorporating radiative cooling and general relativistic effects, we simulated TDEs of stars with different orbital inclination angles relative to the AGN disk under both Keplerian potential and Schwarzschild metric to understand their impact on both hydrodynamics and radiative features. Key Findings include: (1) The flare of disk-TDE originates from the dissipation of kinetic energy of both the debris and the disk via stream shock. The orbital configuration influences the severity and duration of stream collisions, affecting energy conversion and the shapes of the light curves. For a retrograde orbit of the star, the flare has a sharper rise and fall, with a peak luminosity several times higher and a duration several times shorter than that of a prograde orbit. (2) For close-in disruption of main-sequence stars with pericenter distance $R_p < 100R_g$, apsidal precession of the debris is non-negligible since it alters the stream collision process and further influence the predictions of radiative features. (3) With radiative cooling and a misaligned orbit, the inner AGN disk can either be cleared and refilled or tilted, depending on the initial setup of angular momentum, potentially causing a temporary dip in radiation from the inner disk. Our simulations could offer valuable implications for identifying TDE-like flares in AGNs and explain some observational features in AGN TDEs.

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Title: Precessing disk in a tidal disruption event candidate J0456-20

Author: Jinhong Chen[1]

Co-authors: Lixin Dai[1], Kan Cheuk Kwan[1], Thomsen Lars Lund[1], Zijian Zhang[1], Kwan Tom Man[1]

[1]University of Hong Kong

Abstract: Tidal disruption event (TDE) occurs when a star approaches close to a massive black hole. Initially, the stellar orbit may not align with the black hole's spin direction, leading to a tilted disk formation relative to the black hole. The Lense-Thirring effect subsequently induces disk precession. Here, we develop a precessing super-Eddington TDE disk model based on simulation results and compute the spectra from various viewing angles. As the disk precesses, the viewing angle varies over time, causing the light curve to evolve periodically. We apply our precessing disk model to fit the TDE candidate J045650.3-203750, which demonstrates a long-term decay accompanied by superimposed short-term quasi-periodic X-ray variability. Our findings reveal that the precessing disk model can interpret the X-ray and UV light curves of this source with a precession period of approximately 200 days.

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Title: A Tidal Disruption Event from an Intermediate-Mass Black Hole Revealed by Comprehensive Multi-wavelength Observations

Author: Jialai Wang[1]

Co-authors: Mengqiu Huang[1] , Yongquan Xue[1], Ning Jiang[1], Shifeng Huang[1], Yibo Wang[1], Jiazheng Zhu[1], Shifu Zhu[1], W. N. Brandt[2], Lixin Dai[3], Chichuan Jin[4], Bin Luo[5], Xinwen Shu[6], Mouyuan Sun[7], Tinggui Wang[1], Fan Zou[8]

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[3]The University of Hong Kong
[4]National Astronomical Observatories, Chinese Academy of Sciences
[5]Nanjing University
[6]Anhui Normal University
[7]Xiamen University
[8]University of Michigan

Abstract: Tidal disruption events (TDEs) occur when a star crosses the tidal radius of a black hole (BH) and is ripped apart, providing a novel and powerful way to probe dormant BHs over a wide mass range. In this study, we present our late-time observations and comprehensive multi-wavelength analyses of an extraordinary TDE at the center of a dwarf galaxy, which exhibited successive flares in the optical, X-ray, and radio bands. Notably, the well-sampled X-ray light curve reveals an unprecedented prolonged rise lasting at least 550 days and an unexpected newly discovered high-state plateau phase following the peak until the present time. These unique characteristics are consistent with the scenario of a TDE caused by an intermediate-mass black hole (IMBH) with a mass of ~ 10^5 solar masses. Furthermore, scaling relations derived from the host-galaxy properties indicated a similar BH mass in concert. This discovery highlights the invaluable role of TDEs in the search for elusive IMBHs.

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Title: Are AT 2019ehz and AT 2024doo TDEs Around SMBH Binaries?

Author: Sara Faris[1]

[1]Tel Aviv University

Abstract: I will present our observations and analysis of the UV-optical light curves of the TDEs AT 2019ehz and AT 2024doo which show significant post-peak structure: AT 2024doo exhibits at least three distinct luminosity bumps in the decline, while AT 2019ehz shows a non-smooth decline and a re-brightening around 250 days after peak. AT 2019ehz also exhibits luminous short X-ray flares at multiple epochs (at least one of which is coincident with a bump in the optical light curve). The optical-UV light curve features of both events are consistent with some models of tidal disruptions around SMBH binaries.

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Title: Origin of stellar orbits in QPEs and repeating partial TDEs

Author: Wenbin Lu[1]

[1]Universift of California, Berkeley

Abstract: QPEs and repeating partial TDEs are consistent with the picture of a star in a close orbit around a supermassive black hole. We discuss the origin of such orbits based on the Hills mechanism where binary stars are tidally broken up leaving one star bound to the black hole and the other one ejected as a hyper-velocity star.

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Title: Repeating partial disruptions and two-body relaxation

Author: Luca Broggi[1]

Co-authors: Nicholas C. Stone[2], Taeho Ryu[3], Elisa Bortolas[4], Massimo Dotti[1], Matteo Bonetti[1], Alberto Sesana[1]

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[3]Max Planck Institute for Astrophysics
[4]INAF - Osservatorio Astronomico di Padova

Abstract: Two-body relaxation may drive stars onto near-radial orbits around a massive black hole, resulting in a tidal disruption event (TDE). In some circumstances, stars are unlikely to undergo a single terminal disruption, but rather to have a sequence of many grazing encounters with the black hole. It has long been unclear what is the physical outcome of this sequence: each of these encounters can only liberate a small amount of stellar mass, but may significantly alter the orbit of the star. We present our study on the phenomenon of repeating partial tidal disruptions (pTDEs) based on a semi-analytical model that accounts for mass loss and tidal excitations. In the empty loss cone regime, where two-body relaxation is weak, we show how to estimate the number of consecutive partial disruption that a star can undergo, on average, before being significantly affected by two-body encounters. In this empty loss cone regime, a star will be destroyed in a sequence of weak pTDEs, possibly explaining the tension between the low observed TDE rate and its higher theoretical estimates.

