Conference Program

European Space Astronomy Centre, Madrid, Spain

October 21–24, 2024

Monday, October 21

Session 1: INTEGRAL and its legacy

Convenor: Pietro Ubertini

14:30 **Matthias Ehle & Jan-Uwe Ness** . . . . . **Opening, announcements, and mission status updates**
ESA/ESAC, Madrid

14:45 **Olga Dubrovina** . . . . . **The INTEGRAL Project: Historical Overview**
University of Padua

15:15 **Guillaume Belanger** . . . . . **Unveiling the INTEGRAL Science Legacy Archive**
ESA/ESAC, Madrid

15:30 **Carlo Ferrigno** . . . . . **MMODA: Multi-Messenger Online Data Analysis**
University of Geneva

15:45 **Oliver Pedros** . . . . . **22 years of Cd-Te detector in space, the challenges of ISGRI calibration**
University of Geneva

Throughout 22 years of operation in space, the ISGRI Cd/Te detector has been exposed to continuous bombardment of high energy particles, inevitably leading to significant evolution of its properties. This introduces new challenges for the calibration of the instrument, the precision of which is fundamental for scientific analysis of the data. We present key characteristics of the detector evolution from mission launch until today and explain the calibration pipeline allowing us to continuously provide reliable, well-calibrated data to the community.

Session 2: Multi-messenger and time domain astronomy

Convenor: Carlo Ferrigno (University of Geneva)

16:30 **Volodymyr Savchenko** . . **INTEGRAL contributions to establishment of multi-messenger Astronomy**
University of Geneva

I will review unique and fundamental contributions made by INTEGRAL to emergence and establishment of multi-messenger astronomy in the last decade, focusing on observations of transient counterparts of gravitational wave and neutrino events.

17:00 **Alicia M Sintes** . . . **Multi-messenger astronomy with current and future gravitational-wave facilities**
Universitat Illes Balears

GW170817 brought the beginning of the era of multi-messenger astrophysics with gravitational waves. As the breadth and depth of gravitational wave detection capabilities grows, so do the opportunities for multi-messenger observations. This talk will survey the near- and medium-term future for ground- and space-based gravitational wave observatories, the astrophysical sources with the potential to also be observed electromagnetically, and the promise of how joint observations will answer longstanding questions in astrophysics, cosmology, and fundamental physics.

17:30 **Eric Burns** . . . . . **Fast Localization of Gamma-Ray Bursts: Implications of a Technical Challenge**
Department of Physics and Astronomy, Louisiana State University (Presented remotely)

Gamma-ray bursts are the most luminous events from the big bang, and are foundational sources for time-domain, multiwavelength, and multi-messenger astrophysics. We will discuss the revolution brought about by rapid localization of these events, and the global follow-up community it created. We will discuss the technical difficulties missions face in achieving this capability, discuss what INTEGRAL has or could enable, and what future missions lie ahead. We will also emphasize why this capability is needed for the future.

Tuesday, October 22

Session 3: Multi-messenger and time domain astronomy

Convenor: Miguel Mas-Hesse (Centro de Astrobiologia (CSIC-INTA), Madrid)

9:30 **Fabian Schussler**
Multi-messenger programs searching for VHE gamma-ray emission associated with high-energy neutrinos
IRFU / CEA Paris-Saclay

In recent years, there have been several breakthroughs and discoveries in high-energy astrophysics, particularly related to transient phenomena involving all cosmic messengers, including radiation across the full electromagnetic spectrum, high-energy neutrinos, and gravitational waves. Thanks to their high sensitivity and increasingly optimized response to transient events, very-high-energy (VHE) gamma-ray observatories are playing a pivotal role in the evolving field of time-domain and multi-messenger astrophysics. In this talk, I will review some of the recent highlights of the transient multi-messenger programs conducted by ground-based Imaging Atmospheric Cherenkov Telescopes (IACTs), with a special focus on real-time follow-up observations of neutrino events. These programs consist of two main components: the follow-up of individual high-energy neutrino candidates of potential astrophysical origin, such as IC-170922A, and the observation of known gamma-ray sources around which IceCube has identified a cluster of candidate neutrino events. I will outline these programs, highlight recent observations, describe the collaborative efforts involving IceCube and all current IACTs, and give an outlook to the near future.

10:00 **Marta Burgay** . . . . . **The mystery of Fast Radio Bursts**
INAF, Osservatorio Astronomico di Cagliari

Fast Radio Bursts (FRBs) are millisecond-duration, extremely bright, extragalactic flashes of radio waves. While their number has quickly increased in the last decade thanks to new instrumentation and search techniques, the nature of their progenitors and of their emission mechanism is still largely debated. High-energy observations, coupled with deep and detailed studies of these sources in the radio band, represent a key ingredient to solve their mystery and to allow us to fully exploit their potential as astrophysical and cosmological probes.

10:30 **Antoine Foisseau**
Unveiling the hard X-ray emission of NGC 1068, a possible high energy neutrino source
AstroParticules et Cosmologie - APC - Paris

One of the central questions in high-energy astrophysics is the origin of high-energy cosmic rays and neutrinos. The Seyfert 2 Compton-thick AGN NGC 1068 stands out as a promising candidate for high-energy neutrino emission, with a significance level of 4.2 . Various models have been proposed to explain the multi-messenger emission associated with this source. X-ray data are crucial for constraining the presence of a potential hadronic component in the electromagnetic spectral energy distribution of AGNs. In this context, we analyzed publicly available data from XMM-Newton, NuSTAR, INTEGRAL-IBIS, INTEGRAL-SPI and Swift-BAT spanning over more than 20 years. The resulting spectra cover the 3–195 keV energy range, allowing us to investigate the presence of a cutoff in the hard X-ray regime and thereby explore its hadronic versus leptonic origin. Our analysis confirms that the spectrum is dominated by Compton reflection processes up to 80 keV, while the hard X-ray component does not show any significant cutoff. We will discuss the implication of these results in the context of the multi-messenger emission of NGC 1068.

