Time-Domain Astronomy: A High Energy View

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ABSTRACT BOOK

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Edited by

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Chapter 1

Invited Speakers

High Energy Emission and Its Variability in Young Stellar Objects

Costanza Argiroffi[1,2]
[1] *DiFC, University of Palermo*
[2] *INAF - Osservatorio Astronomico di Palermo*

Young stellar objects show a variety of highly energetic phenomena: on the one hand young stars are characterized by accretion and outflow processes, on the other hand young stars possess hot coronal plasmas in their outer atmosphere. Notably all these phenomena are regulated by the intense stellar magnetic fields. I will show how these phenomena are simultaneously responsible for the high energy emission from young stars, and how their individual contributions can be separated. I will present recent results obtained by pushing to the limit the capabilities of nowadays X-ray observatories, and by developing detailed MHD models. These results provide fundamental constraints on accretion stream properties, accretion geometries, coronal loop dimensions, coronal activity, and disk irradiation. I will finally discuss what are the open issues that need to be addressed. Understanding these phenomena will help in comprehending the interplay between magnetic field and matter in young stars, and eventually the exchange of mass, energy, and angular momentum between the central star and its circumstellar environment.

Understanding accretion in supermassive black hole binaries

Tamara Bogdanovic[1]
[1] *Georgia Institute of Technology*

Supermassive black hole binaries are thought to be a natural product of galactic mergers and growth of the large scale structure in the universe. They remain observationally elusive, thus raising a question about characteristic observational signatures associated with these systems. The question of observational signatures is on the other hand intimately related to the nature of accretion in supermassive black hole binaries. In my talk I will discuss how the ongoing theoretical efforts and observational searches contribute to our understanding of accretion and variability in supermassive black hole binaries.

An X-ray spectral-timing (re)view of the inner flow around accreting black holes

Barbara De Marco[1]
[1]*N. Copernicus Astronomical Center PAN*

X-ray variability is one of the main outcomes of accretion onto black holes. Though its origin is yet to be understood, X-ray variability is the fingerprint of processes occurring close to the central black hole, therefore it is a powerful probe of these regions. I will give an overview of results so far obtained by combining the X-ray timing and spectral information in an effort to further our understanding of the physics and geometry of the accretion flow around accreting black holes.

Variability of strongly magnetized neutron stars and how this helps us to understand these systems better

Felix Fuerst[1]
[1]*ESA/ESAC*

Strongly magnetised neutron stars show periodic and aperiodic variability on many time-scales. By obtaining spectral information on these different time-scales, we can obtain a closer look into the physics of accretion close to the neutron star and the properties of the accreted material.

I will talk about strong pulsations, i.e., the rotation of the neutron star itself. Over one rotation our view of the accretion column and X-ray producing region changes significantly, providing us on the one hand with different insights into this region, on the other hand, requiring that we have viewing-angle resolved models to properly describe the physics within the column.

In high-mass X-ray binaries the main source of aperiodic variability is the clumpy stellar wind, which leads to changes in accretion rate (i.e. luminosity) as well as absorption column. This variability allows us to study the behavior of the accretion column as function of luminosity, as well as allows us to investigate the structure and physical properties of the wind, which we can compare with winds in isolated stars. I will present new results of the archetypical source Vela X-1 with high-resolution spectroscopy and non-LTE stellar atmosphere codes, which provide deeper insight into the wind parameters.

Discovery and Opportunity in the X-ray Time Domain

Daryl Haggard[1]
[1] *McGill University/McGill Space Institute*

Ambitious X-ray observatories have enabled a rapid expansion in our knowledge of the X-ray time domain. With state-of-the-art facilities like Chandra, XMM Newton, and Swift performing surveys over a decade and counting, variability catalogs are increasingly rich. Meanwhile, high time resolution from the likes of NuSTAR and NICER (and RXTE before them) continue to uncover new physics in individual systems. These efforts have lead to the discovery of high-energy EM counterparts to the first binary neutron star merger detected via gravitational waves, a likely pulsar-ULX connection, possible magnetar oscillations, X-ray flares from the closest supermassive black hole, Sgr A*, and enabled reverberation mapping of AGN, to name only a few. I will review recent highlights from the X-ray time domain and briefly describe what we hope to achieve with upcoming and proposed X-ray missions.

Mapping the Transient Sky with Gaia

Simon Hodgkin[1]
[1] *Institute of Astronomy, Cambridge University*

Gaia is an ESA cornerstone mission, delivering precision photometry, astrometry, spectrophotometry, and spectroscopy, all based on regular image-scanning the sky through two telescopes and the largest focal-plane array (1Gpixel) yet launched. This by design makes the time-domain the heart of Gaia's scientific requirements and capabilities. Gaia is monitoring the sky with cadences of seconds (between CCDs), hours (between fields-of-view) and weeks (between visits), with real-time source detection implemented by a fixed, available, and well-understood on-board algorithm. Every Gaia source obtains near-simultaneous spectrophotometry.

The GaiaAlerts system has been running routinely and reliably since January 2016, publishing 6 transients per day (see http://gsaweb.ast.cam.ac.uk/alerts/home), using well-defined selection criteria. We scan the whole sky exploring into the Galactic plane and crowded regions which are typically hard to do from the ground. I will describe the challenges we face in searching through half a billion CCD measurements every day to identify and publish Gaias transient events. I will discuss the properties of the alerts published to date and highlight some of our most interesting discoveries. I will examine the completeness and biases in our selection criteria, and look ahead to future improvements in the system, including making the most of Gaias astrometry.

Machine Learning and Data Science in the Era of Survey Astronomy

Daniela Huppenkothen[1]
[1] *DIRAC, University of Washington*

Across almost all scientific disciplines, the instruments that record our experimental data and the methods required for storage and data analysis are rapidly increasing in complexity. This has been particularly true for astronomy, where current and future instruments produce data sets of a size and complexity not accessible with traditional methods. In this talk, I will focus on recent research in survey astronomy and present examples of how we can use modern computational tools, especially machine learning, to help us make sense of large-scale time series data sets. I will also discuss advantages and challenges associated with these methods.

Variability in deep fields

Elisabeta Lusso[1]
[1] *Centre for Extragalactic Astronomy, Department of Physics, Durham University, UK*

I will review the latest results on X-ray AGN variability in deep fields from XMM-Newton and Chandra and I will present the findings on the variability properties as a function of redshift, and physical parameters such as obscuration, black hole mass, and accretion rate. I will discuss how multi wavelength observations can provide further insights on the disk/corona properties and whether simultaneous optical/X-ray observations will help in determining tight correlations amongst physical parameters. Finally, I will discuss possible applications using these correlations by enlarging the current samples of AGN in future surveys.

Astronomy through the kaleidoscope

Matthew Middleton[1]
[1] *University of Southampton*

High energy observations (specifically those in the X-rays) provide a window into extreme environments such as those close to gravitationally compact objects, the formation of stars and even regions of particle acceleration in the gas giants of our solar system. Whilst compelling insights are gained by studying in a single band, the picture remains incomplete (and potentially misleading) without the inclusion of data from other bands sampling different physical processes. This somewhat obvious statement belies the difficulty inherent in performing such multi-wavelength campaigns, especially when they are time-critical (either constrained or requiring near simultaneity for variability studies). I will review some of the recent exciting multi-wavelength results, some of the difficulties that we face as a community and how we might seek to mitigate these as we move into the multi messenger/synoptic era.

Fast Radio Bursts

Emily Petroff[1]
[1] *ASTRON, Netherlands Institute for Radio Astronomy*

Fast radio bursts (FRBs) are quickly becoming a subject of intense interest in time-domain astronomy. FRBs have the exciting potential to be used as cosmological probes of both matter and fundamental parameters, but such studies require large populations. Advances in FRB detection using current and next-generation radio telescopes will enable the growth of the population in the next few years. Real-time discovery of FRBs is now possible with a significant number of FRBs now detected in real-time. I will discuss the developing strategies for maximising real-time science with FRBs as well as the properties of the growing FRB population. I will also discuss upcoming efforts to detect FRBs across the radio spectrum using a wide range of new and refurbished radio telescopes around the world and how these discoveries can inform next generation surveys and pave the way for the enormous number of FRB discoveries expected in the SKA era.

Can X-ray dust-scattering affect the GRB afterglows?

Fabio Pintore[1], Andrea Tiengo[2], Sandro Mereghetti[1], Giacomo Vianello[3], Ruben Salvaterra[1], Paolo Esposito[4], Elisa Costantini[5], Andrea Giuliani[1], Zelika Bosnjak[6]
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X-ray observatories with good imaging capabilities (as XMM-Newton, Chandra and Swift) have extensively observed X-ray halos or expanding rings around bright X-ray Galactic binary systems, magnetars and gamma ray bursts (GRBs). Their origin is nowadays firmly associated to the scattering of X-ray photons by the dust-grains of the interstellar medium, located between us and the source. Recently, X-ray dust-scattering features were found around the afterglow of GRB 160623A. Thanks to a XMM-Newton observation of the afterglow, carried out 2 days after the GRB event, it was possible to find evidence of at least six expanding rings (with sizes ranging between 2' and 9') around its position. The rings were associated to X-ray scattering of the prompt GRB emission by several dust clouds along the line of sight and placed in our Galaxy. On the other hand, it is important to note that dust-clouds are expected to be present also in the host galaxies of GRBS. Hence, dust-scattering effects in the local GRB environments cannot be excluded, even though it is not possible to resolve them spatially with the current instruments. In this talk, we will discuss the possibility that dust-scattering processes may affect the observed long-lasting tails of GRB afterglows.

How stars and planets interact: a look through the high-energy window

Katja Poppenhaeger[1]
[1]*Queen's University Belfast, Astrophysics Research Centre*

The architecture of many exoplanetary systems is different from the solar system, with exoplanets being in close orbits around their host stars and having orbital periods of only a few days. We can expect interactions between the star and the exoplanet for such systems that are similar to the tidal interactions observed in close stellar binary systems. For the exoplanet, tidal interaction can lead to circularization of its orbit and the synchronization of its rotational and orbital period; additionally, irradiation can even lead to planets having star-like surface temperatures. For the host star, it has long been speculated if significant angular momentum transfer can take place between the planetary orbit and the stellar rotation. Investigating if this can lead to increased high-energy emission from stars, as opposed to their regular coronal evolution, is a challenging task, as cool stars already display stochastic flaring as a baseline behaviour. I will review different observational approaches to identify interactions between stars and planets, and discuss how they are expected to influence the long-term evolution of star-planet systems.