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Title: New Surprises from Radio Observations of TDE Outflows

Author: Kate Alexander[1]

[1]University of Arizona

Abstract: 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 and other nuclear transients, including results from the first VLA Large Program dedicated to their study. These data reveal 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.

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Title: The radio properties of 22 eROSITA X-ray selected tidal disruption event candidates

Author: Adelle Goodwin[1]

Co-authors: J. Miller-Jones[2], G. Anderson[2], I. Grotova[3], A. Rau[3], A. Malyali[3], Z. Liu[4], P. Baldini[3], M. Salvato[3]

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[2]Curtin University
[3]Max Planck Institute for Extraterrestrial Physics (MPE)
[4]University of Hertfordshire

Abstract: Radio observations of tidal disruption events (TDEs) are essential for probing synchrotron emission from electrons that are accelerated in the shocks formed from outflows. However, < 30 TDEs have published radio detections so the origin of these outflows is still under debate, with scenarios including accretion disk winds, weak radio jets launched by accretion onto the SMBH, or collisions between debris streams. Some events have even displayed unexplained late-time radio flares years after the disruption. Optically-discovered TDEs dominate the TDEs that have been followed up in radio to date, but given the apparent link between X-ray and radio emission seen in other accreting black hole systems, a study of the radio properties of an X-ray selected sample is required to determine if there is a link between radio outflows and strong accretion. The eROSITA all-sky surveys allowed the search for and identification of many X-ray bright TDE candidates. In this talk I will present an overview of our systematic radio follow-up of the eROSITA TDE "golden sample" with the Australian Compact Array Telescope (ATCA). I will discuss the prevalence of radio emission from bright X-ray TDEs, any link between X-ray and radio bright emitters, the properties of the outflows launched, and a comparison to radio properties of an optically-selected sample. Interestingly, none of the X-ray selected events in our sample show late rising radio emission, compared to 45% of radio-detected sources of an optically-selected sample. I propose that this may indicate that many TDEs launch radio outflows at or near peak X-ray luminosity, which can be significantly delayed from peak optical luminosity. This study presents the first systematic analysis of the radio properties of an X-ray selected sample of TDEs, and gives insight into the possible link between the physical processes that power X-ray and radio emission in TDEs.

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Title: Origins of late time radio flares in tidal disruption events

Author: Tatsuya Matsumoto

[1]Kyoto University

Abstract: Recent radio observations revealed that a significant fraction of tidal disruption events (TDEs) are accompanied by late-time radio flare 1000 days after their optical discovery. One possible origin of the flares is a relativistic jet viewed from an off-axis direction. Relativistic beaming effect initially suppresses the radio flux for an off-axis observer, and as the jet decelerates, the radio flux rises rapidly. However, such evolution of the radio light curve can also be explained by other scenarios such as delayed Newtonian outflows. In this talk I will propose a superluminal motion of a radio source as a smoking gun of the off-axis scenario. Beginning with a brief explanation of calculations for light curve and radio sky map, I will discuss under what conditions we can detect the superluminal motion and how we can constrain parameters.

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Title: Radio beasts and where (and when) to find them - a study of the first radio-bright off-nuclear TDE

Author: Itai Sfaradi[1]

Co-authors: Raffaella Margutti[1], Ryan Chornock[1], Kate Alexander[2], Yuhan Yao[1]

[1]University of California, Berkeley
[1]University of Arizona

Abstract: Tidal Disruption Events (TDEs), the disruption of stars by the tidal forces of a Super-Massive Black Hole (SMBH), are offering a unique real-time opportunity to examine processes related to SMBHs and their interaction with their environments. So far, radio observations of TDEs revealed diverse properties, from the formation of relativistic jets to the interaction of an outflow material with the circum-nuclear material (CNM), and even a possible association with neutrino emission. The new discovery of an off-nuclear TDE located 0.8 kpc from its host's nucleus (Yao et al. 2025) offers a unique opportunity to probe the physical properties of an otherwise dormant, off-nuclear, SMBH and its environment. I will present, for the first time, the remarkable evolution of the radio emission from this TDE which allowed us to study the density profile around an off-nuclear SMBH, and the micro-physical processes governing the radio-emitting outflow (Sfaradi et al. in preparation).

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Title: Study of the radio transient population

Author: Magdalena Kunert-Bajraszewska[1]

Co-authors: Aleksandra Krauze[1] , Naqsh Zafar[1], Kunal Mooley[2,3], Preeti Kharb[4], Amy Kimball[3], Daniel Stern[2], Dorota Kozieł-Wierzbowska[5], Łukasz Stawarz[5]

[1]Institute of Astronomy, NCU
[2]California Institute of Technology,
[3]National Radio Astronomy Observatory
[4]National Centre for Radio Astrophysics - Tata Institute of Fundamental Research
[5]Jagiellonian University,

Abstract: Modern optical-UV time-domain surveys have led to the discovery of two types of variable accretion onto supermassive black holes (SMBHs), both of which can result in the formation of radio jets. On one hand, the tidal disruption of a passing star by a dormant SMBH leads to transient accretion of stellar debris. On the other hand, a class of "changing-state" AGN is characterized by spectral state transitions, which can be explained by intrinsic changes in accretion properties. However, until recently, such observations in the radio range have been rather limited. The advent of modern radio time-domain surveys, such as the Caltech-NRAO Stripe 82 Survey (CNSS) and the ongoing Very Large Array Sky Survey (VLASS), has opened new possibilities. Using these surveys, we discovered a group of objects that appeared as new radio sources after two decades of absence. These objects are transient phenomena relative to previous radio surveys and, following a significant increase in radio luminosity, have been classified as radio-loud. We suggest that, for the vast majority of our sources, the radio transient emission event is likely caused by intrinsic changes in accretion properties, similar to what is observed in changing-state AGNs. However, we cannot rule out the possibility that a few of our sources may belong to the rare class of radio-emitting tidal disruption events (TDEs). We present a comprehensive multi-epoch and multi-wavelength study of these objects. Additionally, based on our analysis, we propose a simple diagnostic diagram that could serve as a useful tool for distinguishing between radio transients caused by TDEs and those originating from intrinsic AGN variability.