10:45 **Anastasia Tsvetkova**
Gamma-ray burst taxonomy: looking for the third class on the spectral peak energy-duration plane in the rest frame
University of Cagliari

Two classes of GRBs, corresponding to the short and the long events, with a putative intermediate class, are typically distinguished in the observer frame. However, in the rest-frame, due to the dispersion in durations and hardnesses, introduced by the wide range of redshifts, the boundaries between the classes become blurred. We check for the evidence of the third class of GRBs and investigate how the transition from the observer to the rest frame affects the hardness-duration-based classification. We apply the skewed and non-skewed Gaussian and Student distributions to the sample of 409 GRBs with measured redshifts to cluster the bursts on the plane of their durations (T90) and spectral peak energies (Ep). The total sample consists of three subsamples: the events (1) detected by Konus-Wind (KW) in the triggered mode, (2) simultaneously detected by KW in the waiting mode and by Swift/BAT in the triggered mode, (3) detected by Fermi/GBM in the triggered mode. To address instrumental biases and selection effects, each subsample was studied separately, and a sample with the dimmest bursts being excluded was investigated. We fitted one-, two-, and three-component distributions to the data and claimed the preferred model based on the AIC and BIC. We used modelling of the original data to address the reliability of the method. As a result, we found that the statistically preferred number of clusters based on the GRB rest-frame hardnesses and durations does not exceed two and, accordingly, did not find any solid evidence of the third "intermediate" class.

Session 4: X-ray binaries

Convenor: Jan-Uwe Ness (ESA, ESAC, Madrid)

11:30 **Francis Fortin** ..... **X-ray binaries from the INTEGRAL to the Gaia era**
IRAP, Toulouse

X-ray binaries are stellar couples where a compact object (NS, BH) accretes material from a companion star. Both low (LMXBs) and high (HMXBs) mass X-ray binaries exhibit a huge variety in the mean of accretion, presence of disks, winds and jets, and are ideal laboratories to probe the formation channels of double compact binaries, potentially ending in gravitational wave mergers. These systems pose great observational challenges to be fully characterized, hence new information about them tends to spread in the literature over multiple papers and several years. I propose to the community two updated catalogues of Galactic X-ray binaries that gather information spanning the last 22 years, from the INTEGRAL to the Gaia era: multi-wavelength coordinates, orbital periods, spectral types, radial velocities... New discoveries are regularly added to the catalogues upon request, so that they should remain up to date for the years to come. The catalogues can be a resource for planning observations or for studies on the global population of X-ray binaries of our Galaxy.

12:00 **Nathalie Degenaar** . **Thermonuclear bursts on neutron stars as a new way to study the physics of jets**
University of Amsterdam

Accreting neutron stars can display thermonuclear explosions due to unstable nuclear burning of the gas accumulating on the stellar surface. These explosions are visible as 1-minute long X-ray flashes that can repeat as regularly as every few hours. Using coordinated observations between INTEGRAL and the ATCA radio telescope, our team discovered that these explosions cause a brightening of the radio jets launched by neutron stars. This has delivered the first-ever measurement of the speed of neutron star jets, traveling with nearly 40% of the speed of light. The observable impact of thermonuclear bursts on radio jets opens up a completely new and powerful way to study the fundamental properties of neutron star jets that is not possible by any other means.

12:30 **Gaurava Kumar Jaisawal** .... **A comprehensive study of thermonuclear X-ray bursts from 4U 1820-30**
DTU Space, Technical University of Denmark

We present results from timing and spectral studies of 15 thermonuclear Xray bursts from the ultracompact X-ray binary 4U 1820-30, observed with the Neutron Star Interior Composition Explorer (NICER). All bursts exhibited clear signs of photospheric radius expansion, with the neutron star's photosphere expanding over 50 km above the surface. Notably, one burst displayed super-expansion, reaching a blackbody radius of 902 km. We searched for burst oscillations across all 15 bursts and found evidence

of a coherent oscillation at 716 Hz in one burst, with a 3σ detection level based on Monte Carlo simulations. If confirmed with future observations, 4U 1820-30 would become the fastest-rotating neutron star known in X-ray binaries. Additionally, we will discuss the results of our time-resolved burst spectroscopy using different modeling approaches, highlighting the connection between accretion and burst emission.

12:45 **Fiamma Capitanio** ..... **Unveiling the nature of 4U 1630-47 with INTEGRAL and IXPE**
INAF, IAPS, Rome

4U 1630-47 is a peculiar transient X-ray binary believed to host a black hole as its compact object. Its behavior differs from that of other BH-XRBs, as it exhibits both recurrent outbursts and a lack of bright hard states. Consequently, relativistic radio jets are rarely detected. On the other hand, as demonstrated by several observations performed by INTEGRAL, the source spectra in soft state are characterized by the presence of a bright power-law component extending up to 200 keV without any cutoff. Moreover, recent IXPE observations, performed simultaneously with INTEGRAL, have measured a higher level of polarization, not detected in other LMXBs, which is difficult to explain as the result of scattering, even for a high-inclination source with a highly asymmetric corona. Here, I will review the main characteristics of this enigmatic source and the possible explanations for its peculiar behavior in light of the new spectro-polarimetric results.

Session 5: Survey from Gamma-ray to soft X-rays

Convenor: Angela Bazzano (INAF, IAPS, Rome)

14:30 **Roman Krivonos** ..... **INTEGRAL: 20 years of hard X-ray surveys and background measurements**
Space Research Institute (IKI), Moscow (Presented remotely)

The INTEGRAL hard X-ray surveys have proven to be of fundamental importance. In more than twenty years of operation, the INTEGRAL observatory has given us a sharper view of the hard X-ray sky, and provided the triggers for many follow-up campaigns from radio frequencies to gamma-rays. In addition to conducting a census of hard X-ray sources across the entire sky, INTEGRAL has carried out unique observations of the Galactic X-ray background, which will without question be included in the annals of X-ray astronomy as one of the mission's most salient contribution to our understanding of the hard X-ray sky. In my talk I will review the INTEGRAL all-sky surveys, including our recent work based on 17 years of operation. Also, I will present our current study of the large scale morphology and spectral properties of the Galactic hard X-ray and soft gamma-ray background emission from 25 to 200 keV.