Accretion, ejection and variability in CVs and novae

Gloria Sala[1,2]
[1] *Universitat Politècnica de Catalunya-BarcelonaTech (UPC)*
[2] *Institut d'Estudis Espacials de Catalunya (IEEC)*

Accreting white dwarf binaries show a wide range of timescales of variabilities, from seconds to months and years. Disc instabilities, disc-jet connection and magnetic accretion are present in accreting white dwarfs, making them interesting laboratories of the accretion and ejection mechanisms. In addition, the explosive events of nova outbursts involve the massive ejection of the accreted envelope on top of the white dwarf. Among novae, the subclass of recurrent novae are thought to contain a massive white dwarf. This, in combination with a high outburst frequency, make them good candidates to progenitors of Type Ia supernovae. Novae are luminous X-ray sources. Soft X-rays probe the residual nuclear burning, while the ejected shell and/or the accretion disk are the site of harder X-rays. Recently discovered very high gamma-ray emission is though to be related to particle acceleration in the ejecta. Transient short period oscillations have been detected in the soft X-rays of both novae and persistent supersoft sources. Their origin is still unclear. They may be connected to the rotation of the white dwarf in some cases, but they may also arise from pulsations in the H-burning envelope.

The complex phenomena of YSOs revealed by their X-ray variability

Salvatore Sciortino[1]
[1] *INAF/Osservatorio Astronomico di Palermo, Palermo, Italy*

X-ray observations of Young Stellar Objects (YSOs) have shown several complex phenomena at work. In recent years a few programs based on long continuous X-ray, and sporadically on simultaneous coordinated multi-wavelength, observations have paved the way to our current understanding of the physical processes at work that very likely regulates the interaction between the star and its circumstellar disk. I will present and discuss some recent results based on a novel analysis of very large flares observed with the Chandra Orion Ultra-deep Pointing (COUP), on the systematic analysis of a large collection of flares observed with the Coordinated Synoptic Investigation of NGC 2264 (CSI 2264) as well as on the Class I YSO Elias 29 in the rho Oph star forming region whose data have been recently gathered as part of a joint continuous XMM-Newton and NuStar large program.

Multiwavelength studies of gravitational wave sources: physics and phenomenology

Nial Tanvir[1]
[1] *University of Leicester*

The electromagnetic detection of events that are also detected as gravitational wave sources has long been a holy grail of astrophysics, allowing, as it does, determination of redshifts, distance estimates and characterisation of galactic environments linked to source properties. This ambition was finally realised in August 2017 with the discovery of the binary neutron star merger GW170817 by LIGO/Virgo, and the subsequent detection its counterpart across the electromagnetic spectrum. I will review what we have learnt about the physics of this event from the pan-chromatic view of the kilonova and also the emission from a relativistic component that led to the initial accompanying gamma-ray flash. Finally I will consider implications for future studies.

Variable cosmic-ray acceleration in eta Carinae

Roland Walter[1]
[1] *University of Geneva*

Galactic cosmic-rays are likely produced through Fermi acceleration in supernova remnant shocks and other exotic sources. Identifying the different contributors is fundamental to understand galactic processes, how Fermi acceleration works in various environments, and the feed-back between cosmic-ray acceleration, galactic magnetic fields and the dynamics of the interstellar medium. Variable sources are fundamental to study particle shock acceleration as the correlated observations in various energy bands provide key signatures of the physical processes at play. Particle acceleration in stellar wind collision can be particularly well studied in η Carinae, the most luminous massive colliding wind binary system of our Galaxy and the first one to have been detected at very high energies without hosting a compact object. Most of the shock power is released on both sides of the wind collision zone downstream of the wind-collision region. The photon-photon opacity could also be estimated as $< 10^{-2}$, excluding a significant effect on the observed GeV spectrum. γ-ray observations can probe the magnetic field and shock acceleration in details. η Carinae could yield to 10^{48-49} erg of cosmic-ray acceleration, a number close to the expectation for an average supernova remnant.

Chapter 2

Statistics, Methods and Tools

Global Fit Time Resolved Spectroscopy: Getting the Most from Low Count Rate Data

Anton Chernenko[1]
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Many transient and variable astrophysical objects are known to manifest variability starting from at least sub-millisecond time scales. Even with the most advanced modern experiments, spectroscopy with such a high time resolution is hardly or not possible even for the brightest objects of their classes.

The use of the Global Fit Analysis (GFA) allows one to investigate spectral variability with the finest time resolution where traditional spectroscopy techniques fail due low count rate. This is achieved thanks to special assumptions about intrinsic properties of the spectra. With the GFA one could extend spectral analysis to far tails of emission where traditional spectroscopy fails due to low S/N ratio. Or, to reach by an order of magnitude finer time resolution during brighter periods of the emission.

In GFA, instead of parameterizing individual spectra and analyzing spectral evolution in terms of numerous individual spectral fit parameters we define a spectral evolution model with a set of constant global parameters and just a few (N=1-2) time dependent variables. Besides the time histories of physically meaningful spectral parameters GFA also allows us to obtain, for each object, a set of global parameters for population studies.

Hunting for Binaries in the Fermi FL8Y List: Timing and Multiwavelength Analyses

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The Fermi LAT team recently released the FL8Y list of gamma-ray sources. This contains 5524 sources compared to the 3033 in the third Fermi LAT catalog. We are searching for gamma-ray binaries in the FL8Y using a combination of techniques. We construct high signal-to-noise gamma-ray light curves for all sources, then search these for indications of periodic variability that could be the sign of a binary system. We then employ a multi-wavelength approach including radio, optical, and X-ray to identify counterparts, and search for similar periodic variability at other wavelengths. Our approach previously led to our discovery of the gamma-ray binaries 1FGL J1018.6-5856 and LMC P3. We will report on our search results for the FL8Y list, and the prospects for improved searches using the 4FGL catalog which will be a refinement of the FL8Y.

EXTraS: Exploring the X-ray Transient and variable Sky

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The EXTraS project extracted all temporal domain information buried in the whole database collected by the EPIC cameras onboard the XMM-Newton mission. This included a search and characterisation of variability, both periodic and aperiodic, in hundreds of thousands of sources spanning more than eight orders of magnitude in time scale and six orders of magnitude in flux, as well as a search for fast transients, missed by standard image analysis. All results and products of EXTraS are made available to the scientific community through a web public data archive. A dedicated science gateway allows scientists to apply EXTraS pipelines on new observations. EXTraS is the most comprehensive analysis of variability, on the largest ever sample of soft X-ray sources. The resulting archive and tools disclose a very large scientific discovery space to the community, with applications ranging from the search for rare events to population studies, with impact on the study of virtually all astrophysical source classes. EXTraS, funded within the EU/FP7 framework, was carried out by a collaboration including INAF (Italy), IUSS (Italy), CNR/IMATI (Italy), University of Leicester (UK), MPE (Germany) and ECAP (Germany).

An X-ray source population study in NGC 7331

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We present Chandra X-ray observations of the nearby spiral galaxy NGC 7331. Fifty-five X-ray point sources with source significance larger than 3 are found within the optical D_{25} region according to seven Chandra ACIS-S observations taken between 2001 and 2016. The detection limit of our sample is 3.59×10^{37}erg s^{-1} in the 0.5 – 7.0 keV energy range. Twenty of our detected X-ray sources are variables and 3 of the variables are transients. We also find 9 new ultra-luminous X-ray sources (the maximum detected luminosities large than 1×10^{39}erg s^{-1}) comparing to previous study. Some of the sources possess a bimodal luminosity-hardness ratio (HR) feature, which is often observed among X-ray binaries. We also performed spectral fits for 8 sources with high signal-to-noise ratios as well as the supernova 2014C. The cumulative X-ray luminosity functions (XLF) of point sources can be well described with a power-law with a slope of around -0.99 by using PyMc3, a Bayesian inference based package, in three different ways: pooling, unpooling and hierarchical. We conclude that neither the variability of the X-ray sources nor the bright outliers has much impact on the XLF of NGC 7331 in fitting with a power-law, especially for a hierarchical method.

Automated detection and analysis of Be X-ray binary outbursts

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We report on the development of an extensive database of Be X-ray binary properties, observations, and long term variability, which will serve as a prototype for connecting archival data of pointed and monitoring observations from existing and historic missions with source meta data. As an example for meta data, we focus on source activities such as X-ray outbursts and long-term light curves. We present an automated software pipeline for detecting and characterizing these outbursts. During a first step, all monitoring light curves, e.g., as recorded by *Swift*-BAT and *MAXI*, are matched against activity criteria. Each detected activity period is then analyzed to derive the outburst properties, such as rise and decline time scale. Once the results have been ingested into the database, this will enable us, for the first time, to study Be X-ray binary outbursts in a systematic and quantitative way

Tools for Period Searching in AGN in the Era of Big Data

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Active Galactic Nuclei persistently emit across the electromagnetic spectrum and are dominated by stochastic, aperiodic emission that is variable on timescales from hours to decades. The stochastic variability tends to overwhelm any possible periodic signal, preventing us from robustly confirming if periodic signals are present in AGN. It has also been seen that pure stochastic red noise signals spuriously mimic few-cycle periods. Hence in our project we try to account for the red noise properly using different methods (ACF, epoch folding, wavelet analysis and Bayesian analysis) and test if each method can robustly distinguish between pure red-noise processes and mixtures of a strictly- or quasi-periodic signal (QPO) plus red noise, while pursuing the following questions: When the variability process is pure red noise (no QPO present), what is the false-alarm probability and how does it depend on broadband continuum shape? When there is intrinsically a mixture of red noise and a QPO, is there a range in detection sensitivity between the various methods? How many observed cycles are needed for confirmation of a detection? Here we present preliminary results and inferences drawn from analysis in progress.

Spectral and Temporal variability in RXTE Data of Mrk 421

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NASAs Rossi X-ray Timing Explorer (RXTE) has provided time-domain data of highest quality for several categories of sources. Among the high-frequency peaked BLlac objects, Mrk421 was observed numerous times through the 16 years of operation during which the source flared up by several orders of magnitude. The three instruments (All Sky Monitor-ASM, Proportional Counter Array-PCA and High Energy X-ray Timing Experiment - HEXTE) on board RXTE observed the source at different range of wavelengths spanning 2 keV 250 keV. We are conducting an exhaustive study of the entire data to investigate various aspects of temporal and spectral variability. The light-curves are being analyzed using various statistical techniques to investigate the presence of inherent timescales of variability and to check if the times scale is unique to the entire range of wavelength of the satellite. The pattern of spectral hysteresis with flux is being examined as a function of strength of the flare and the relative position of spectral energy range in relation to the peak of the synchrotron emission. The data shows indications of self-similarity at multiple timescales on which the data can be binned. Some of the results of this systematic study will be presented.