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Title: Exploring galactic nuclei with tidal disruption events

Author: Brenna Mockler[1]

[1]Carnegie Observatories

Abstract: Tidal disruption events provide windows into the hearts of galaxies, teaching us about stellar and galaxy evolution at size scales that are difficult to probe observationally outside our own galactic neighborhood. For example, recent observations of these transients have shown evidence for higher mass and higher metallicity stellar populations in the centers of galaxies – suggesting that the dense, dynamic galactic nuclei environment influences the birth and evolution of stars. I will give an overview of ongoing work to combine observations with theoretical models to use TDEs both to probe stellar populations in the extreme environment around the supermassive black hole and to connect them to large-scale changes in the galaxy such as star formation and merger history

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Title: The Utility of Coronal Line Emitters as Probes of Tidal Disruption Event Physics

Author: Jason Hinkle[1]

Co-authors: Benjamin Shappee[1], Katie Auchettl[2], Athena Engholm[1]

[1]Institute for Astronomy, University of Hawaii
[2]University of Melbourne

Abstract: Recent studies have shown that coronal line emitters (CLEs), transients with high ionization (>100 eV) emission lines in their spectra, are tidal disruption events (TDEs) occurring in gas-rich environments. In this talk, I will discuss the evidence for this physical connection and explore the ways in which CLEs are promising laboratories of TDE physics. In particular, I will highlight three key opportunities: (1) the use of coronal line emission to uncover obscured X-ray emission from TDEs, (2) the unique ability of CLEs to probe the unobservable EUV SED of TDEs, and (3) how CLEs allow us to examine the circumnuclear environments of otherwise-quiescent supermassive black holes. Finally, I will draw connections between CLEs and the diverse body of nuclear transients including ambiguous nuclear transients and quasi-periodic eruptions.

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Title: The Observed Delay Time Distribution of TDEs

Author: Margaret Shepherd[1]

Co-authors: K. Decker French[1]

[1]University of Illinois at Urbana-Champaign

Abstract: To investigate the stellar environment around supermassive black holes, we study a sample of tidal disruption event (TDE) host galaxies with the goal of determining why the rate of TDEs is enhanced in post-starburst (PSB) galaxies. It is unknown which characteristics of the host galaxy; such as the stellar profile, gas structure, and central kinematics; determine the TDE rate. We construct a catalog of 40 TDE hosts and fit archival optical spectra using the stellar population synthesis code BAGPIPES to determine the TDE rate as a function of time since a burst of star formation, also known as a delay time distribution (DTD). We compare the observational DTD with theoretical DTDs for TDE rate enhancements, and find that no single model is a best fit to the data. We will present the comparison between our observed DTD and potential models that have been proposed for enhancing the TDE rate in PSB galaxies.

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Title: Peering into the photospheres of tidal disruption events: what causes their multi-wavelength emission?

Author: Hannah Wichern[1]

[1]DTU Space (Technical University of Denmark)

Abstract: By virtue of their short lifetimes of months to years, tidal disruption events (TDEs) are the key tracers of the dynamics in the inner regions surrounding supermassive black holes. As they emit radiation across the electromagnetic spectrum, they show erratic behaviour that is not easily understood in context of the - clearly diverse - total population. Specifically, it is unclear where the optical emission comes from, and if and how it is tied to their X-ray emission (which is likely accretion-powered). The optical radiation could be produced in self-intersection shocks of the debris stream, or formed through X-ray reprocessing in an envelope launched by winds and outflows. In the latter scenario, viewing angle effects and geometry may play an important role.

Polarimetry is the prime tool to study the photosphere geometry of transients such as TDEs . In this presentation I will present a sample of 19 TDEs with optical polarimetry data, which offers insights into the nature of their optical emission, as well as the ties between the X-ray evolution and the changes in geometry.

We find that most TDEs have continuum polarisation levels of P = 1 - 2%, which drop rapidly after peak light. Together with evidence from their polarisation spectra, this favours an electron scattering origin, supporting the X-ray reprocessing scenario. However, several events do not fit into this picture, and require alternative models yet to be explored. This talk aims to characterise the gap in our understanding of the diversity TDEs, a gap that may be filled in the future by combining multi-epoch polarimetry observations with improved polarisation predictions.

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Title: The clockwork outbursts of ASASSN-14ko: polarimetry of a repeating partial disruption event

Author: Beatriz Agís González[1]

Co-authors: K. Wiersema[2] , I. Liodakis[1] , D. Hutsemékers[3]

[1]Institute of Astrophysics - FORTH
[2]University of Hertfordshire
[3]Université de Liège

Abstract: ASASSN-14ko is a very special repeating nuclear transient, characterized by bright optical flares every 115 days, best explained as a repeating partial tidal disruption event (TDE). TDEs usually prefer dormant supermassive black holes (SMBHs). However, ASASSN-14ko is found in a system with not one, but two active galactic nuclei (AGN) separated by 1.7'. So far, the observational properties of the TDE population are far from homogeneous and what their differences reveal about the process of accretion disc formation are unknown. The two main competing theories produce almost identical total intensity signatures preventing progress through conventional methods. Instead, polarization offers new paths to understand the dynamics of the accretion flow and provides information on the orientation and geometry of the accretion disc. We will present novel photo- and spectro-polarimetry observations with FORS2@VLT following two consecutive flares of ASASSN-14ko. Our observations provide invaluable insight into accretion around supermassive black holes and new tests for state-of-the-art models.