15:00 **Andrea Merloni** ..... **SRG/eROSITA: highlights from the all-sky survey first data release**
MPE, Garching

Wide-area, sensitive X-ray surveys map the hot and energetic Universe to reveal key processes across many areas of astrophysics and Cosmology, including the most massive collapsed structures of the Universe (clusters and groups of galaxies), the hot ISM and CGM of the Milky Way and the Supernova remnants that energise it, the atmospheres of neutron stars, the magnetic coronae of accretion discs around black holes, and many more. eROSITA (extended Roentgen Survey with an Imaging Telescope Array), the soft X-ray instrument on the Russian-German Spektrum-Roentgen-Gamma (SRG) mission is expanding the horizon of X-ray astronomy and delivering large legacy samples thanks to its high sensitivity, large field of view, high spatial resolution and survey efficiency. I will present an overview of the instrument capabilities, the current status of the mission, and a few science results from the survey program selected from the first data release.

15:30 **Dominik Patryk Pacholski**
INTEGRAL observations of Galactic magnetars and search for extragalactic giant flares
INAF, IASF, Milano

INTEGRAL has extensively observed the Galactic plane, where most magnetars are located, providing an excellent opportunity to study their hard X-ray emission over the entire mission period. Using archival data from the INTEGRAL IBIS instrument, we conducted a comprehensive analysis of both persistent hard X-ray emission and short bursts. This large dataset allowed us to explore the variability and characteristics of the emission throughout the INTEGRAL mission. Additionally, since the high luminosity of magnetar giant flares (MGFs) makes them detectable at extragalactic distances, we used archival data from observations of the Virgo Cluster and a small sample of nearby star-forming galaxies

to search for MGFs. We present in addition to the results of the study of Galactic magnetars, the results of the search for extragalactic MGF and the resulting lower and upper limits on their occurrence rate.

Session 6: Supernovae, Cosmic Rays and Magnetars

Convenor: Philippe Laurent (CEA/DRF/IRFU/DAp, Saclay)

16:30 **Jordi Isern** ..... **Gamma emission from Type Ia Supernovae**
CSIC, ICE, Barcelona

For a long time, it was assumed that the light curve of Type Ia supernovae (SNIa) was mainly powered by the radioactive disintegration of the 56Ni chain. The detection and measurement by INTEGRAL of the gamma-rays emitted by SN 2014J provided the first direct proof that this hypothesis was correct and that the total amount of 56Ni synthesized was in agreement with the values predicted by light curve models. Because of the existence of many SNIa subtypes it is clear at present that the thermonuclear explosion of a white dwarf can occur in multiple scenarios leading to light curves that depend not only on the total amount of 56Ni synthesized but also on its distribution within the debris and, consequently, on the line of sight as it can be seen in few examples. For instance, the early gamma emission detected in SN2014J could be an example of such effects. This fact emphasizes the convenience of an instrument able to detect the early emission of a significant number of SNIa events.

17:00 **Sandro Mereghetti** ..... **INTEGRAL catching magnetar flares**
INAF, IASF, Milano

Magnetars, isolated neutron stars powered mainly by magnetic energy, are characterised by a remarkable variability in the X-ray/gamma-ray bands. They show a variety of phenomena spanning a broad interval in dynamic range and duration, from short bursts of a few milliseconds to outbursts lasting several months or even years. Among these, the giant flares, releasing up to 10^{47} erg in gamma-rays in less than one second, are the most spectacular events and can be observed also from sources at distances of several megaparsecs. The unpredictable occurrence of magnetar flares complicates their accurate study, but, thanks to the large sky coverage and good imaging, timing and spectroscopic capabilities of its instruments, INTEGRAL has given several significant contributions in this field. In this invited talk I will review the main results on bursts and flares from galactic and extragalactic magnetars obtained in more than two decades of observations with INTEGRAL.

17:30 **Tomotaka Nishikawa**
Observational prediction of gamma-ray emission from knee-energy cosmic rays accelerated by core-collapse supernovae
Graduate School of Science, Nagoya University, Nagoya

Galactic cosmic rays are believed to be accelerated through diffusive shock acceleration (DSA) within supernova remnants (SNRs). Recent observations of SNRs aged around 100–1000 years indicate that cosmic rays do not reach PeV energies. However, Inoue et al. (2021) demonstrated via kinetic-MHD simulations that cosmic rays can reach up to $\sim$3 PeV when a blast wave shock propagates through a dense circumstellar medium (CSM) within tens of days after the explosion. This dense CSM is assumed to be produced by a red supergiant (RSG) wind with a mass-loss-rate of $10^{-3}\ M_{\odot} yr^{-1}$, supported by recent supernova observations. Observing 100 TeV gamma-rays, produced by PeV cosmic rays through neutral pion decay, can confirm PeV accelerations. However, these gamma-rays from young SNRs are often attenuated by interactions with photons from the supernova photosphere and cosmic background radiation. Previous studies suggested it is difficult to detect these gamma-rays with a conventional RSG wind ($\sim 10^{-5}\ M_{\odot} yr^{-1}$). Using Inoue et al. (2021) kinetic-MHD simulation data, we calculate the gamma-ray flux from a blast wave in a dense CSM, considering environmental attenuation. We find a significantly higher gamma-ray flux than previous studies if we assume a modern mass-loss rate wind ($\sim 10^{-3}\ M_{\odot} yr^{-1}$). We predict that the CTA can detect 100 TeV gamma-rays with 1.3 hours of integration if a type II SN occurs within 5.2 Mpc. Based on observed star formation rates, such an event is expected once every 6 years.

17:45 **Guillaume Belanger** ..... **Using OSA in ESA Datalabs**
ESA, ESAC, Madrid

Wednesday, October 23

Session 7: Radio-Gamma extragalactic results

Convenor: Francesca Panessa (INAF, IAPS, Rome)

9:30 **Gabriele Bruni** ..... **Extra-galactic jets in the high energy sky**
INAF, IAPS, Rome

The advent of new generation radio telescopes is opening new possibilities on the classification and study of extragalactic high-energy sources, specially the underrepresented ones like radio galaxies. Among these, Giant Radio Galaxies (GRG, $\sim$1 Mpc) are among the most extreme manifestations of the accretion/ejection processes on supermassive black holes. Our recent studies have shown that GRG can be up to four times more abundant in hard X-ray selected samples (i.e. from INTEGRAL/IBIS and Swift/BAT at $>$20 keV) and, most interestingly, the majority of them present signs of restarted radio activity. This makes them the ideal testbed to study the so far unknown duty cycle of jets in active galactic nuclei. Open questions in the field include: How and when jets are restarted? How jets evolve and what's their dynamic? What is the jet's duty cycle and what triggers them? Our group has recently collected a wealth of radio data on these high-energy selected GRGs (the GRACE project), allowing us to study their jet formation and evolution from the pc to kpc scales across different activity epochs, estimating their duty cycle. In particular, thanks to our EVN large programme, we were able to probe the newborn radio phase in their core. Finally, we are devoting an effort to the exploitation of new radio surveys data for the discovery of misaligned AGN as counterparts of Fermi/LAT and ANTARES catalogues. In particular, we are unveiling the hidden population of radio galaxies associated with gamma-ray sources, and possibly with neutrino events.