HILIGT - an upper limit and flux server for photon-counting instruments

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The advent of all-sky facilities, such as Swift, ASASSN, eRosita and LSST has led to a new appreciation of the importance of transient sources in solving outstanding astrophysical questions. Identification and catalogue follow-up of transients has been eased over the last two decades by the Virtual Observatory but we still lack a tool to provide a seamless, self-consistent, analysis of all observations made of a particular object by current and historical facilities. HILIGT is a web-based interface which polls individual servers, written for XMM-Newton, INTEGRAL, ROSAT and other missions, to find the fluxes, or upper limits, from all observations made of a given target. These measurements are displayed as a table or a time series plot which may be downloaded in various formats.

Automatic detection of tidal disruption events and other long duration transients in XMM-Newton data

Natalie Webb[1]
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XMM-Newton's large field of view and excellent sensitivity have resulted in hundreds of thousands of serendipitous X-ray detections. Whilst their spectra have been widely exploited, their variable nature has been little studied. Part of this is due to the way XMM-Newton currently operates, where observations generally have a 12 month proprietary period. It is often too late to follow-up a serendipitous transient a year after detection. New robust software could be introduced into the pipeline to automatically identify bright transients that are not the target of the observation. Statistically, hundreds of tidal disruption events (TDEs) have been detected serendipitously by XMM-Newton. With prior consent from the PI of the observation, an automatically generated ATEL could alert to a new transient, allowing it to be followed-up within weeks, ideal for TDEs that are bright for about a year. Over the next decade, hundreds more TDEs should be detected. Following-up the brightest in quasi-real time would allow constraints to be made on the black hole mass, spin and accretion regime and identify intermediate-mass black holes that are expected to be hidden in faint, low-mass galaxies. We will discuss the advantages that such changes would have on the follow-up of transients and TDEs.

Chapter 3

Variable Multiwavelength Emitters and Multiwavelength Facilities

The Kepler/K2 Supernova Experiment

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Many transient surveys tend to find supernovae only at or past maximum light. In contrast, NASA's Kepler Space Telescope, now operating in its extended K2 mission, recently embarked on an ambitious experiment to continuously monitor a sample of >20,000 nearby galaxies using uninterrupted, high-precision, 30-minute cadence photometry. The goal of the experiment is to capture dozens of supernovae from the very start of the explosions, allowing the tremendous amount of information contained in the early rise light curves to be recorded. For Type Ia supernova the data is expected to help elucidate the trigger mechanism, while for Type II supernovae the curves help reveal the shock breakout. In this contribution I will present this new data set, which is fully public, and summarize the early science results. I will also highlight Kepler/K2's recent observations of AGN, CVs, Young Stars, and X-ray sources.

Time Domain X-Ray Astrophysics: ISS/TAO

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The Transient Astrophysics Observer on Board the International Space Station (ISS/TAO) is a NASA mission selected for a concept study, with contributions from ISA. It will employ a wide field X-ray telescope in conjunction with a Gamma-ray Transient Monitor (GTM) Its primary goal is to observe electromagnetic counterparts of gravitational wave (GW) events emanating, e.g., from neutron-star (NS) binary mergers, as soon as possible after the merger, and following a trigger from GW instruments or from the GTM. The wide field imager will employ advanced Lobster optics on a fast slewing platform and observe several hundred square degrees at a time, thus tracking down the GW source. The GTM will detect gamma-ray bursts (GRBs) in the half-sky above the ISS and provide sufficient directional information to trigger and point the WFI towards the source. The talk will present the ISS/TAO concept, main capabilities, and current status, as well as its unique contribution to time domain astrophysics at high energies.

Coordinated Multi-wavelength Observations of Transitional Millisecond Pulsars

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Within the past few years, three neutron star binaries have been observed to switch between accreting and rotation-powered pulsar states, cementing the standard model for the formation of rotation-powered millisecond pulsars via spin-up by accretion in a low-mass X-ray binary. These so-called transitional millisecond (tMSPs) pulsars exhibit intriguing behavior spanning from radio frequencies to the GeV gamma-ray range. Multi-wavelength observations of tMSPs hold the promise of providing fresh insight into the physics of accretion and shocks, as well as compact binary evolution. I will present an overview of our extensive coordinated multi-wavelength observing campaigns of confirmed and candidate tMSPs, as well as on-going surveys to uncover new systems.

The e-ASTROGAM space mission for MeV-GeV gamma-ray astrophysics

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Future high-energy time-domain astronomy will not develop in a comprehensive, synergetic, powerful, serendipitous way, if a particularly important broad and multiple-physical ambient spectral window in the Universe is left unobserved. In this view e-ASTROGAM is a breakthrough observatory space mission project, with large international interest, characterized by a detector composed by a silicon tracker, calorimeter, and anticoincidence system, dedicated to the observation of the Universe from 0.3 MeV to 3 GeV gamma-ray energies. The lower limit can be pushed as low as 150 keV for the tracker and 30 keV for calorimetric detection. e-ASTROGAM dramatically improve the COMPTEL, INTEGRAL and Fermi sensitivities. e-ASTROGAM is optimized for the simultaneous detection of Compton and pair-producing photon events over such wide band, with unprecedented capabilities in gamma-ray continuum and line spectroscopy and imaging, large field of view sky survey, time-domain monitor, and polarization measurement, all opening a ultra-rich and interdisciplinary science menu. e-ASTROGAM is the solution for the big problem of the next two decades astronomy: the lack of observations in a wide photon energy band, placed between those of the current/next XMM-Newton, Chandra, Swift, INTEGRAL, NuSTAR, eROSITA, HXMT, SVOM, IXPE, XARM, Athena, and other and the, above 40GeV, energy band of CTA.

The evolving jet spectrum of the neutron star X-ray binary Aql X-1 in transitional states during its 2016 outburst

Maria Diaz Trigo[1], Diego Altamirano[2]
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I will report on quasi-simultaneous observations from radio to X-ray frequencies of the neutron star X-ray binary Aql X-1 over accretion state transitions during its 2016 outburst. All the observations show radio to millimetre spectra consistent with emission from a jet, with a spectral break from optically thick to optically thin synchrotron emission that decreases from ∼100 GHz to < 5.5 GHz during the transition from a hard to a soft accretion state. During the decay of the outburst, the jet spectral break is detected again at a frequency of ∼40-100 GHz. This is the first time that a change in the frequency of the jet break of a neutron star X-ray binary has been measured, indicating that the processes at play in black holes are also present in neutron stars, thus supporting the idea that the internal properties of the jet rely most critically on the conditions of the accretion disc and corona around the compact object, rather than the black hole mass or spin or the neutron star surface or magnetic field.

The nature of the soft X-ray excess in AGN

Chris Done[1]
[1] *University of Durham*

The origin of the soft X-ray excess in AGN is still controversial. I will review new constraints on its nature and geometry that come from both fast X-ray spectral-timing observations and from longer term multiwavelength monitoring campaigns.I will discuss how this component changes as a function of L/LEdd, and how it may be linked to the 'changing-look' AGN phenomena, as seen in the disappearing BLR in Mkn 1018.

Studying optical and very-high-energy gamma-ray variability with Imaging Atmospheric Cherenkov Telescopes

Tarek Hassan[1], Juan Abel Barrio[2], Ralph Bird[3], Jose Luis Contreras[2], Juan Cortina[4], Michael Daniel[5], John Hoàng[2], Jamie Holder[6], Marcos Lopez Moya[2], Luis Angel Tejedor[2], Greg Richards[6]
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[6] *University of Delaware*

During the last two decades, the great success of space missions and the development and refinement of new detection techniques from ground has allowed outstanding scientific results in the gamma-ray astronomy field. Imaging Atmospheric Cherenkov Telescopes are currently the most sensitive instruments to detect very-high-energy gamma-ray photons (E $>$ 50 GeV), especially excelling in short time-scale observations required to study fast variability.

Additionally, as IACTs are sensitive to the Cherenkov light (UV/blue) and use photodetectors with extremely short time responses, they are also able to perform simultaneous optical observations. The large reflecting surface of these telescopes (larger than 100 m^2) makes them world-class detectors to study fast optical transient phenomena from the millisecond regime down to nanosecond scales with moderate angular resolution and wide field of view.

In this talk we will evaluate the capabilities of IACTs to study fast variability in both optical and VHE ranges and report some of their excellent scientific results.

Compact binary millisecond pulsars: new views from X-ray and optical variability

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[2] *IEEC, Barcelona, Spain*

Compact binary millisecond pulsars (with orbital periods shorter than about a day) have become a sizeable and rapidly-growing pulsar population during the last decade. I will review their three main states, and the unique interplay they show between accretion- and rotation-powered phenomena. I will also present recent results from our studies of optical and X-ray variability, including: i) our measurement of one of the highest pulsar masses found to date ($2.27^{+0.17}_{-0.15}$ $M_\odot$) and ii) the discovery of the brightest optical companion to a compact binary millisecond pulsar, in a 21-hr orbit.

Magnetar-like Activity and Radio Variability from High Magnetic Field Pulsar J1119- 6127

Walid Majid[1], Aaron Pearlman[2], Thomas Prince[2]
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[2] *Caltech*

X-ray and gamma-ray outbursts were recently observed from the high magnetic field pulsar PSR J1119-6127, along with additional magnetar-like activity. We present results from a high frequency radio monitoring campaign of PSR J1119-6127 at S-band (2.3 GHz) and X-band (8.4 GHz) with the Deep Space Network (DSN) 70 m antenna (DSS-43) in Canberra, Australia following these recent outbursts. After an initial disappearance of radio pulsations, the S-band pulse profile evolved from a multi-peaked structure into a single-peak over several weeks, which is unusual for radio pulsars. Bright, transient X-band pulsations were detected as the S-band pulse profile became single-peaked, which led to a significant flattening of the spectral index to -0.4(1). This transition is likely further evidence of magnetar-like behavior since this spectral index agrees remarkably well with measurements from other known radio magnetars, such as XTE J1810-1917, PSR J1622-4950, and SGR J1745-2900. PSR J1119-6127 is clearly a transitional object, and these observations may provide the missing evolutionary link between pulsars and magnetars.