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Title: Nuclear Transients in the Next Decade(s)

Author: Sjoert van Velzen[1]

[1]Leiden Observatory

Abstract: The next decade will be transformative for time-domain astrophysics, particularly in the study of nuclear transients such as tidal disruption events (TDEs) and quasi-periodic eruptions (QPEs). The Vera C. Rubin Observatory, through its Legacy Survey of Space and Time (LSST), will detect an unprecedented number of nuclear transients, expanding samples by an order of magnitude and thus enabling population studies across cosmic time. Complementing this, the Nancy Grace Roman Space Telescope will provide deep infrared imaging and time-domain surveys, offering key insights into obscured and high-redshift nuclear transients. Synergies between Rubin, Roman, and other facilities - such as X-ray observatories (e.g., Athena), radio telescopes (e.g., MeerKAT, DSA2000, ngVLA, SKA), plus gravitational-wave detectors and neutrino telescopes - should allow for a multi-wavelength, multi-messenger approach to nuclear transient discovery and classification. These combined capabilities will enhance our ability to identify rare events and uncover new kinds of nuclear variability. This talk will explore the discovery space enabled by future surveys, highlighting the challenges and opportunities.

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Title: Discovering periodic and repeating nuclear transients in the XMM-Newton archives

Author: Natalie Webb[1]

Co-authors: Dacheng Lin[2], Matteo Bachetti[3], Olivier Godet[1], Erwan Quintin[4], Robbie Webbe[1], Norman Khan[1], Vincent Foustoul[1], Lydie Roosens[1]

[1]Institut de Recherche en Astrophysique et Planétologie
[2]North Eastern University
[3]Cagliari Astronomical Observatory
[4]European Space Agency - ESAC

Abstract: The regions around massive black holes can show X-ray variability on timescales from seconds to decades. Observing many black holes over different timescales can enhance our chances of detecting variability coming from (partial) tidal disruption events, massive black hole binaries, changing state AGN, blazar activity and much more. I will talk about work that has been done to fully exploit the whole of the XMM-Newton archive to identify these phenomena and present plans for the upcoming XMM-Newton X-ray catalogues.

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Title: Needle in a Poissonian haystack - An X-ray astronomer's guide for QPE fishing

Author: Erwan Quintin[1]

Co-authors: N. Webb[2], N. Khan[2]

[1]European Space Agency - ESAC
[2]Institut de Recherche en Astrophysique et Planétologie

Abstract: After six years of studies following the discovery of GSN069, a link is starting to appear between the elusive Quasi-Periodic Eruptions and other types of nuclear transients, among which are Tidal Disruption Events. As such, observing strategies are adapting, with a current trend focusing on late-time X-ray follow-ups of (optical) TDEs.

While these campaigns are so far proving quite successful, the inherent confirmation bias they introduce in our sample could lead the community to hasty, and perhaps erroneous, conclusions. It is thus important to still pursue the search for nuclear transients in other, more agnostic directions. In this presentation, I will focus on the instrumental aspects of our field, and lay out two different methods we have deployed in order to reveal yet undetected serendipitous nuclear transients in XMM-Newton data.

These complementary methods enable the detection of long-term (years) and short term (minutes) transient events, that would have otherwise be missed by the standard detection pipelines. Both of these methods can be used either for data mining in the 25 years worth of archive, or to trigger real-time follow-ups upon a more recent discovery. I will show some of their initial results, including a confirmed QPE source in an optical TDE, and a faint new QPE candidate

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Title: Repeating Flares, X-ray Outbursts and Delayed Infrared Emission: A Comprehensive Compilation of Tidal Disruption Events

Author: Dimitrios Alkinoos Langis[1]

Co-authors: I. Liodakis[1] , K. Koljonen[2], A. Paggi[1], N. Globus[3,4], L. Wyrzykowski[5], N. Ihanec[5]

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Abstract: Tidal disruption events (TDEs) are prime laboratories for studying dormant black holes. However, progress has been hampered by the limited number of observed events. I will present a comprehensive catalogue of 133 confirmed TDEs (TDECat) discovered up to the end of 2024, accompanied by multi-wavelength photometry (X-ray, ultraviolet (UV), optical, and infrared) and publicly available spectra. Our compilation allowed us to discover six new potential repeating TDEs. The newly discovered repeating events show a variety of interesting features from sharp flares and extreme separations – up to 18 years between outbursts – to double-peaked flares suggesting potential binary star system disruptions. Intriguingly, in both new and archival repeating events the secondary flares appear to have the same shape as the primary, and 11 out of 12 events are accompanied by X-ray emission that varies from event to event. TDEcat enables large population studies across wavelengths and spectral classes, and provides essential tools for navigating the data-rich era of upcoming surveys.

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Title: Early identification of optical tidal disruption events with the Fink broker

Author: Etienne Russeil[1]

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Abstract: Detecting Tidal Disruption Events (TDEs) candidates early is essential for follow-up observations at peak brightness, enabling confirmation of their nature and a deeper understanding of their complex multi-wavelength behavior. TDEs are rare events, and their detection is one of the key goals of large ground optical facilities, such as the Zwicky Transient Facility (ZTF) and the upcoming Vera C. Rubin Observatory. However, managing their vast alert streams requires automated pipelines that identify the nature of the detected events. We introduce a module developed within the Fink alert broker, designed to enable the early identification of TDEs observed by ZTF. A first step consists in the automatic selection of light curves compatible with a rising transient scenario. It is followed by a tailored feature extraction based on a multi-band fit of the rising part of the light curves. It enables the computation of physically-motivated features, such as temperature and rise time, which are essential to distinguish TDEs from other long-lasting transients. Lastly, a Random Forest classifier is trained on a sample of high quality TDEs to construct a classifier. Despite the challenge offered by the highly imbalanced training dataset, the classifier provides good completeness and purity metrics.

During the development of this module, several promising candidates have been identified, including particularly rare events, such as repeated partial TDEs, or ones presenting infrared echoes. In this talk I will describe the construction of the pipeline, present in detail the identified candidates and discuss potential adaptations for the Rubin Observatory.