10:00 **Claudio Ricci** ..... **A Hard X-ray View of the Accretion and Obscuration Properties of AGN**
Universidad Diego Portales, IEA, Santiago

X-ray emission is a ubiquitous property of Active Galactic Nuclei and, being produced within a few gravitational radii from the supermassive black hole, it can provide fundamental information about the structure and geometry of the circumnuclear material, as well as on the characteristics of the accretion flow. Most accreting supermassive black holes are obscured by circumnuclear gas and dust. Studies of AGN in the X-rays are typically limited by this strong obscuration, which reduces significantly their completeness. Thanks to hard X-ray satellites, such as INTEGRAL, Swift/BAT and NuSTAR, over the past two decades we have been gaining fundamental insights into the properties of AGN in the local Universe. These hard X-ray selected samples provide an excellent low-z benchmark for studying AGN at higher redshifts and have been followed up with numerous observations across the entire multi-wavelength spectrum. In my talk, I will review recent results obtained by studying the obscuration and accretion properties of these highly complete samples of nearby AGN, focussing on both their X-ray and multi-wavelength properties.

10:30 **Eugenio Bottacini** ..... **Black Hole Physics in the Low-Redshift Universe**
Department of Physics and Astronomy, University of Padova (Presented remotely)

The INTEGRAL mission has been successfully charting the high-energy sky for black hole physics at the centers of galaxies for more than two decades. Very specifically, the extragalactic sky has been explored primarily at low redshift where the detected supermassive black holes have been systematically followed up, providing comprehensive insights into the black hole environment. Yet, long-term precision observations unveil unexpected results that challenge our understanding of the physics of black holes. I will review the most advanced high-energy observations that address the physics related to supermassive black holes in the local Universe. A detailed example of Mrk 876 will be presented to illustrate the challenges in reconciling theory with observations, both in the context of a single source and within a broader sample.

10:45 **Lorena Hernández-García**
The galaxy discovered by INTEGRAL that dramatically changed the direction of its relativistic jet
University of Valparaiso, Valparaiso

Galaxies are usually classified based on their observational properties. They are called radio galaxies when we see the relativistic jets in the plane of the sky, while they are called blazars when the jet points towards us. PBC J2333.9-2343 is a very peculiar galaxy because it shows two radio lobes extended over

1.1 Mpc, and a bright central core associated to a blazar nucleus. This galaxy was first selected from the INTEGRAL sample because of its different classifications when observed at different wavelengths. After a comprehensive multi wavelength monitoring (from radio frequencies to gamma rays) and multi scale observations (from kpc to pc scales) we were able to confirm the blazar nature of its nucleus. This result is confirmed by its spectral energy distribution, that shows two peaks, and the derived jet angle of 3 degrees is also typical of a blazar. The small orientation angle, compared to the Mpc scale radio lobes, suggests a dramatic change of the jet direction. Other extreme objects like this may be discovered through the cross-correlation of future X-ray and radio surveys, using the latest generation instruments.

Session 8: Radio-Gamma galactic results

Convenor: Francesca Panessa (INAF, IAPS, Rome)

11:30 **Sara Elisa Motta** ..... **An INTEGRAL view of accreting black hole X-ray binaries**
INAF-OAB, Milan

Galactic X-ray binaries hosting stellar mass black holes are ideal laboratories where to study the accretion processes and the launch of outflows which is ubiquitously observed in accreting systems. Accretion is best studied in the X-rays, and it is based on the properties of the X-ray emission that several accretions states are defined, which are also used to describe the multi wavelengths behaviour of these systems. I will give an overview of the phenomenology ascribed to the accretion process and to the generation of outflows in black hole X-ray binaries in the framework of the accretion states, and especially on the connection between the accretion processes and the generation of outflows. In particular I will focus on the contributions of the INTEGRAL observatory to the study and understanding of the black hole X-ray binary population in our Galaxy.

11:50 **Floriane Cangemi** ..... **High energy emission in Black Hole X-ray Binaries**
UPC/APC, Paris

Black hole X-ray binary systems provide ideal environments for studying extreme physical phenomena, such as matter accretion and the formation of relativistic jets. Although the emission below 100 keV is generally well understood, a high-energy component, often referred to as the ”high-energy tail”, is occasionally detected in some sources. The origin of this high-energy component is widely debated, and INTEGRAL, with its unique observational capabilities in hard X-rays, has played a crucial role in enhancing our understanding of this emission. In this presentation, we will highlight recent findings with INTEGRAL et and explore the different scenarios that might explain the origin of this component. We will present spectral analyses conducted on multiple sources, as well as recent polarization results obtained thanks to IBIS and SPI, which provide unique insights into the nature of this emission. These findings emphasize the importance of studying high-energy emissions in black hole binaries to refine our understanding of the physical processes occurring in these systems.

12:10 **Melania Del Santo** ... **High-energy emission and disk/jet connection in Galactic black-hole binaries**
INAF, IASF, Palermo

Galactic black hole binaries show several and complex accretion states and transitions in the X/gamma-ray domain, also connected to different behaviors of the outflows, either jets or winds. I will review both on the observations performed in the last years, in particular with the INTEGRAL satellite, and on the emission models used to explain the involved physical processes. Thanks to INTEGRAL, we have a new view on the high energy emission observed in several systems above 200 keV. The origin of this emission is unclear, it could be either due to the presence of a small fraction of non-thermal electrons in a hot Comptonising plasma or originate in the jet. Finally, I will present preliminary results obtained applying the jet emission model ISHEM to a few systems recently observed emitting in the soft gamma-ray domain.