Challenges of coordination and possible solutions

Jan-Uwe Ness[1], Aitor Ibarra[1], Celia Sanchez-Fernández[1], Erik Kuulkers[1], Peter Kretschmar[1], Jesus Salgado[1], Emilio Salazar[1], Matthias Ehle[1], Carlos Gabriel[1]
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Over the last years, scientific demands for simultaneous observations using several observatories have substantially increased. The availability of other facilities is limited by various factors, primarily their celestial constraints, but also technical constraints (calibrations, maintenance) and high-priority time-critical observations of other targets. Telescope availability is communicated to the public but in diverse ways without any standard format. Achieving simultaneous coverage with multiple missions thus relies on effective communication of the respective planning teams, embedding coordinated observations in a systematic long-term planning approach.

We propose two services, defining an international standard in which visibility and planning information can be provided by all participating observing facilities. We plan to involve as many facilities as possible for agreeing on the standard that shall later be certified by the Virtual Observatory (VO). Based on the services, clients can be developed to improve efficiency of coordinated observations.

Hardness Ratio cycles in AGN - classifying different states, and the possible XRB connection

Uria Peretz[1], Ehud Behar[1]
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The physics behind the dramatic and unpredictable X-ray variability of AGNs has eluded astronomers since it was discovered. We present an analysis of Swift/XRT observations of 44 AGN selected as heavily monitored objects. Change of Hardness Ratio (HR) with luminosity is measured for all objects in order to: 1. Classify different AGN according to their HR-L/L_Edd (Luminosity over Eddington luminosity) relation. 2. Identify trends observed by combining the entire sample 3. Compare trends with similar results in X-ray binaries. This work aims to improve on previous works by collecting all AGN classified objects and uniformly analyzing them, comparing them in a phase diagram of HR and L/L_Edd. In addition we compare results using a photon count based HR definition and an energy based HR definition. Using energy units when defining hardness ratios results in a more clear classification of AGN types. In all cases we observe a clear dichotomy between Seyferts and BL LACs. We provide schematic physical models to explain the observed scenarios. Finally, we find evidence for a possible cyclic behavior of Seyferts in the HR-L/L_Edd Diagram, possibly beginning in the BL LAC part of the phase diagram.

Optical precursors to X-ray binary outbursts

David Russell[1], Dan Bramich[1]
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Disc instability models predict that for X-ray binaries (XRBs) in quiescence, there should be a brightening of the optical flux prior to an X-ray outburst. Tracking the X-ray variations of XRBs in quiescence is generally not possible, so optical monitoring provides the best means to measure the mass accretion rate variability between outbursts. With our regular Faulkes Telescope/Las Cumbres Observatory (LCO) monitoring we are routinely detecting the optical rise of new XRB outbursts before they are detected by X-ray all-sky monitors, helping to ensure continued monitoring of the optical/X-ray sky. We present detections of an optical rise in several XRBs prior to outbursts. Our current understanding of the quiescent variability in these high energy astrophysical objects is summarised. We show that it may be possible to predict when new outbursts may occur, by estimating the accumulation of matter in the disc from optical monitoring. Finally, we introduce our new real-time data analysis pipeline, the "X-ray Binary New Early Warning System (XB-NEWS)" which aims to detect and announce new XRB outbursts within a day of first optical detection. This allows us to trigger X-ray and multi-wavelength campaigns during the very early stages of outbursts, to constrain the outburst triggering mechanism.

XMM-Newton study of the symbiotic binary systems in the Draco dwarf spheroidal galaxy

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We present the results of the study of symbiotic binary systems in the Draco dwarf spheroidal galaxy (dSph) using 31 XMM-Newton observations. The sources have been classified on the basis of multi-wavelength studies of the counterparts in the optical, infrared and near-infrared surveys. The X-ray, UV, and optical long-term variability of the systems were simultaneously investigated using the data of X-ray cameras (EPICs) and the optical/UV monitor telescope (OM) onboard of XMM-Newton. The deep XMM-Newton observations allowed us to significantly analyse the spectrum of different types of symbiotic binaries. We have identified 15 symbiotic systems and candidates Draco dSph. Out of these sources, 2 systems are classified as super-soft sources (type α), with a spectrum that can be fitted with a blackbody model. 7 systems show soft X-ray emission mainly below 2.4 keV (Type β), which is consistent with a single or multiple components of collisionally ionised gas. One candidate also shows highly absorbed X-ray emission above 2.4 keV (Type δ) and has a spectrum which can be fitted with a two-component model of optically thick plasma.

Towards the SuperWASP - XMM stellar rotation-activity relation

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SuperWASP is the most successful ground-based survey for transiting exoplanets, having discovered more than 150 hot Jupiters. As a spin-off, data from the survey can also be used for in-depth studies of variable stars. The SuperWASP archive contains high cadence light curves of more than 30 million unique objects, up to 1 million of which have detectable photometric periodicities on timescales from hours to years. The 3XMM-DR7 catalogue, the most recent data release of another big survey, XMM-Newton, contains 727,790 X-ray source detections, relating to 499,266 unique X-ray sources.

We summarise the cross-correlation between the SuperWASP variable star catalogue and the 3XMM-DR7 catalogue, which has detected 15,740 X-ray visible unique objects displaying photometric variability, including sinusoidal variables, eclipsing binaries, and pulsators. This new catalogue will, itself, be cross-correlated with Gaia Data Release 2 (Gaia DR2), giving the parallaxes and proper motions, as well as light curves for 500,000 variable sources.

We look ahead to making use of this cross-correlation to complete the largest study of the rotation-activity relation for main sequence stars - an important probe for the stellar dynamo process, and for fundamental information on the spin evolution of late-type stars.

Biases in Gamma-ray and MWL timing studies of AGN

Stefan Wagner[1]
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Most gamma-ray emitting AGN are variable and multiwavelength temporal studies provide insights into acceleration and radiation mechanisms, source size, radiative re-processing and source structure.

The gamma-ray band is very wide and is explored with very different techniques. In different energy bands very different biases affect temporal studies. Many of them are specific to the gamma-ray domain. The biases have significant implication for statistical analysis within the spectral range covered by a single facility, for comparisons between different gamma-ray facilities and for analyses of multiwavelength correlations between other High Energy bands.

The study characterizes the most significant biases and presents examples of potential errors in AGN studies that are specific to the gamma-ray domain and correlations to the X-ray band. Astrophysical implications cover a wide range from AGN structure, acceleration processes, and fundamental physics.

Chapter 4

Timing from Accretion and Ejection Phenomena

Probing the inner accretion region with the deepest XMM-Newton observation of a highgly variable AGN

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The fast timing properties of accreting black hole light curves allow us to probe the direct vicinity of black holes, the region most affected by strong gravity. We present an extensive X-ray variability analysis from a new 1.5 mega-second XMM-Newton VLP observation of the highly variable Seyfert 1 galaxy, IRAS 13224-3809. This is the longest observation taken to date on a nearby variable AGN. This long observation has revealed complex underlying variability processes, displaying the first non-linear rms-flux relation in any accreting source. We will show modelling of the coronal and reverberation delays using GR ray tracing models. This allows us to build up the most detailed picture to date of the inner X-ray emitting regions of AGN. We discuss the implication of these results for accreting sources across the mass range.

The flickering jet of MAXI J1535-571

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We present optical and infrared (REM, Faulkes telescope; VLT-VISIR) observations of the new black hole candidate transient X-ray binary (BHB) MAXI J1535-571 during outburst.

The target is well detected in the mid-infrared, reaching a dereddened flux of >100 mJy, which makes MAXI J1535-571 the brightest mid-infrared BHB known so far.

At the beginning, the target shows an optical-NIR spectrum that is consistent with an optically thin synchrotron power-law from a jet. After a certain epoch, the source faded considerably, the drop in flux becoming more evident at decreasing frequencies. Simultaneously, a significant softening of the X-ray spectrum, obtained with Swift and MAXI, occurred. We interpret this result as due to the quenching of the jet, similar to the accretion-ejection coupling seen in other BHBs.

We also observe the source flaring in the infrared after the softening. All the detected activity correlates with X-ray hardness deviations.

We then show the first mid-IR variability study of a BHB on minute timescales. On some dates the mid-IR flux of MAXI J1535571 varied by a factor of two in < 15 minutes, and on one date there is a sudden decrease of the flux to undetectable levels.

Disk Structure of Cataclysmic Variables and Broadband Noise Characteristics in comparison with XRBs

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Flicker noise and its variations in accreting systems have been a diagnostic tool in understanding accretion disk structure and state transitions. I will present broadband noise variations of nonmagnetic cataclysmic variables (CVs) in comparison with magnetic CVs extrapolating the comparisons into X-ray binaries, mostly in the X-ray wavelengths. CVs demonstrate band limited noise in the UV and X-ray energy bands (and also some optical), which can be adequately explained in the framework of the model of propagating fluctuations (Balman & Revnivtsev 2012, Balman 2014, 2015). The detected frequency breaks in the nonmagnetic CVs are in the range (1-6) mHz in quiescence and indicates an optically thick disk truncation (i.e., transition) indicating existence of hot flows in the inner regions. Analysis of other available data (e.g., SS Cyg, SU UMa, WZ Sge, Z Cha) reveal that during the outburst the inner disk radius moves towards the white dwarf and receeds as the outburst declines (with some exceptions) while changes in the X-ray energy spectrum is also observed. Cross-correlations between the simultaneous optical, UV and X-ray light curves show time lags consistent with truncated optically thick disk and inner disk hot flows. I will also discuss the hysteresis effects in nonmagnetic CVs.

X-Ray and mm-Wave Monitoring of Radio Quiet AGNs

Ehud Behar[1]
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X-ray and mm-wave observations have the potential of revealing the physics of gas in the innermost regions of AGNs, just before it accretes onto the black hole. X-ray and radio luminosities have been shown to be correlated in radio quiet (RQ) AGNs. However their temporal behavior are starkly different. While the X-rays can vary dramatically on short time scales of hours, radio emission at a few GHz is relatively stable over months or even years. If the radio emission is due to synchrotron, it would be self absorbed at radio frequencies, but much less so at mm-wave frequencies (100 GHz and more). To that end, it is beneficial to monitor RQ AGN variability in mm-waves, and compare it with X-rays variability. The talk will describe recent observations, and suggest new ones, with contemporary and future instruments, which could shed new light on the nature of radio and mm-wave emission from these sources.