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Title: Massive Black Hole's be-messenger Science with LISA

Author: Elena Maria Rossi[1]

[1]Leiden Observatory

Abstract: The next decay will see the launch of the space mission LISA (Laser Interferometer Space Antenna). This is a space-based gravitational wave interferometer, and one of its main targets will be Massive Black Holes (MBH) Binaries and Extreme Mass Ratio Inspirals, where a stellar mass compact object revolves around an MBH and eventually falls into it. These sources are slow transients and can remain in the LISA band for weeks to years. This opens the exciting prospects of detecting electromagnetic signals before and after the merger. In this review talk, I'll present SMBH binaries and EMRIs as gravitational wave sources and emphasise possible electromagnetic and gravitational wave synergies and their scientific gain.

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Title: Extreme Mass Ratio Inspirals with LISA

Author: Alberto Sesana[1]

[1]Università di Milano Bicocca

Abstract: One of the many reasons why QPEs are exciting is that they might represent electromagnetic precursors of extreme mass ratio inspirals (EMRIs), a class of extremely interesting gravitational wave (GW) sources that will be among the primary targets of the Laser Interferometer Space Antenna (LISA). I this talk, I will describe the physics of EMRIs, their importance for probing astrophysics, cosmology and fundamental physics, and their connection with QPEs. If this connection is confirmed, QPEs can be used to learn about these GW sources and to forecast LISA potential, including the possibility of using EMRIs as multimessenger probes.

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Title: Cliffhanger EMRIs

Author: Nicholas Stone[1]

[1]University of Wisconsin-Madison

Abstract: Extreme mass ratio inspirals (EMRIs) are a long-standing gravitational wave (GW) science target for the LISA mission. More recently, EMRIs have attracted significant interest as possible sources of electromagnetic radiation as well, via the phenomenon of star-disk collisions. However, both event rates and parameters for EMRIs are highly uncertain, with theoretically predicted rates spanning multiple orders of magnitude. A key uncertainty in the computation of EMRI rates is the 'plunge-to-EMRI ratio,' the amount by which direct plunges outnumber true, GW-luminous EMRIs. The classic understanding of this ratio is that only compact objects originating on highly bound orbits can become true EMRIs; the much larger number of compact objects originating from more loosely bound orbits will plunge without significant GW emission, and without the chance to produce quasi-periodic eruptions from a sustained interaction with an accretion disk. We have recently shown that this classic dichotomy can break down severely for (i) smaller massive black holes, (ii) larger secondary black holes, or (iii) rapidly spinning massive black holes. In all of these cases, a 'cliffhanger EMRI' may result, in which a trajectory that naively should plunge undergoes a transition to become a true EMRI. I will discuss how this new category of EMRIs will operate, and how it may change the composition of the both the vacuum LISA sample and the sample of compact object-disk collisions.

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Title: Supermassive black hole with a stripped subgiant companion as a gravitational wave source detectable by LISA

Author: Aleksandra Olejak[1]

Co-authors: Jakob Stegmann[1], Selma E. de Mink[1], Ruggero Valli[1], Re'em Sari[2] and Stephen Justham[1]

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Abstract: Stars orbiting supermassive black holes (SMBHs) at sufficiently close distances can avoid tidal disruption, instead evolving into a regime dominated by gravitational wave (GW) emission. This process causes their orbits to shrink and circularize. Recent studies suggest that, on average, once per million years in a typical galaxy, some of these stellar inspirals may initiate mass transfer (MT) to the SMBH while on nearly circular orbits. Systems undergoing or emerging from a stable MT phase could become bright GW sources detectable by the Laser Interferometer Space Antenna (LISA). However, the stability and duration of this MT phase remain poorly understood. In this work, we investigate the evolution of a low-mass, early subgiant star transferring mass to an SMBH companion on a circular orbit. We find that early-type, slightly expanded subgiants can sustain a prolonged and stable MT phase, even when no angular momentum is returned to the orbit to counterbalance GW-driven orbital decay. These subgiant stars begin mass transfer before entering the LISA band and lose their hydrogen envelopes during the MT phase, forming compact helium cores. These cores subsequently undergo a sustained GW-driven inspiral. The frequency and amplitude of GW emissions from such systems make them highly promising for LISA detection. If located in the Galactic Center, such systems would be detectable by LISA for over 100,000 years, achieving extreme signal-to-noise ratios (SNRs) exceeding 1,000,000. Based on formation rates and detectability from various distances, we estimate that LISA could discover up to ten such events from post-MT subgiant cores during its 4-year mission. The probability of hosting this type of system in the Milky Way, however, remains low (~1%).

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Title: Searching for Binary Supermassive Black Hole candidates in ZTF optical Light Curves

Author: Santiago Rios[1]

[1]Universidad de Chile

Abstract: Detecting and quantifying binary black hole (BBH) mergers is essential for deepening our understanding of galaxy formation and evolution. These detections provide insight into potential black hole growth pathways, the frequency of such events, and their role in the broader context of black hole growth. In this study, we aimed to detect periodic or quasi-periodic oscillations (QPOs) in the optical light curves of Seyfert galaxies (z¡0.5) using aperture photometry applied to difference images provided by the Zwicky Transient Facility (ZTF). To identify potential candidates, we conducted a Bayesian analysis and evaluated its robustness through simulations of light curves based on Damped Random Walk (DRW) and DRW+QPO models, based on the observed properties of ZTF light curves. Our simulations showed that the Bayesian approach effectively recovers input periods for light curves with higher QPO amplitudes. Additionally, we identified 10 real candidates exhibiting periodic and quasi-periodic behaviour. These results highlight the utility of Bayesian analysis in detecting QPOs in optical light curves, particularly in cases where QPO amplitudes are significant

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Title: A sample of good milliparsec separation massive black hole binaries

Author: Vincent Foustoul[1]

Co-authors: N. A. Webb[1], R. Mignon-Risse[2], E. Kammoun[3], M. Volonteri[4], C. A. Dong-P´aez[1]