12:30 **Tristan Bouchet** ..... **Polarization properties of Swift J1727.8-1613 and others with INTEGRAL/IBIS**
CEA Saclay, Paris

The IBIS telescope onboard the INTEGRAL satellite can be used to probe the polarization of bright sources above 200 keV, thanks to the Compton scattering of photons between its two detectors: ISGRI (30 – 500 keV) and PICsIT (150 keV – 10 MeV). In this talk we will first describe the recent improvement of the IBIS Compton mode in the low energy band (200 - 300 keV), and show how it compares to other independent polarization measurements of the Crab nebula, providing support for the results

in this new energy range. This method can also be used with observations of Black Hole X-ray Binaries/Microquasars, most of which have been found to emit a high-energy tail (above typically 100-200 keV) during some phases of their outbursts. This emission detected by INTEGRAL has yet to be fully explained. Following previous studies by our team we found a high polarization degree in the Microquasar Swift J1727.8-1613, both in the hard and soft intermediate states, compatible with synchrotron emission. Interestingly the polarization angle was found to be aligned with the jet axis in the Soft Intermediate State, and the same jet alignment was found after reanalyzing data of the source MAXI J1348-630. We therefore argue that this behavior may be more generic than first thought. Finally, we interpret the possible orientation of the polarization angle and magnetic field compared to the gamma-ray emitting jet during the outburst, and we suggest a way to constrain the inclination of the jet using the polarization fraction and photon index.

12:45 **James Rodi**
Exploring the Long-term Average Spectra of the Persistent Black Hole Candidates GRS 1758-258 and 1E 1740.7-2942
INAF-IAPS, Roma

The persistent Galactic Center black hole candidates GRS 1758-258 and 1E 1740.7-2942 have been monitored extensively throughout the INTEGRAL mission. During this time the sources exhibited both soft and hard spectral states. Using over 20 Ms of exposure time, we investigate the long-term average spectral states of GRS 1758-258 and 1E 1740.7-2942 up to soft gamma-rays with IBIS-ISGRI.

Session 9: Galactic and extragalactic astronomy

Convenors: Julien Malzac (IRAP (CNRS, UPS, OMP, CNES))

14:30 **Francesco Massaro** . . . . . **Hunting active galaxies within the unidentified high energy sources**
University of Turin, Turin

I will briefly review the state-ofthe-art of the unidentified source problem in the hard X-ray and in the gamma-ray bands highlighting recent progresses made to associate and identify sources. I will recent results of ongoing follow up campaigns at different frequencies carried out to search for active galaxies within the sample of unidentified high energy sources. Then I will focus on the classes of extragalactic sources that dominates the high energy sky, in the keV-GeV, energy range thus providing important clues to unveil the origin to the extragalactic background. Finally, I will show possible links between the hard X-ray and the gamma-ray emissions of blazars that could potentially be used to decrease the number of unidentified sources.

15:00 **Alessandro Papitto**
Bridging accretion and rotation-powered neutron stars, the case of transitional millisecond pulsars
INAF, OAR, Roma

Millisecond pulsars in binary systems play a substantial role in the astrophysics of neutron stars. We usually observe them as either radio/gamma-ray pulsars powered by the rotation of their magnetic field or as X-ray pulsars that accrete mass transferred by the companion star. According to a long-standing paradigm, these two mechanisms are mutually exclusive. However, in transitional millisecond pulsars, variations of the mass accretion rate produce swings between a radio pulsar regime and an X-ray pulsar state. These systems showcase the different possible outcomes of the interaction between a quickly spinning magnetized NS and the accretion disk matter as they unfold over timescales accessible to human life. I will review the rich and complex phenomenology unveiled by a decade of observations of transitional millisecond pulsars. In particular, I will focus on the peculiar state achieved when the accretion luminosity is comparable to the pulsar spin-down power. In this context, the recent discovery of optical and UV pulsations from a transitional (and later from an accreting) millisecond pulsar suggests that magnetospheric particle acceleration can proceed even when an accretion disk surrounds a pulsar. The dichotomy between radio and X-ray millisecond pulsars might be less pronounced than commonly assumed, with accretion and rotation-powered processes coexisting under certain circumstances.

15:30 **Philipp Thalhammer**
Unprecedented X-ray flaring in Cyg X-1 discovered by a lifetime of INTEGRAL monitoring
Remeis Observatory & ECAP, FAU Erlangen-Nürnberg, Bamberg

We present INTEGRAL observations covering an extraordinarily bright triplet of X-ray flares originating from Cyg X-1. The flares had a duration on the order of only ten minutes and within seconds

reached a peak luminosity of $\sim 2 \times 10^{36}$ erg s^{-1} or a flux of $\sim$14 Crab in the hard X-ray band of 30–80 keV. The associated INTEGRAL/IBIS count-rate about $\sim 10\times$ higher than is usually reached in the hard state. To our knowledge, this is the first time that such strong flaring has been seen in Cyg X-1, despite the more than 21 years of INTEGRAL monitoring, with almost $\sim$20 Ms of exposure, and the similarly deep monitoring with RXTE-PCA that lasted from 1997 to 2012. The flares have been seen in all three X-ray detectors of INTEGRAL and tentatively by the MAXI all-sky monitor. Radio monitoring by the AMI Large Array with observations 6 hr before and 40 hr after the X-ray flare was unable to detect a corresponding increase in radio flux. During the flare the spectral shape shows only marginal spectral change, i.e., largely preserving photon index and cut-off energy, indicating a sudden and brief release of energy. We hypothesize about the physical mechanism behind such an eruption being connected to "blob" ejection along the jet, magnetic reconnection cascades, or other physics of the accretion flow. The NRT data products of the respective INTEGRAL revolution can readily be inspected at https://www.astro.unige.ch/mmoda/gallery/data-products-gallery/.

15:45 **Lara Sidoli** ..... **Discovery of mm emission from a neutron star High Mass X-ray Binary**
INAF, IASF, Milano

High Mass X-ray Binaries (HMXBs) hosting a neutron star accreting matter from an OB supergiant can show persistent (SgXBs) or transient X-ray emission (Supergiant Fast Xray Transients, SFXTs). It has been proposed that this dichotomy might be due to the different properties of their supergiant winds (mass loss rates and wind velocities). In order to investigate this issue, we have started a pilot study at 100 GHz with the Northern Extended Millimetre Array (NOEMA), observing one source per each type: one SgXB (X1908+075) and one SFXT (IGR J18410–0535). We detected significant 100 GHz emission from the SFXT IGRJ18410–0535 at a level of 63.4 $\pm$ 9.6 μJy, resulting in the first detection of mm emission from a neutron star HMXB. Assuming a source distance of 3.2 kpc this detection implies a 100 GHz luminosity of Lmm = (7.8$\pm$1.2) $\times 10^{28}$ erg s^{-1}. On the contrary, no significant mm emission was detected from the SgXB, X1908+075. Given the large uncertainty in the source distances, this result does not necessarily imply a systematic difference between the two targets or their sub-classes. However, our pilot study is a promising starting point to study the supergiant winds in HMXBs, demonstrating that neutron star HMXBs are detectable by current mm facilities, yielding the first low-frequency detection of a SFXT.