X-Ray Spectrum of RBS 315: Absorption or Intrinsic Curvature

Sivan Ben Haim[1], Ehud Behar[1]
[1] *Technion, Israel*

X-ray absorption in high-redshift quasars is enigmatic because it remains unclear where in the universe is the absorbing gas. If absorption occurs near the host, it could help us understand the universe at the early stages of galactic formation. We report on observations of one of the brightest X-ray sources at a high redshift, RBS 315 (z=2.69), which is also a bright radio source (FSRQ). Despite previous analyses, no definite conclusion as to the source of the curvature in its spectrum could be reached. We present observations by XMM-Newton (EPIC, RGS), Swift/XRT and Nustar. A statistical analysis of the spectrum yielded no clear results - the spectrum is as likely to be absorbed as it is to be intrinsically curved. Variability provided an insight, and we find that the observed curvature of the spectrum of RBS 315 varied within a month, hence if an absorber is responsible for the curvature, it must be located near the host. Such an absorber should have a high column density, thus creating spectral lines in the spectrum, yet these are not discernible in the RGS spectrum. By ruling this option out, we concluded that the curvature is intrinsic to the source.

IGR J17329-2731: the birth of a symbiotic X-ray binary

Enrico Bozzo[1]
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I will report on the results of the multi-wavelength campaign carried out after the discovery of the INTEGRAL transient IGR J17329-2731. The optical data allowed us to identify the donor star as a late M giant at 2.7(+3.4,-1.2) kpc. The XMMNewton and NuSTAR data showed the presence of a modulation with a period of 6680 s in the X-ray lightcurves of the source that we interpreted as the neutron star spin period. The broad-band X-ray spectrum showed the presence of a strong absorption ($\sim$5E23 cm^{-2}) and prominent emission lines at 6.4 keV, and 7.1 keV. The presence of an absorption feature at $\sim$21 keV suggests a cyclotron origin, measuring the neutron star magnetic field at $\sim$2.4E12 G. IGR J17329-2731 is thus a new symbiotic X-ray binary. As no X-ray emission was ever observed from the source by INTEGRAL during the past 15 yrs and considering that symbiotic X-ray binaries are known to be variable but persistent X-ray sources, we concluded that INTEGRAL most likely caught the first detectable X-ray emission from IGR J17329-2731. The Swift XRT monitoring performed up to 3 months after the discovery of the source, showed that it maintained a relatively stable X-ray flux and spectral properties.

Using multiwavelength spectral variability to uncover the accretion structure in AGN

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AGN are powered by accretion onto a supermassive black hole in a system which includes a UV emitting disc and central X-ray emitting corona, as well as other material which may include an outflowing wind. Variability of the X-ray emission both heats the disc, causing correlated changes in UV emission, and changes the amount of reflected X-ray emission. Recent studies comparing X-ray and UV variability have shown that in some sources the time lags between these bands are longer than is predicted by the standard disc model. In other sources, including IRAS 13224-3809, the correlation is not observed at all. Using results from a sample of sources monitored with Swift and a large XMM program dedicated to IRAS 13224-3809, we will explore which physical conditions could be responsible for extending or obscuring X-ray to UV lags and in particular whether relativistic winds, as observed in IRAS 13224-3809, may have an influence.

Discovery of a new ULX pulsar in NGC 300

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Thanks to a very long and simultaneous observation of NGC 300 with XMM-Newton and NuSTAR between 2016 December 16 and 20, we discovered pulsations from the supernova impostor SN 2010da located in NGC 300, later identified as a B[e] high-mass X-ray binary. The pulse period is changing from 31.71 s to 31.52 s from the start to the end of the observation, leading to a spin-up rate of $-5.56 \times 10^{-7}\,\mathrm{s\,s^{-1}}$, which is extremely fast. The 0.3–30 keV unabsorbed luminosity is of 4.7×10^{39} $\mathrm{erg\,s^{-1}}$ is much higher that what was initially reported in previous Swift, Chandra and XMM-Newton observations. Applying our best-fit model to the spectra, we find that the lower flux from the archival XMM-newton observation of 2010 was caused by a larger amount of absorption, while the intrinsic luminosity was similar as seen in 2016. We conclude that the source is another candidate for the new class of ultraluminous X-ray pulsars.

23.8 h QPO in the Swift light curve of XMMU J134736.6+173404

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XMMU J134736.6+173404 is an X-ray source discovered serendipitously by XMM-Newton which is now found to be spatially coincident with a Seyfert 2 galaxy, but presented once a very sharp persistent flux drop of a factor 6.5 within 1 h that is hard to relate to any AGN activity, due to the short time scale. Thanks to a set of 29 Swift observations conducted from the 6 February to the 23 May 2008, we discovered a twin peak quasi-periodic oscillations with periods of 23.82±0.07 h and 71.44±0.57 h that we attribute to resonances of epicyclic frequencies. The AGN is radio-loud and the broadband SED modelling indicates a black hole with a mass of $2.8 \times 10^7 M_\odot$, that accretes at an Eddington ratio of 0.008. QPOs for active galaxies have been reported so far in only few cases, the most reliable one being from RE J1034+396 for which a 1 h periodicity has been discovered analysing a 91 ks XMM-Newton observation. Twin peak QPOs with an observed frequency ratio of 3:1 have not been reported so far for any AGN. From resonances models of the epicyclic frequencies we evaluate the different possible mass-spin relations.

First evidence of an X-Ray activity cycle on the young solar-analog Epsilon Eridanae

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Chromospheric CaII activity cycles are frequently found in late-type stars, but their coronal X-ray counterparts are difficult to catch. The typical time scale of activity cycles goes from years to decades, probed by CaII monitoring campaigns. Therefore, long-lasting missions are needed to detect the coronal counterparts. XMM-Newton has so far detected X-ray cycles in four stars. We are now moving from the first detections to an exploration of the parameter space ruling dynamo cycles. As stellar variability has a known impact on the evolution of planets, a particularly intriguing question is at what age (and at what activity level) X-ray cycles set in. I present here the first results of an ongoing XMM-Newton monitoring campaign for the young solar-analog Epsilon Eridanae. At 500 Myr, it is one of the youngest solar-like stars with a known chromospheric CaII cycle. The cycle lasts only 3 years, allowing to confirm or disprove the X-ray cycle in reasonable time-scales. In our ongoing XMM-Newton campaign started in 2015, we find clear and systematic X-ray variability. I discuss these observations together with our contemporaneous CaII monitoring of the cycle and I put Epsilon Eridanae in the context of other stars with X-ray cycles.

Morfology of the fast variability in selected AGNs observed by XMM-Newton

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Fast stochastic variability is a typical finger print of accretion process powering systems like cataclysmic variables, X-ray binaries and active galactic nuclei. This variability comprises of superposed shots with characteristic time scales. Based on previous work on Cyg X-1 (Negoro 1994) and thanks to the Kepler data of cataclysmic variable MV Lyr we know that the characteristic PDS frequencies can be directly seen in the shot profile. We performed shot and PDS study of selected AGNs observed by XMM-Newton and we searched for distinct shot patterns with time scales corresponding to the frequencies present in the PDSs. Some other features detected in Cyg X-1 are discussed in order to show signatures of common physical origin of the fast variability in X-ray binaries and AGNs.

Variability from weakly magnitized neutron stars in low-mass X-ray binaries to highly magnitized neutron stars in ultra-luminous X-ray sources

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Quasi-periodic variability timescale of high-energy emission from neutron-star and black-hole low-mass X-ray binaries (LMXBs) extends from milliseconds to seconds, including kilohertz quasi-periodic oscillations (kHz QPOs) and low frequency QPOs. The recent discovery of QPOs from ultra-luminous X-ray sources (ULXs) with a frequency range from a few hertz to millihertz (mHz) has ignited a new discussion on the nature of the accreting compact object. The interpretation of these ULX QPOs in comparison with those observed in black-hole LMXBs has led to the conclusion that the compact object is an intermediate-mass black hole (IMBH) in a high-mass X-ray binary (HMXB). The recent discovery of pulsations from several ULXs has, however, indicated that the majority of ULXs might consist of neutron stars accreting at super-critical rates. We hereby introduce a unified picture for the interpretation of QPOs in terms of the magnetosphere-disk interaction within the context of neutron stars accreting at sub-Eddington rates in LMXBs and at super-critical rates in HMXBs. We speculate that the main difference between kHz QPO sources in LMXBs and ULXs as mHz QPO sources in HMXBs could be the strength of the dipole magnetic field on the surface of the neutron star.

Simultaneous Kepler and XMM observations of bright flares in the Pleiades

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Flares are among the most powerful phenomena occurring in late-type stars. Stellar flares can not be spatially resolved as we do on the Sun, and thus temporal analysis is the only tool available to derive their physical properties. Furthermore, a multi-wavelength approach is desirable: Optical and hard X-rays are mainly emitted from the footpoints of the flaring magnetic loops, while UV and soft X-rays emission from the dense heated plasma filling up the loops. Several possible mechanisms for flare triggering and evolution are debated with important implications, given the impact that UV and X-ray photons may have on circumstellar material and close planets.

I will present a combined X-ray (four XMM/Newton observations, between 50 ksec and 80 ksec) and optical (Kepler/K2, campaign 4) study of the most powerful flares observed in the 100 Myrs old stars in the Pleiades, aimed at constraining the energy released in the optical and X-ray bands, and the geometry and evolution of the flaring loops. I will also compare these flares to those observed so far in stars at different age and evolutionary stages to derive an evolutionary pattern of the energy budget released in optical and X-rays and other flare properties.

Phase resolved spectrum analysis of mHz QPOs in 4U 1636-53 using Hilbert-Huang Transform

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We present the phase-resolved spectroscopy based on Hilbert-Huang Transform (HHT) for millihertz quasi-periodic oscillations (mHz QPOs) in 4U 1636-536. This $\sim$8mHz QPO can be detected about several thousand seconds before type-I X-rat burst. It was interpreted as marginally stable burning on neutron-star surface. We used the HHT to extract the QPOs instantaneous phases, and constructed its phase-resolved spectra for whole cycle. The spectral parameter modulations show the neutron star surface temperature is likely positively correlated with the variation of neutron star luminosity.