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[4]Institut d'Astrophysique de Paris

Abstract: Whilst stellar mass black holes form at the end of the lives of massive stars, the formation of supermassive black holes is less clear. The detection of high-mass quasars at redshifts greater than 7 make it difficult to reconcile their origin with stellar mass black hole seeds. Different possibilities are possible to explain their emergence; accretion, mergers or intermediate mass black hole seeds, or a combination of two or three of those scenarios. The recent plausible detection of gravitational waves at nanoHz by Pulsar Timing Arrays hints at the ability of relatively low redshift (1-2) supermassive black holes to form tight binaries. A few dual AGN or massive black hole binaries (MBHBs) with kiloparsec separation have been discovered but observational evidence for close sub-parsec separation MBHBs is weak. Such systems are expected to display detectable periodic oscillations in the optical/UV, due to the accretion flow in the binary. We conducted a systematic search for sub parsec separation MBHBs, looking for sinusoidal variations in optical lightcurves using Catalina Real-Time Transient Survey (CRTS) and Zwicky Transient Facility (ZTF) data and found 36 good candidates showing between 3 and 5 cycles. We confirmed their periodic variability using several methods and tested their modulation with a red noise process, usually observed in AGN. Also, considering the redshift of these candidates, the number density we find is in agreement with predictions from simulations. The X-ray flux of the candidates, when available, hints that they are high-accreting objects, as expected from MBHBs. Moreover, we created a catalog of 221 weaker candidates that would require additional observations. In addition, thanks to joint XMM-Newton and NuSTAR observations, we study the X-ray spectrum of one of the best candidates that we propose, revealing further evidence to the MBHB possibility. Considering the mass and period of the candidates, they will not be detected as individual events by the next space-based gravitational wave observatory LISA, however they might still contribute to the gravitational background.

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Title: Quasi-Periodic Oscillations around Supermassive Black Holes

Author: Megan Masterson[1]

[1]Massachusetts Institute of Technology

Abstract: Our expectations for how matter accretes onto supermassive black holes (SMBHs) are rapidly evolving in the era of time-domain astrophysics, thanks in part to the increased number of short-timescale, quasi-periodic events around SMBHs. In this talk, I will focus on quasi-periodic oscillations (QPOs), which arise from coherent variability and can provide insight into the innermost regions of the accretion flow. I will present a history of X-ray QPOs around SMBHs, highlighting their connection to the more abundantly observed QPOs in black hole X-ray binaries. In addition, I will also show where these connections break, including in the recent discovery of a mHz frequency X-ray QPO in 1ES 1927+654, an extreme accreting SMBH that underwent a major optical, UV, and X-ray outburst beginning in 2018. The QPO was first detected in 2022 at an 18-minute period, and over the next 3 years, the QPO period dropped to 7 minutes and stabilized there. This dramatic evolution in the QPO period has never been seen in SMBH QPOs nor in high-frequency QPOs in stellar-mass black holes. To highlight the importance of this discovery, I will discuss its connections to the recently-discovered quasi-periodic eruptions (QPEs) and the prospects for next-generation X-ray and gravitational wave synergies.

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Title: An Interconnected Evolution of X-ray QPO and its modulation in RE J1034+396

Author: Ruisong Xia[1]

[1]University of Science and Technology of China

Abstract: The X-ray quasi-periodic oscillation (QPO) is a remarkable form of variability in systems of compact object accretion. RE J1034+396, harboring the most significant X-ray QPO in active galactic nuclei (AGNs), is the most noteworthy source for in-depth analysis of AGN X-ray QPO properties. A long-term evolution of its QPO has been observed over the course of the observations. However, the short-term variability of its QPO properties remains unexplored within each observation that has long good time intervals (GTIs). We collect 12 XMM-Newton observations of RE J1034+396 with GTIs longer than 60 ks from publicly available data and conduct a detailed wavelet analysis focusing on the short-time modulation of the QPO. The QPO signals are found to undergo amplitude modulation in both the soft and hard bands, with a typical timescale of 17 ks. The soft flux is significantly higher when the hard QPO is present. They are highly correlated, with an average cross-correlation function (CCF) peak coefficient of 0.61 and a lag of approximately 3 ks. This novel finding provides fresh insights into the potential connection between the components of the corona emitting soft and hard X-ray photons. The CCF lag between the soft flux and the hard QPO evolves across the observations, potentially sharing the same origin as the previously observed interconnected evolution between QPO frequency and time lag.

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Title: A new X-ray variable Bowen Fluorescence Flare and Extreme Coronal Line Emitter discovered by SRG/eROSITA

Author: Pietro Baldini[1]

[1]Max Planck Insitute for Extraterrestrial Physics

Abstract: Tidal disruption events (TDEs) can reveal dormant supermassive black holes (SMBH), and allow us to probe the ignition, evolution, and exhaustion of accretion flows. eRASSU J012026-292727 (J012026) is a new X-ray-selected TDE candidate discovered in the second eROSITA all-sky survey. Initially detected as a bright, soft X-ray source, J012026 exhibited unusual X-ray flaring activity on both short (hour-) and long (year-) timescales. In particular, the short-timescale X-ray flares, which seemed to recur every 16 hours, appear similar to quasi-periodic eruptions, showing typical harder-when-brighter behavior. However, follow-up observations seem to dismiss this scenario. We also detected a strong mid-infrared flare, evolving over 2 years, and a weaker optical counterpart, with possible hints of a rise >3 years before discovery. Follow-up optical spectroscopy revealed transient features, including redshifted Balmer lines, FeII, HeII, Bowen fluorescence lines, and high-ionization coronal lines such as [FeX] and [FeXIV]. The spectroscopic features and the slow evolution of the event place J012026 within the class of Bowen fluorescence flares (BFFs) and extreme coronal line emitters (ECLEs). BFFs have been connected to rejuvenated accreting SMBH, although the mechanism triggering the onset of the new accretion flow is yet to be understood. Additionally, ECLEs have been associated with TDEs in gas-rich environments. The association of J012026 to both classes, combined with the multi-wavelength information, supports the idea that the BFF emission could be, at least in some cases, triggered by TDEs perturbing high gas density environments. The observed short- and long-term X-ray variability, uncommon in standard TDEs, adds complexity to these families of nuclear transients. These results highlight the diverse phenomenology of nuclear accretion events and their lightcurves and demonstrate the value of systematic X-ray surveys for uncovering such them and characterizing their physical origin.