Session 10: Galactic astronomy

Convenor: Lara Sidoli (INAF, IASF, Milano)

16:30 **Joern Wilms** ..... **High Mass X-ray Binaries with INTEGRAL**
Remeis-Sternwarte & ECAP, FAU Erlangen-Nuernberg, Bamberg

One of INTEGRAL's most important legacies are its deep observations of X-ray binaries in the hard X-rays. The presentation will give a main overview of the main results on high mass X-ray binaries, compact objects accreting from a Be-star or a supergiant companion. INTEGRAL was the first mission to reveal the large number of strongly absorbed accretors in the galaxy and with its long exposures permitted studies of their long-term variability, transient phenomena, and the magnetic fields of strongly magnetized neutron stars in these systems. This presentation will give an overview of the main results of INTEGRAL and provide an outlook on further studies of sources discovered with the mission.

16:50 **Ruediger Staubert**
The state of cyclotron line research in accreting neutron stars and INTEGRAL's contribution
University of Tuebingen

I will present an update on the state of research of cyclotron lines in accreting neutron stars – highlighting the contributions by INTEGRAL.

17:10 **Lorenzo Ducci** ..... **Studying High-Mass X-ray Binaries with SPI**
University of Tuebingen

This talk will provide an overview of the SPI instrument's capabilities on board INTEGRAL for studying High-Mass X-ray Binaries (HMXBs), highlighting key results obtained with it. I will discuss the observability of HMXBs with SPI, focusing on its spectroscopic potential for investigating the hard X-ray continuum and cyclotron resonance scattering features. Furthermore, I will review the search for the 2.2 MeV line in HMXBs and outline prospects for future research on these sources using SPI and next-generation instruments operating in similar energy ranges.

17:30 **Antonella Tarana**
A new look on weakly magnetized low mass X-ray binaries with INTEGRAL and IXPE
INAF, IAPS, Rome

Low-mass X-ray binaries hosting weakly magnetized neutron stars (NSLMXBs) are among the brightest sources in the X-ray sky. Since 2021, the Imaging X-ray Polarimetry Explorer (IXPE) has provided new measurements of the X-ray polarization of these sources. IXPE observations have revealed that most NS-LMXBs exhibit significant X-ray polarization, offering an unprecedented opportunity to explore the geometry of their accretion flow. However, IXPE's limited energy resolution and bandwidth pose challenges in disentangling the various spectral components, leading to ambiguities in the results. To address this, a multi-frequency coordinated observation campaign has been organized to run simultaneously with IXPE, involving other facilities across different energy ranges. In some cases, however, it has been possible to use archival data. Here, we present the results obtained from the simultaneous or non-simultaneous INTEGRAL/IXPE observations.

17:45 **Sergio Fabiani** ..... **A broad band Spectro-polarimetric view of BH-LMXRBs**
INAF, IAPS, Rome (Presented by Fiamma Capitanio)

The launch of the Imaging X-ray Polarimetry Explorer (IXPE) at the end of 2021 has opened a new window on X-ray polarized light, allowing us to disentangle the nature of the comptonising corona in X-ray binaries. However, IXPE's limited energy resolution and bandwidth make it challenging to determine the various spectral components, leading to ambiguities in the results. A multi-frequency coordinated observation campaign has been organized, involving other facilities across different energy ranges. In particular, we will present the results of a broad-band simultaneous campaign on several black hole low-mass X-ray binaries observed by IXPE, NICER, NuSTAR, and INTEGRAL. In some cases, these observations are also correlated with optical and radio band data

Thursday, October 24

Session 11: Gamma-ray lines

Convenors: M. Hernanz (Institute of Space Sciences (ICE-CSIC & IEEC)) / J. P. Roques (IRAP, Toulouse)

9:30 **Mark Leising** ..... **Gamma-ray Lines in the INTEGRAL Era**
Clemson University, Clemson, South Carolina

Starting from INTEGRAL launch, we review the progress in understanding supernovae and novae via their nucleosynthetic gamma-ray line emission as observed by the INTEGRAL instruments. We discuss electron-positron annihilation observations, especially as they relate to these sources. We briefly discuss prospects for further progress in the near future.

10:00 **Peter von Ballmoos** ..... **What Antimatters in Gamma-Ray Astronomy**
IRAP, Toulouse

While it's widely acknowledged that equal amounts of matter and antimatter have been produced in the Big Bang, gamma-rays have so far failed to detect substantial amounts of baryonic antimatter in the Universe. The tentative detection of a few anti-Helium nuclei (1) has reignited the discussion on the existence of cosmic antimatter. We review gamma-ray observations that constrain baryonic antimatter, including recent FERMI observations ($\sim$100 MeV) that set upper limits on the fraction of nuclear antimatter contained in our local and Galactic neighbourhood (2). (1) S. Ting, https://indico.cern.ch/event/729900, (2018) (2) S. Dupourque, et al., Phs. Rev. D 103, 083016, (2021)

10:30 **Pedro De la Torre Luque** ..... **Probing new physics with Galactic (keV-MeV) gamma-ray emission**
Insitute of theoretical physics (IFT-UAM), Madrid

Measurements of the 511 keV emission reveal the presence of a steady injection of positrons that is very concentrated around the Galactic bulge, and whose origin remains unknown. I will briefly introduce the "positron puzzle" and discuss its possible relation to other anomalous emissions at the Galactic centre. Then, I'll show how we can use the observations of the 511 keV line to constrain the properties of beyond Standard Model particles, such as sub-GeV dark matter, feebly interacting particles (e.g. sterile neutrinos or axion-like particles) or satellite-mass primordial black holes. In addition, I'll show that other mechanisms of (keV to MeV) continuum photon emission associated to the production of positrons can improve existent constraints on these particles.