Global radio versus bolometric X-ray flux correlation in the black hole X-ray binary GX 339–4

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Compact radio jets are ubiquitous in stellar mass black hole binaries in their spectrally hard state. The correlation between the radio emission from the compact jets and X-ray emission from the accretion disk around the black hole, is of major importance in understanding the nature of accretion disk- jet coupling in black hole X-ray binaries. Previous works investigating the radio versus X-ray emission correlation properties, used the narrow 3-9 keV or 1-10 keV X-ray energy band luminosity as proxy for accretion rate. However, the bulk of X-ray emission in the spectrally hard state of black hole X-ray binaries, is emitted around 100 keV. We investigated the global radio versus bolometric X-ray luminosity correlation for the black hole X-ray binary GX 339-4 using RXTE observations. We have found that these correlations show an effect of hysteresis, previously found in the relationship between the X-ray hardness and flux, but not in the radio band. These correlations will provide new insights into the various accretion disk and jet ejection models.

Spectral-Timing Models: The Key to XRB Accretion

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The nature of the accretion flow in Black Hole binaries in their low/hard state is highly controversial, as fitting to the time averaged energy spectra is degenerate. Potential models involve contributions from a truncated disc/hot inner flow, and/or from the jet, and/or from highly relativistic reflection. Addressing this degeneracy, we use the vital information contained in the fast variability together with the spectrum. We build a quantitative model where density fluctuations propagate down through a hot flow connected to a truncated disc to simultaneously fit to the spectrum, the power spectra in different energy bands, and the frequency-dependent lags between these bands. Our models show the importance not just of the transition between the disc and hot flow, but the way the hot flow itself must be radially stratified in temperature/optical depth. We show how the fast spectral-timing data eliminate other potential models of the low/hard state, and hence how these spectral-timing techniques are the key to understanding the physical nature of the accretion flow.

High-density relativistic reflection as the origin of soft and hard X-ray excess in highly-accreting AGN

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We perform spectral-timing studies of a highly-accreting AGN using data from a deep *XMM-Newton* observation and quasi-simultaneous *NuSTAR* and *Swift* observations. The broadband (0.3-50 keV) spectrum is characterized by a strong soft X-ray excess below ~ 2 keV, one narrow Fe K_α emission line at ~ 6.4 keV, one broad, ionized Fe emission line at ~ 6.8 keV and a hard X-ray excess emission around 20-30 keV. We find that relativistic reflection from an ionized, high-density accretion disc, can simultaneously produce the soft excess, broad Fe line and hard X-ray excess emission from the source. At the lowest frequencies ($\leq 6 \times 10^{-5}$ Hz), we find a hard lag where the direct coronal emission dominated hard band (1.5-5 keV) lags behind the disc reflection dominated soft band (0.3-1 keV), while at higher frequencies, we detect a soft lag which is interpreted as a signature of X-ray reverberation from the accretion disc. The combined spectral and timing analyses suggest that the soft X-ray excess emission results from the relativistic reflection off an ionized, high-density accretion disc at around 3-20 gravitational radii, whereas the broad Fe line and Compton hump originate from the relativistic reflection off the disc at around 1 gravitational radius.

Complex Circumnuclear Structures in the Radio-Loud AGN Mkn 6 from X-ray Absorption Variability

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The Sy 1.5 AGN Mkn 6 is only the second RL AGN (besides Cen A) to exhibit strong line-of-sight X-ray absorption variability. It has multiple sets of radio bubbles indicating accretion activity within last 1e5-6 years, and Kharb et al. (2006) gave evidence for a precessing jet ejection axis. Such a jet could interact with and churn up circumnuclear gas; the accretion structure thus may not yet be fully stabilized. Here, we present preliminary results from simultaneous broadband multi-epoch NuSTAR/Suzaku and NuSTAR/Swift observations of Mkn 6 in 2015. We apply self-consistent torus models to infer the current geometry of the circumnuclear X-ray-absorbing and -reflecting gas, and apply our models to archival X-ray data, 1997-2009 to expand on the results of Mingo et al. (2011). We find evidence for a sustained zone of moderately-Compton thick clumps near the X-ray source, as well as Compton-thick reflecting gas out of the line of sight. We place our results in the context of both radio-loud AGN and "changing-look" Seyferts.

Rapid X-ray spectral variability observed in the star forming galaxy MCG–3–58–007

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We report the result of a detailed analysis from a deep simultaneous 130 ks *XMM-Newton* & *NuSTAR* observation of the nearby ($z = 0.0315$) and bright starburst-AGN system: MCG–03–58–007. Rapid short-term X-ray spectral variability has been detected, which may be caused by two variable zones of highly ionized fast ($v_{\mathrm{w},1} \sim 0.10c$ and $v_{\mathrm{w},2} \sim 0.35c$) outflowing wind. Here we show that such powerful outflow is launched from within a few $100\,R_{\mathrm{g}}$ from the black hole, whose kinetic output matches the prescription for significant feedback required by galaxy evolution models. Such dramatic and fast variability of the wind, places MCG–3–58-007 among the unique objects such as the luminous quasar PDS 456 which is considered the prototype of fast disc-wind.

Mildly obscured AGN and the CXB: From averaged properties to individual sources

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The diffuse cosmic X-ray background (CXB) is the sum of the emission of discrete sources, mostly black-holes accreting matter in active galactic nuclei (AGN). The comparison of the CXB with the spectra of individual sources is an important tool to check our knowledge of the AGN population. High signal-to-noise average hard X-ray spectra, derived from more than a billion seconds of effective exposure time with the Swift/BAT instrument, indicated that mildly obscured Compton thin AGN feature a strong reflection and contribute massively to the CXB. As a result population of Compton thick AGN larger than that effectively detected is not required, as no more than 6% of the CXB flux can be attributed to them. The hard X-ray sensitivity of NuSTAR allows to measure the primary X-ray continuum, the reflection and the iron K line emission, with unprecedented signal-to-noise. NuSTAR spectra of local Seyfert galaxies, confirm the link between reflection and obscuration statistically and in individual sources. The stronger reflection observed in mildly obscured AGN suggests that the covering fraction of the gas and dust surrounding their central engines is a key factor in shaping their appearance and confirms the need for a revision of the AGN unification model.

The X-ray continuum time-lags and intrinsic coherence in AGN

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I will present the results from a systematic analysis of the X-ray continuum time-lags and intrinsic coherence for ten X-ray bright and highly variable AGN. The continuum time-lags have a power-law dependence on frequency with a slope of ~ -1, and their amplitude scales with the logarithm of energy. We also find that their amplitude increases with the square root of the X-ray Eddington ratio. Regarding the intrinsic coherence, we found that it is approximately constant at low frequencies, and then decreases exponentially at frequencies higher than a characteristic 'break frequency'. Both the low-frequency constant intrinsic-coherence value and the break frequency have a logarithmic dependence on the light-curve mean-energy ratio. Neither the low-frequency constant intrinsic-coherence value, nor the break frequency exhibit a universal scaling with either the central black hole mass, or the the X-ray Eddington ratio. I will discuss briefly implications of our results on various theoretical models of AGN X-ray variability.

Rapid variability of ultra-fast outflows and timing prospects

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Variability of ultra-fast outflows has long been observed, but recently it has been seen on timescales down to 1ks, and with both the velocity and ionization of the gas responding to the X-ray source. The rapid variability and correlation with the continuum raid the possibility of using timing based techniques to study these outflows, both as a means of detecting them and as a probe of their physics. I will show that simple variability spectra can be used to detect spikes in variability from UFO absorption lines, and explore the potential uses of more advanced timing techniques to directly measure the density of the gas and hence its location.

The rapid growth of black holes in the early Universe

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Observational searches for faint active nuclei at $z > 6$ have been extremely elusive. Interpreting this lack of detections is crucial to improve our understanding of high-z supermassive black holes (SMBHs) formation and growth. We present a model for the emission of accreting BHs in the X-ray band, taking into account super-Eddington accretion, which can be very common in gas-rich systems at high-z . We compute the spectral energy distribution for a sample of active galaxies simulated in a cosmological context. We find an average Compton-thick fraction of 45 per cent and large typical column densities (N_H ¿ 10^{23} cm^2). However, faint progenitors are still luminous enough to be detected in the X-ray band of current surveys. Even accounting for a maximum obscuration effect, the number of detectable BHs is reduced at most by a factor of 2. In our simulated sample, observations of faint quasars are mainly limited by their very low active fraction (1 per cent), which is the result of short, supercritical growth episodes. To detect high-z SMBHs progenitors, large area surveys with shallower sensitivities, such as XMM-LSS+XXL, are to be preferred with respect to deep surveys probing smaller fields, such as CDF-S.

Long-term variability of high-mass X-ray binaries with MAXI

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In this work we present our long-term analysis of some X-ray binary sources observed by MAXI. We start to obtain its light-curves, then we estimate its orbital periods and finally derive the good time interval to extract orbital phase-resolved spectroscopy. Our data show an excellent coverage for many orbits of the systems and extend over more than five years. Thus, the study of the X-ray spectrum from the neutron star at different orbital phases provides us the variability of the model parameters we can use to compare with the different stellar wind accretion scenarios. This analysis strategy allow us to study the permanent structures present in the stellar wind and circumsource environment.

The Vast Potential of Exoplanet Hunting Satellites for High Energy Time Domain Astrophysics

Krista Lynne Smith[1]
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The unmatched photometric precision, monitoring baselines and rapid, even sampling rates required by modern satellites designed for detecting the signal of transiting exoplanets are ideally suited to a large number of applications in high energy astrophysics. These precision instruments are currently underutilized for high energy applications perhaps due simply to lack of intersectional marketing. I will exemplify this by discussing my results for AGN and accretion disks from Kepler, which show new and different properties than ground-based light curves, as well as summarizing other high energy results from Kepler/K2. I will then explain how future missions like TESS and PLATO can be used very effectively for studies of accretion onto compact objects, especially when used in conjunction with X-ray timing instruments like XMM, Swift, and NICER.

Radiative transfer in the neutron star atmosphere: reflection model

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We present the new theoretical model for calculating the reflection of the radiation from the neutron star surface illuminated by the accretion column for high-mass X-ray binaries. We calculate the trajectories of photons emitted from the column onto the neutron star surface considering the gravitational light bending to obtain the external boundary condition for radiative transfer simulation in the neutron star atmosphere. The equation of the radiative transfer is solved using the Feautrier method for two photon polarization modes with partial angle and frequency redistribution, taking into account the possibility of the mode conversion. The resulting spectrum is treated as the additional to the direct column one flux component. The intention of the currently developing model is to investigate the effects of the reflection from the neutron star surface on the spectrum characteristics of the X-ray pulsars.