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Title: Back from the dead: The Neutrino Source AT2019aalc as a Candidate Repeating TDE in an AGN

Author: Patrik Milan Veres[1]

[1]Ruhr University Bochum

Abstract: AT2019aalc is one of the few nuclear transients associated with high-energy neutrino events detected by the IceCube Observatory. Initially classified as a TDE-like flare with a prominent infrared dust echo, this transient underwent a remarkable re-brightening in 2023/2024, offering a great opportunity to further investigate its nature. We conducted an extended multi-wavelength monitoring campaign, spanning from radio to X-rays. Our observations reveal a uniquely bright UV counterpart, recurring soft X-ray flares, gradually declining optical emission, a long-lasting radio flare, and AGN-like optical spectrum featuring emission lines driven by the Bowen fluorescence mechanism. Based on these characteristics, we classify AT2019aalc as a Bowen Fluorescence Flare (BFF). Moreover, due to the strong high-ionization potential coronal lines we also classify it as an Extreme Coronal Line Emitter (ECLE). We conclude that the second optical/UV flare of AT2019aalc is powered by recurrent soft X-ray accretion flares, likely resulting from a partial tidal disruption event in a pre-existing active galactic nucleus. In my talk, I will present the key findings from our observational campaign and discuss their implications for understanding the leading mechanisms driving BFFs. Furthermore, I will highlight the connection between another BFF, AT2021loi, and a high-energy neutrino event.

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Title: The Star Formation Histories of CL-AGN Host Galaxies Revealed with Prospector

Author: Margaret Verrico[1]

Co-authors: K. Decker French[1]

[1]University of Illinois Urbana-Champaign

Abstract: Changing-look active galactic nuclei, or CL-AGN, are AGN which appear to transition between Seyfert Type 1 and 2 over periods of months to years. Several mechanisms to trigger these transitions have been proposed, but we have yet to conclusively determine their cause. Recent studies suggest CL-AGN are hosted primarily in galaxies which are shutting down star formation (e.g. Dodd et al. 2021; Liu et al. 2022; Wang et al. 2023), which may indicate a link between galaxy quenching and changing look events. We use Prospector Stellar Population Synthesis software to model non-parametric star formation histories for 53 CL-AGN host galaxies. In this work, we find that CL-AGN host galaxies are mostly star forming or in the Green Valley and that CL-AGN host galaxies follow a similar distribution in specific star formation rate to other AGN host galaxies. We find that CL-AGN are not more likely to occur in post-starburst galaxies, indicating a distinct host galaxy population from tidal disruption events.

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Title: Improving transient identification with Swift-XRT

Author: Srijan Srivastava[1]

Co-authors: Phil Evans[1]

[1]University of Leicester

Abstract: The Living Swift-XRT Point Source Catalogue (LSXPS) is a unique facility, updated in near real-time, enabling a sensitive, “live” search for new high-energy transients. This capability opens a new area of transient phase-space for exploration, as evidenced by the LSXPS discovery of Swift J0230, a unique repeating X-ray transient thought to be a partial tidal disruption event (TDE). Swift J0230’s quasi-periodic eruptions (QPEs) with a 25-day cycle make it significantly longer than typical QPEs, underscoring LSXPS’s potential for uncovering new classes of astrophysical phenomena. However, the majority of transient candidates detected are faint, classified as “low significance” transients within LSXPS. Identifying which of these are truly transient, particularly near the XRT detection limit where Eddington bias becomes significant, remains a major challenge. We present a simulation-based approach which yields confidence intervals on source flux, corrected for the Eddington bias and accounting for the increasing number-density of sources at lower fluxes. This enables more reliable identification of true transients and rejection of those whose apparently increased flux is a measurement effect. Currently, LSXPS has detected approximately 8000 transients, with about 2400 classified as low significance. Improving the categorization of even 10% of these detections could significantly enhance the catalog’s quality and reliability. This technique will soon be integrated into the real-time LSXPS analysis, improving transient detection rates and impacting high-energy transient astronomy in the Time-Domain and Multi-Messenger (TDAMM) era.

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Title: The effect of relativistic precession on light curves of tidal disruption events

Author: Diego Calderón[1]

Co-authors: Ondřej Pejcha[2], Brian D. Metzger[3], Paul C. Duffell[4], Stephan Rosswog[5]

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[5]University of Hamburg

Abstract: The disruption of a star by the tidal forces of a spinning black hole causes the stellar stream to precess, affecting the conditions for triggering the tidal disruption event (TDE). In this work, we study the effect that precession imprints on TDE light curves due to the interaction of the TDE wind and luminosity with the stream wrapped around the black hole. We perform two-dimensional radiation-hydrodynamic simulations using the moving-mesh hydrodynamic code JET with its radiation treatment module. We study the impact of black hole mass, accretion efficiency, and inclination between the orbital and spin planes. From our results, we identified two behaviours: (i) models with low-mass black holes (~10^6 Msun), low inclination (~0), and low accretion efficiency (~0.01) show light curves with a short early peak caused by the interaction of the wind with the inner edge of the stream. The line of sight has little effect on the light curve, since the stream covers a small fraction of the solid angle due to the precession occurring in the orbital plane; and (ii) models with high-mass black holes (>10^7 Msun), high inclination (~90°), and high accretion efficiency (~0.1) produce light curves with luminosity peaks that can be delayed by up to 50-100 d depending on the line of sight due to presence of the precessed stream blocking the radiation in the early phase of the event. Our results show that black hole spin and misalignment do not imprint recognizable features on the light curves but rather can add complications to their analysis. We will also discuss our efforts towards generating more realistic initial conditions based on three-dimensional general relativistic hydrodynamic modelling of stellar disruptions.