10:45 **Elena Orlando** ..... **The MeV Excess in the Inner Galaxy**
University of Trieste and Stanford University (Presented remotely)

The inner Galaxy observed at high energies is a complex region where interstellar emission and sources are difficult to disentangle, as both can appear as diffuse emission. To address this challenge, we have developed specialized models for interstellar emission in the INTEGRAL energy bands. This emission is believed to be produced by inverse Compton scattering of Galactic cosmic-ray electrons and positrons on interstellar photons and the CMB. First, we constrained these models using the latest cosmic-ray measurements (AMS-02 and Voyager) and recent multifrequency observations of the inner Galaxy (Fermi-LAT gamma rays, radio, and microwaves). Then, by comparing our models with the available source-subtracted INTEGRAL/SPI data, we identified an unexplained excess in the MeV range.

Session 12: From INTEGRAL to the next generation high-energy facilities

Convenors: P. Ubertini (INAF, IAPS, Roma) / E. Bozzo (University of Geneva)

11:30 **Arianna Vasini** .... **26Al: how to model a short-lived radioactive isotope from a 1D to a 2D approach**
University of Trieste, Trieste

26Al is a short-lived radioactive nucleus ($\tau 1/2$ $\sim$1 Myr) that can be used as tracer of active star formation regions. In the past decades, observational data were collected in the Milky Way by γ-satellites as COMPTEL and INTEGRAL and I will show how we can reproduce them via chemical evolution models. The starting point is adopting a 1D chemical evolution model where the Milky Way is a collection of concentric homogeneous rings. By making assumptions regarding the star formation rate (SFR), the initial mass function (IMF) and the stellar yields this approach puts new constraints on the production of 26Al by nova systems, that can be further investigated by first exploring different environments and then by adding a second dimension to the model. Therefore, I will also show predictions regarding the amount of 26Al in the Large Magellanic Cloud in view of an upcoming NASA survey, COSI (COmpton Spectrometer and Imager), and will introduce a 2D chemical evolution model to account for SFR inhomogeneities caused by the spiral arm structure of the Milky Way.

12:00 **Lorenzo Amati** ..... **The Transient High-Energy Sky and Early Universe Surveyor (THESEUS)**
INAF, OAS, Bologna

The Transient High-Energy Sky and Early Universe Surveyor (THESEUS) is a mission concept aimed at fully exploiting Gamma-Ray Bursts (GRB) for investigating the early Universe and as key phenomena for multi-messenger astrophysics. Developed by a large European collaboration coordinated by INAF and under study by ESA since 2018, THESEUS is currently one of the three candidate M7 missions for a launch in the mid '30s. By providing an unprecedented combination of X-/gamma-ray monitors, on-board IR telescope and spacecraft autonomous fast slewing capabilities, this mission would be a wonderful machine for the detection, multi-wavelength characterization and redshift measurement of any kind of GRBs and many classes of X-ray transients, including highredshift GRBs for cosmology (pop-III stars, cosmic reionization, SFR and metallicity evolution up to the "cosmic dawn") and electromagnetic counterparts to sources of gravitational waves (e.g., short GRBs, soft X-ray and KN emission from NS-NS / NS-BH mergers). Through these unprecedented capabilities and a flexible guest observer programme, THESEUS will also have a great impact on general time-domain astrophysics and, in all respects, will provide an ideal synergy with the very large astronomical facilities of the future in the e.m. (e.g., ELT, CTA, SKA, Athena) and multi-messenger (e.g., Einstein Telescope, Cosmic Explorer, km3NET) domains.

12:20 **Erik Kuulkers**
Einstein probe: searching the Universe for cosmic variable objects and transient phenomena shining in X-ray light
European Space Agency, ESTEC, Noordwijk

The Einstein Probe (EP) is a mission of the Chinese Academy of Sciences (CAS) in collaboration with ESA, MPE and CNES dedicated to time-domain high-energy astrophysics. Its primary goals are to discover high-energy transients and monitor variable objects. To achieve this, EP employs a very large instantaneous field-of-view (3600 square degrees), along with moderate spatial resolution (FWHM 5 arcmin) and energy resolution. Its wide-field imaging capability is achieved by using established technology of novel lobster-eye optics, thereby oPering unprecedentedly high sensitivity and large Grasp,

which supersedes previous and existing X-ray all-sky monitors. To complement this powerful capability to discover and monitor sources over a wide area, EP also carries a conventional X-ray focusing telescope with a larger ePective area to perform follow-up characterization and precise localization of newly-discovered transients. Public transient alerts will be issued rapidly to trigger multi-wavelength followup observations from the world-wide community.

12:40 **Stephane Schanne** ..... **Status of the recently launched Gamma-Ray Burst mission SVOM**
CEA Paris-Saclay / IRFU / DAp, Paris

The French-Chinese SVOM satellite (Space Variable Objects Monitor) has been launched successfully on June 22, 2024, from the Xichang launch site in China and is currently in its inflight commissioning phase. The objectives of the mission cover the detection and observation of astrophysical transient events, with a prime focus on Gamma-Ray Burst real-time detection and afterglow observation. All instruments are operational and well functioning in flight. The GRB trigger onboard the ECLAIRs instrument has already discovered some very interesting bursts and sent Alerts in real-time over the SVOM VHF network to the instrument team, initiating follow-up campaigns involving several space and ground based facilities. This talk gives a status report on the SVOM mission 3 months after launch.

Session 13: From INTEGRAL to the next generation high-energy facilities

Convenors: P. Ubertini (INAF, IAPS, Roma) / E. Bozzo (University of Geneva)

14:30 **Julien Malzac** ..... **The Compton Spectrometer and Imager**
IRAP (CNRS, UPS, OMP, CNES), France

The Compton Spectrometer and Imager (COSI) is a NASA Astrophysics Small Explorer (SMEX) satellite mission in development with a planned launch to low-Earth orbit in 2027. COSI is a wide-field gamma-ray telescope designed to survey the entire sky at 0.2-5 MeV. It provides imaging, spectroscopy, and polarimetry of astrophysical sources, and its germanium detectors provide excellent energy resolution for emission line measurements, including the positron annihilation line at 0.511 MeV and nuclear lines. Polarimetry measurements focus on studies of accreting black holes, including Active Galactic Nuclei. The instantaneous field of view for the germanium detectors is $>$25% of the sky, and they are surrounded on the sides and bottom by active shields, providing background rejection as well as allowing for detection of gamma-ray bursts and other gamma-ray transients over most of the sky. This presentation will include an overview of the COSI mission and science and the project status.