Energy dependent timing studies of the low-hard state of black hole X-ray binaries with XMM-Newton

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Almost all low mass black hole X-ray binaries are transient sources. During outburst most of these sources evolve from the low-hard state through intermediate state(s) into the high-soft state and then return to the hard state at lower luminosity. However, there are outbursts that remain in the hard state. By fitting mean X-ray spectra, one studies the time-averaged spectral shape of a source, learning nothing about how the individual spectral components vary with respect to each other in time. This variability can be studied using covariance spectra. Here we present the results of a comprehensive study of covariance spectra for a sample of black hole X-ray binaries obtained during the two outburst patterns outlined above and discuss what covariance spectra can tell us about outburst evolution. Furthermore we present covariance ratios obtained during a soft-to-hard transition of an outburst and show that their evolution is consistent with increased disc instabilities.

Super-Eddington X-ray pulsars in the Magellanic Clouds

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In 2016, SMC X-3 underwent an long-duration X-ray outburst of extreme brightness. It's luminosity peaked at 1.2 x 10^{39} erg/s, making it one of the closest known ultra-luminous X-ray sources (ULX). SMC X-3 is one of a small number of very nearby X-ray binaries to reach super-Eddington accretion rates, making them important systems in understanding more distant ultra-luminous X-ray pulsars (ULP). I will discuss the properties of SMC X-3 during this luminous outburst, emphasising the similarities and differences between SMC X-3 and more distant, 'bona fide' ULPs. These nearby systems can potentially be used as tools to better understand the accretion physics occurring in more distant ULPs and ULX sources in general.

Fast quasi-periodic oscillations in magnetic cataclysmic variables

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Several Polars (accreting magnetic white dwarfs rotating synchronously with the orbital motion) have revealed 1-Hz quasi-oscillations (QPOs) in the optical, while upper limits only have been derived from XMM-Newton observations. These oscillations are thought to be associated with the existence of hydro-radiative instabilities in the post-shock zone which induce shock height oscillations with a period of the order of the post-shock cooling time scale. The cooling is dominated either by bremsstrahlung or cyclotron radiation, depending on the magnetic field and the accretion rate values.

We will review the current observational properties of QPOs in Polars and compare them with the radiative properties of our numerical 1D simulations of the structure and dynamics of the post-shock region relevant to the physical parameters of polars exhibiting QPOs (masses, accretion rate, magnetic field). Though large uncertainties exist for these parameters, we will show that the standard model of column instability remains insufficient to account for the observations, thus leaving the origin of QPOs as an opened question. Different solutions, such as a fragmentation of the accretion flow, are proposed, which require 3D simulations.

Living on the edge: the RWI in accretion disk around Kerr Black hole

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The Rossby-Wave Instability (RWI) has been proposed to be at the origin of the high-frequency QPOs observed in black-hole system. Here we are presenting the first full GR simulation of the instability around a Kerr black-hole which allow us to explore the impact of the spin on the instability. Those simulations, coupled with a full GR ray-tracing, allow us to directly compare our simulation with observables we get in X-ray.

NOVAs: a Numerical Observatory of Violent Accreting systems

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Here we are presenting NOVAs, a Numerical Observatory of Violent Accreting systems, which couples a GR AMR MPI (GRAMRVAC) code able to follow accretion around a Kerr Black-hole with the ray-tracing code GYOTO. Together, they allow us to test different models by running the simulation and obtaining spectral energy distribution and power-density spectrum from which we can extract the same observables as in for "real" observations, hence making it a Numerical Observatory.

Multiwavelength variability of GX 339-4 during its 2015 outburst decay

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We present the results from the first multi-wavelength fast-photometry campaign of a black-hole transient outburst decay. We observed GX 339-4, simultaneously in X-rays and near-infrared, at high time resolution during the OIR re-brightening at the end of its 2015 outburst. We find timing properties that are significantly different from the ones found during past multi-wavelength observations. The cross correlation function has a strongly asymmetric shape, with an anti-correlation peak at IR positive lags. The measured lags show a clear dichotomy between low and high frequencies. While at frequencies lower than 0.3Hz an approximately constant phase lag of $-\pi/2$ is present, for frequencies higher than 1Hz the lag inverts sign and a 0.1 s time lag emerges. Such behaviour can be fully explained in terms of internal shocks models. We also report the detection in the IR Fourier power spectrum of a type-C quasi-periodic oscillation at 0.1 Hz, with evidence of a X-ray QPO at the same frequency. Further IR high time resolution observations taken in the same period, without simultaneous X-ray coverage, reveal that the IR QPO evolves, with a centroid frequency passing from 0.2 to 0.05 Hz in less than a week.

Chapter 5

Triggers of Variability: Magnetism, Shocks, Companions

General Relativity through OJ 287 light curve timing

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The proper understanding of blazars, and other AGNs, time-domain variability at the various electromagnetic energy bands is an important goal of multifrequency astrophysics, where periodicity represents a peculiar and controversial phenomenology claimed for very few objects. The well-known BL Lac object OJ 287 (PKS 0851+202, z=0.306) is not only a high-variable extragalactic source with hints for recurrent pseudo-cyclical optical outbursts, but it also represents a case of substantial intensive and extensive (long-term) multi-frequency time-domain data archive. Under a post-Newtonian General Relativity approach OJ 287 can be modeled as a binary supermassive black hole system, with a spinning primary and a non-spinning secondary, assuming the primary has an accretion disk which is impacted by the secondary at specific times. The model clocking of optical, UV, X-ray light curves provides clues on several General Relativity properties of the system, including spin, precession and energy losses by radiation of nano-Hz gravitational waves. This rich time series database on OJ 287 allowed us also a deeper variability power spectrum analysis, across the electromagnetic spectrum.

Fast X-ray flares and quiescent emission from the quadruple system GT Muscae

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GT Muscae is a quadruple system hosting an RS CVn binary that shows a highly variable X-ray emission. We present a work based on the entire public archival INTEGRAL data set (exposure time: 11 Ms; energy range: 3-40 keV) which covers the period 2003-2017, and on the recent XMM-Newton observation of June 2016. The WFC BeppoSAX data set (energy range: 2-28 keV), which covers the period 1997-2001 with an exposure time of about 0.85 Ms, is explored as well. The aims of this work are to study the temporal variability and spectral properties of GT Muscae and in particular its thermal component and to detect and constrain the non-thermal hard X-ray emission component. In our preliminary work, we detected 11 bright flares which reached X-ray luminosities of 1E33 erg/s, about 20 times brighter than the low luminosity level of the source. In three cases, we detected with the ISGRI instrument hard X-ray emission up to 40 keV. We discuss the results in the framework of the current models proposed for the X-ray emission from RS CVn stars.

Is there any Correlation between Radiative Outbursts and Timing Irregularities in Magnetars?

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Magnetars are strongly magnetized pulsars and they occasionally show violent radiative outbursts. They also often exhibit glitches, which are sudden changes in the spin frequency. It was found that some glitches were associated with outbursts but their connection remained unclear. We present a systematic study to identify any statistical correlations between them. We found that the glitch size of magnetars showed a wide distribution, different from the distribution of the Vela-like recurrent glitches but consistent with the high end of that of normal pulsars. Except for the outbursts from newly determined transient magnetars, a glitch is likely a necessary condition for an outburst but not a sufficient condition because only 30% of glitches were associated with outbursts. In the outburst cases, the glitches tend to have larger sizes in both the spin frequency and the spin-down rate compared to the unassociated ones. We argue that a larger glitch is more likely to trigger the outburst mechanism, either the reconfiguration of the magnetosphere or the deformation of the crust, or vice versa. A more frequent and deeper monitoring of magnetars is necessary for further investigation of their connection.

Seven years in the cyclic coronal life of iota Hor

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XMM-Newton has been used to monitor the corona of ι Hor during seven years. The presence of a previously known chromospheric activity cycle of 1.6 yr has been confirmed. Activity cycles are commonly found among late type stars through the chromospheric Ca II emission. Their coronal counterpart, however, remains elusive in most cases, despite of the clear X-ray cycle observed in the solar corona, spanning as much as 1.7 dex in Lx. Here we present the final results of this long term monitoring, where we clearly identify a quite stable coronal cycle of similar periodicity. ι Hor, with an age of $\sim$600 Myr and spectral type F8V, represents a young solar analogue at the age at which life appeared on Earth

Calibrating the time-evolution of the X-ray emission of M dwarfs

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The time-evolution of the X-ray emission of M stars is fundamental for our understanding of stellar dynamos and the irradiation of planet atmospheres with high-energy photons. However, the (X-ray) activity - age relation is still unconstrained, mainly due to the difficulty in the age determination. Our approach is to determine the evolution of X-ray luminosity (L_x) and X-ray plasma temperature (T_x) with age for M dwarfs, observing M stars in wide pairs with a white dwarf that (through its progenitor and cooling age) serves as chronometer for a reliable age constraint. We present XMM-Newton and Chandra observations of 14 such systems spanning ages of 1-7 Gyrs. Our study reveals that some old M dwarfs display unexpectedly strong X-ray emission. Due to the high sensitivity of the observations we could analyse the X-ray spectrum for some of the M stars. This has allowed us to derive a relation between coronal temperature and flux - to our knowledge for the first time for M stars with known age.

Chapter 6

Explosive Astrophysics/Fast Astrophysics

The Transient High Energy Sky and Early Universe Surveyor (THESEUS)

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The Transient High-Energy Sky and Early Universe Surveyor (THESEUS) is a mission concept developed in the last years by a large European consortium, with interest in prospective participation by research groups in USA and other non-European countries. As detailed in Amati et al. 2017 (arXiv:1710.04638) and Stratta et al. 2017 (arXiv:1712.08153), THESEUS aims at exploiting high-redshift Gamma-Ray Bursts for getting unique clues to the early Universe (star formation rate and metallicity evolution up to redshift 10-12, Pop III stars, sources and physics of re-ionization, faint end galaxy luminosity function) and, being an unprecedentedly powerful machine for the detection, accurate location and redshift determination of all types of GRBs (long, short, high-z, under-luminous, ultra-long) and many other classes of transient sources and phenomena, at providing a substantial contribution to multi-messenger astrophysics and time-domain astronomy. Under these respects, THESEUS will show a beautiful synergy with the large observing facilities of the future, like E-ELT, TMT, SKA, CTA, ATHENA, in the electromagnetic domain, as well as with next-generation gravitational-waves and neutrino detectors, thus enhancing importantly their scientific return. Moreover, it will also operate as a flexible IR and X-ray observatory, thus providing an even larger involvement of the scientific community.