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Title: X-ray Quasi Periodic Oscillations in AGNs with XMM-Newton

Author: Alok C. Gupta[1]

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Abstract: In the present talk, I will report the detection of hour scale quasi periodic oscillations (QPOs) in the TeV emitting blazar PKS 2155 - 304 and narrow line Seyfert 1 (NLSy1) galaxy MCG-06-30-15 using observations from XMM-Newton. We used various analysis QPO detection analysis techniques to verify the results. We briefly discuss AGN models capable of producing an X-ray QPO in the blazar PKS 2155 - 304 and NLSy1 MCG-06-30-15.

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Title: A Systematic Search for X-ray Eclipse Events in Active Galactic Nuclei Observed by Swift

Author: Tianying Lian[1]

Co-authors: Chichuan Jin[1] and Weimin Yuan[1]

[1]National Astronomical Observatories, Chinese Academy of Sciences (NAOC)

Abstract: The nuclear regions of active galactic nuclei (AGNs) likely host clumpy clouds that occasionally obscure the central X-ray source, causing eclipse events. These events offer a unique opportunity to study the properties and origins of such clouds. However, these transient events are rarely reported due to the need for extensive, long-term X-ray monitoring for years. Here, we conduct a systematic search for eclipse events in 40 AGNs well-monitored by the Swift X-ray Telescope (XRT) over the past 20 years, comprising a total of ~11,700 observations. Our selection criteria rely on significant variations in X-ray flux and spectral shape. We identify 3 high-confidence events in 3 AGNs and 8 candidates in 6 AGNs, all in type I AGNs. The observed clouds have column densities of $N_H \sim (0.2 - 31.2) \times 10^{22}$ cm^{-2} and ionization degrees of log $\xi \sim (-1.1 - 2.4)$. For the 5 events with well-constrained duration, their distances from the central black hole range from $(2.4 - 179) \times 10^4$ R_g, with 2 clouds near the dust sublimation zone, 2 farther out. Interestingly, we find tentative correlations between the cloud properties (e.g. ionization state and column) and the black hole mass and mass accretion rate, implying their strong connection to the accretion process, potentially via outflows. Our study also demonstrates the potential of the new X-ray all-sky monitor Einstein Probe in providing more detection and physical constraints for such events.

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Title: A new 'old' TDE discovered in the Chandra archive

Author: Andrea Sacchi[1]

[1]CfA — Harvard & Smithsonian

Abstract: Tidal disruption events, systems exhibiting quasi-periodic eruptions, some changing look AGN, and other anomalous nuclear transients, when X-ray bright, are characterized by extremely soft and bright emission. Although these objects are rare phenomena amongst the population of X-ray sources, we developed an efficient algorithm to identify promising candidates in archival observations, exploiting their characteristic X-ray properties. In my talk, I will present the results of a search for hyperluminous supersoft X-ray sources in the recently released Chandra catalog. This archival search has been performed via both a manual implementation of the algorithm we developed and a novel machine-learning-based approach. This search identified a new tidal disruption event, which might have occurred in an intermediate-mass black hole. This event occurred between 2001 and 2002, making it one of the first tidal disruption events ever observed by Chandra.

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Title: AGN Pairs in CDFs

Author: Chen Qin[1]

Co-authors: Yongquan Xue[1]

[1]University of Science and Technology of China

Abstract: Galaxy interactions drive gas inflows which can fuel star formation and trigger supermassive black holes (SMBHs), forming AGN pairs. While optical spectroscopy from SDSS has identified most known AGN pairs, obscuration in mergers leads to selection biases. X-ray observations offer a more complete view but are limited by observational costs. The Chandra Deep Fields (CDFs), the deepest X-ray surveys, provide an ideal dataset for detecting faint and obscured AGNs with high spatial resolution. Using multiband data from CDFs, we study spectroscopically confirmed high-redshift merging systems. We find that AGN fractions and X-ray detection rates increase as galaxy separations decrease. Additionally, the previously observed low-redshift trend of X-ray luminosity first rising and then falling with decreasing separation also holds at high redshifts. These findings offer less biased insights into AGN triggering in galaxy mergers across cosmic time.

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Title: Probing Hidden Emission in Tidal Disruption Events: Insights from the Coronal Line Emitter ATLAS22kjn (AT2022fpx)

Author: Athena Engholm[1]

Co-authors: Jason Hinkle[1] and Benjamin Shappee[1]

[1]Institute for Astronomy - University of Hawaii

Abstract: Studies of tidal disruption events (TDEs) have long faced a 'missing energy problem,' with proposed solutions that are difficult to test observationally. However, recent discoveries of TDEs with coronal lines (CLs), characterised by ionisation potentials ¿ 100 eV, enable insight into the otherwise unobservable EUV and ultrasoft X-ray regimes of the TDE spectral energy distribution (SED). In this presentation, I will discuss a case study of the well-observed TDE ATLAS22kjn (AT2022fpx), and its broader implications for TDE emission. I will first introduce a novel method to model CL emission. This assumes a blackbody ionising continuum, allowing us to constrain the temperature of the unseen portion of the SED. I will then explore connections between CL and X-ray emission based on their consistent blackbody temperatures and temporal evolution. Finally, I will highlight the utility of multi-wavelength observations in probing SMBH environments. We additionally observe a MIR dust echo with a 210-day lag. From this lag time, we estimate the dust distance and find it comparable to the virial radius of the CL-emitting region, suggesting both trace the inner edge of a dusty torus. In future, our method for modelling the CLR of ATLAS22kjn can be applied to other TDEs with CLs. As evidenced by our study of ATLAS22kjn, the utility of CLEs motivates the need for rapid classification of TDE candidates to identify those with CLs and initiate follow-up that can reveal the environments of SMBHs and their active phases of accretion.

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