14:50 **Carlotta Pittori** ..... **The AGILE Legacy**
INAF-OAR and ASI-SSDC, Rome

AGILE has been a unique and successful space mission of the Italian Space Agency (ASI), with the programmatic and technical contribution of INAF and INFN. During almost 17 years of observations, since the launch on April 23, 2007 to the satellite re-entry on February 14, 2024, AGILE contributed to high-energy astrophysics and terrestrial physics with many discoveries and detections. Thanks to its sky monitoring capability and fast ground segment alert system, AGILE produced several important scientific results, among which the unexpected discovery of strong and rapid gamma-ray flares from the Crab Nebula over daily timescales (Bruno Rossi Prize 2012). I will give an overview of the main AGILE scientific results, including some recent updates on the science of Gamma-Ray Bursts (GRBs), Fast Radio Bursts (FRBs) and the hunt for electromagnetic counterparts to Gravitational Waves (GW) and cosmic neutrinos. With the satellite re-entry the in-orbit phase ends, but a new phase of scientific work on the AGILE legacy data archive opens: AGILE may still hold future surprises.

15:10 **Matteo Guainazzi** ..... **NewAthena**
ESA, ESTEC, Noordwijk

NewAthena is a powerful, open observatory, enabling unprecedented studies of a wide range of astronomical phenomena. These include distant gamma-ray bursts, the hot gas found in the space around clusters of galaxies, accreting compact objects such as black holes over their whole mass range and neutron stars, supernova explosion and remnants, stars, white dwarfs, exoplanets and their parent stars, Jupiter's auroras and comets in our own Solar System, and the interstellar medium (gas and dust). The scientific payload comprises: the X-ray Integral Field Unit a cryogenic imaging spectrometer covering the 0.2 to 12 keV energy range with energy resolution of less than 4 eV at 7 keV over $\sim$1500 pixels covering an effective diameter of 4', and; the Wide Field Imager (WFI) covering the 0.1 to 12 keV energy range,

with 40'x40' field of view (FoV), excellent spatial and energy resolution and count rate capabilities up to the Crab regime and beyond. During each sky observation one of the two instruments will be placed in the focal plane of a single X-ray telescope with a large collecting area exceeding 1 square-meter at 1 keV, and an angular resolution of 9" (HalfEnergy Width, 1 keV on-axis), averaging to 10" over the WFI FoV.

15:30 **Enrico Bozzo**
University of Geneva

In this talk, I will provide a brief summary of the different probe mission concepts that have been submitted in response to the NASA PROBE MISSION call at the end of 2023. The probe mission concepts known so far are: LEM, STROBE-X, HEX-P, ARCUS, and AXIS.

15:50 **Concluding Remarks**

16:10 **End of the conference**

Poster Presentations

— **John Fabio Aguilar Sánchez** . . . . . **INTEGRAL-OMC Light Curve Classification with Transformers**
Universidad Militar Nueva Granada, Colombia. Universidad Autonoma de Madrid, Espana

We present the classification of variable stars from the first INTEGRAL-OMC catalog of optically variable sources (Alfonso-Garzón et al. 2012). We have adopted a subset calculated period and well-recognized classification in catalogs such as the International Variable Star Index (VSX). We adopted a method based on a Machine Learning transformer architecture to classify the OMC light curves, analyzing both the time series and the phase-folded light curves. This classification includes intrinsic (e.g., pulsating, eruptive) and extrinsic (e.g., eclipsing binaries, rotating stars) variable sources, and also some of their subclasses, such as Algol, beta Lyr, Orion, W UMa, Cepheids, Ellipsoidal, Orion, TTauri, Bes, DSCT, LPVs, RR, RRAB, RRC, RV Tauri, ACV, BYDrac s. We selected objects with periods defined in this catalog, and we present our preliminary results. This methodology will be applied to the final INTEGRAL-OMC catalog with over 25,000 sources.

— **Isabel Caballero Doménech** . . **4 years of successful INTEGRAL science operations without thrusters**
ESA, ESAC, Madrid

On May 2020 INTEGRAL suAered a major anomaly in the propulsion system. The performance of the thrusters became unpredictable, and no more propellant was usable. A new observing strategy (z-flip strategy) was developed by the Flight Control team at ESOC to redistribute the accumulated angular momentum between the reaction wheels and reduce their speeds. This was done by flipping the spacecraft by 180 deg around its z-axis. This new observing strategy was implemented at ISOC and we have been using it since August 2020. We present an overview of the strategy and its application to science operations. Despite some limitations in the observing strategy, we have been able to resume full operational eAiciency with no impact in the scientific programme.

— **Albert Domingo** . . . . . **INTEGRAL/OMC Legacy Archive**
Centro de Astrobiologia (CSIC-INTA), Madrid

The Optical Monitoring Camera (OMC) has been providing simultaneous Johnson V-band photometry with the X-ray and gamma-ray instruments on board the International Gamma-Ray Astrophysics Laboratory (INTEGRAL) since its launch on 17 October 2002. The observations include both the primary targets of the gamma-ray instruments and approximately 100 additional objects of scientific interest within the 5°×5° OMC field of view of each exposure, the majority of which are optically variable or suspected variable sources. After two decades of operations, the OMC Archive contains light curves for approximately 105 000 scientific objects, with more than 50 photometric points for each. The INTEGRAL/OMC Legacy Archive at CAB will contain all derived data products from the OMC. The light curves for all objects observed by OMC, including the identified counterparts of INTEGRAL-detected high-energy sources, and a result source catalogue of detected OMC sources, comprising information on coordinates, source classification and average source magnitude, will be made available. All of these OMC data products will be incorporated into the INTEGRAL Legacy Science Archive (ISLA), the final and official archive of all data collected during the course of INTEGRAL's scientific operations. In this contribution, we provide a summary of the ongoing work to construct the INTEGRAL/OMC Legacy Archive. This includes the reprocessing of all OMC scientific data from the beginning of the mission with updated calibrations and an updated version of the OSA software package.