Coordinated X-ray and Radio Observations of the Repeating Fast Radio Burst FRB 121102

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FRB 121102, discovered with the Arecibo radio telescope, is the only known repeating fast radio burst source. Its extragalactic nature was unambiguously established via sub-arcsecond localization using the VLA along with Gemini and Hubble optical observations, which identified the host as a faint, low-metallicity, star-forming dwarf galaxy at redshift z=0.193. Recent radio polarimetry revealed that the FRB source resides in an extreme magneto-ionic environment. In an attempt to constrain the nature of the underlying source, we have undertaken X-ray observing campaigns with XMM-Newton, Chandra, and NuSTAR in coordination with radio observations of FRB 121102 to search for X-ray burst as well as persistent counterparts. I will present the results of these observations and discuss them in the context of the host environment of this FRB and of possible sources of fast radio bursts in general. I will conclude with a review of future prospects for high energy studies of FRBs using existing and future facilities.

Disk-jet alignment in Tidal Disruption Events: hints from Swift J1644+57

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An important problem of astrophysics is whether the jet from an accreting black hole is aligned with the black hole spin axis or the accretion disk angular momentum vector. An answer to this question can provide important information about the jet triggering mechanism, disk-jet coupling, and the high energy radiation mechanisms in a black hole system. Tidal Disruption Event (TDE) of a star by a super massive spinning black hole provides a unique astrophysical laboratory to study the jet alignment through the possibility of Lense-Thirring precession of the jet. In this work, we investigate the Swift XRT light curve of the most well sampled jetted TDE, Swift J1644+57. In the thick disk regime of the light curve, we estimate, using a known optimistic method and a new conservative method developed by us, the tilt angle of the jet with respect to the black hole spin axis as a function of the black hole spin parameter. We find that the previously reported dips are less likely to be caused by Lense-Thirring precession, i.e., the jet in Swift J1644+57 is more likely to be aligned with the black hole spin axis.

Multiple X-ray bursts and the model of a spreading layer of accreting matter over the neutron star surface

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We report the detection with INTEGRAL/JEM-X of series of close type I X-ray bursts consisting of two or three events with a recurrence time much shorter than the characteristic time of matter accumulation needed for a thermonuclear explosion to be initiated on the neutron star surface. We show that such series of bursts are naturally explained in the model of a spreading layer of accreting matter over the neutron star surface in the case of a sufficiently high accretion rate (corresponding to a mean luminosity $L_{\rm tot} > 4 \times 10^{36}$ erg/s). In this model matter is accumulated in two high-latitude ring zones. When the first explosion occurs in one of the zones the flame propagates with a velocity of the deflagration wave to another zone and ignites its matter. The existence of triple bursts requires some refinement of the model - the importance of a central ring zone is shown. In the standard model of a spreading layer no infall of matter in this zone is believed to occur. The model explains also the observed enhancement of the burst generation rate by luminous bursters over the rate expected for the case of complete burning of matter accumulated between the bursts.

X-ray observations of Tidal Disruption Events in the era of Time Domain Astronomy

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Tidal Disruption Events, where a star gets ripped apart by the strong tidal forces of a supermassive black hole, create an impulse of accretion, thus providing a unique opportunity to probe accretion physics at its extremes, all while revealing properties of a population of dormant supermassive black holes. X-rays broke open the field of TDE astronomy, through initial discoveries with the ROSAT All-Sky Survey, and subsequent discoveries with the XMM-Newton Slew Survey and the Swift Burst Alert Telescope. In recent years, large optical time domain surveys have expanded the field, finding TDEs soon after the initial disruption. Several of these optical discovered TDEs have been followed up in detail with pointed X-ray telescopes, like Swift, Chandra and XMM-Newton. In this talk, I will present a few of the exciting X-ray results, including the discoveries of ultrafast outflows in two super-Eddington TDEs. I will highlight some of the open questions in the field, and how future X-ray missions will revolutionize TDE studies in the 2020s.

Two Distinct-Absorption X-Ray Components from Type IIn Supernovae: Evidence for Asphericity in the Circumstellar Medium

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We present multi-epoch X-ray spectral observations of three Type IIn supernovae (SNe) 2005kd, 2006jd, and 2010jl, acquired with XMM-Newton, Chandra, Suzaku, and Swift. Previous extensive X-ray studies of SN 2010jl have revealed that X-ray spectra are dominated by hard thermal emission, likely arising from a very hot plasma heated by a forward shock propagating into a massive circumstellar medium (CSM). Interestingly, an additional soft X-ray component was required to reproduce the spectra at a period of 1-2 yr after the SN explosion. Its origin remained an open question. We find a similar soft X-ray component from the other two SNe IIn as well. Here we present a new interpretation for the origin of this component; it is thermal emission from a forward shock, directly reaching us from a void of the dense CSM. Namely, the soft and hard components are responsible for the heavily- and moderately-absorbed components, respectively. The co-existence of the two components with distinct absorptions as well as the delayed emergence of the moderately-absorbed X-ray component would be evidence for asphericity of the CSM. Based on our X-ray spectral analyses, we estimate the radius of the torus-like CSM to be on the order of 5e16 cm.

Identifying the XMM-Newton slew variable source population and the implication for Einstein Probe

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The Einstein Probe is a small mission dedicated to time-domain astronomy to monitor the sky in the soft X-ray band. It has similar sensitivity to that of the XMM-Newton slew survey (XMMSL) and will carry out systematic survey and characterization of high-energy transients. A catalogue of variable sources in the soft X-ray band is very important to EP. By comparing the 0.2-2 kev flux in the XMMSL observation to that in RASS (Rosat All Sky Survey), we have got a catalogue of 301 variable sources, which have varied more than a factor of 10. We did the identification with multi-wavelength catalogue and got the category distribution. Among these sources, 2 of them are Cvs (Or candidate CVs), 15 are X-ray binaries, 67 are galaxies (5 TDEs), 56 are QSO/AGN and 119 are stars. We will talk about scientific goals of EP and the properties of the sources in the variable source catalogue got from XMMSL. Implications of this catalogue for future missions (especially EP) will be discussed.

Searching for fast transients in XMM-Newton data

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The variability of X-ray detections in the 3XMM catalogue is explored through their fractional variability and chi-squared tests. However, some sources may show very short duration outbursts, resulting in few X-ray counts and thus having insufficient counts over a long observation to be detected. Examples of such objects are distant and thus strongly redshifted faint short gamma-ray bursts that last less than two seconds, the electromagnetic counterparts of gravitational wave events. Alternatively these could be type-I X-ray bursts in distant galaxies, or possibly X-ray counterparts to fast radio bursts (FRBs).

Building on existing software, I am developing an algorithm to automatically search XMM-Newton data for new sources that may have shown very short outbursts, but which are drowned out by the background noise summed over the whole observation. Searching for new objects in short time bins throughout the duration of the observation may be one way to identify these sources.

Here I will present the variability tests and results of the most interesting variable sources discovered. This code could be used to conduct automatic searches across observations to search for gravitational wave event counterparts as well as other fast transients.

Observations of tidal disruption events: past, present and future

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The tidal disruption of a star by a nuclear supermassive black-hole was predicted in the 1970s and first confirmed by soft X-ray flares seen from quiescent galaxies in the ROSAT all-sky survey. Similar events have continued to be found in XMM-Newton and Chandra data and more recently flares in large-area hard X-ray, UV and optical transient surveys have also been attributed to the same phenomenon. Each of these spectral components, sometimes complemented by radio and IR activity, have their own timescale and possibly physical mechanism. Current models and simulations revolve around trying to explain how the energy released by the fall back of stellar debris in the gravitational well of the black hole is converted into radiation in each wave band. We provide an overview of the current state of knowledge on tidal disruption events, highlighting the outstanding questions: what is the connection between UV and X-ray emission?, why are jets rarely formed?, what determines whether an event is X-ray or optically bright ? We look at the observations which are needed to make further breakthroughs in the field and assess the optimum follow-up strategies needed for events discovered in future large survey missions such as eRosita and LSST.

Fast extragalactic transients in the XMM-Newton archive

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Thanks to the analysis of the full XMM-Newton archive within the EXTraS project, we identified a large number of transient X-ray sources with a duration spanning from several minutes to a few hours. Although most of them are flares from relatively nearby stars, some of the shortest bursts are very likely powerful extragalactic events. In particular, through the measurement of the redshift of its host galaxy, we could estimate the luminosity of one of these events and interpret it as the X-ray flare likely from a core-collapse supernova. Our sensitivity to this kind of events has been estimated through detailed simulations and can be used to constrain their rate in the local Universe.

A network of optical telescopes dedicated to the early follow-up of multimessenger triggers

Damien Turpin on behalf of the GWAC team[1], Sarah Antier[2], Alain Klotz[3,4], Nicolas Leroy[2], En-wei Liang[5], Xiang-Gao Wang[5], Zi-Gao Dai[6], Xiang-Yu Wang[6], Yuan-Gui Yang[7], Bertrand Cordier[8], Damien Dornic[9], Bo-Bing Wu[10], Cyril Lachaud[11]

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By multiplying close exhanges between various facilities from different astrophysical communities (gravitational wave-GW-, astroparticle, electromagnetic), the study of the multimessenger time-domain astronomy has deeply changed our way of observing the sky. The time-domain astronomy has brought new challenges as it requires to quickly answer to multimessenger alerts with a good sensitivity and sometimes with an instrument able to cover large error boxes. In the next few years, the dramatic increase of the number of multimessenger alerts will make their follow-up even more complex since it will require smart strategies to filter the triggers, to fully characterise the (numerous) candidates and to schedule efficient early and late follow-ups. The optimisation of the performances of each facility is a need to guarantee the best scientific return. In this contribution, we present the strategy we have developped with a network of optical telescopes located in China to quickly follow-up LIGO/Virgo GW and GRB triggers. The results obtained during the GW-O2 follow-up campaign and from our current observational program to catch the early optical afterglow counterpart from the Gamma-ray Bursts will be also shown. Finally, we will discuss our plan to significantly extend this network and our strategy for the next GW-O3 campaign.

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