Supernovae

The science activity in 2024 explores some topics of the modern Astrophysics, such as transient phenomena, supernova progenitors, and high-energy astrophysics. It looks at GRB evolution, polarization mechanisms, and possible links to gravitational waves. New research on supernova progenitors and interactions with surrounding material sheds light on stellar explosions. Studies on the nova rate in M87 and advancements in gamma-ray astronomy, like the Galactic Plane Survey, reveal new details about galactic dynamics. Finally, investigations into Intermediate Luminosity Transients provide fresh insights into the properties and origins of these mysterious events.

From an instrumental point of view we have almost completed the setup of SOXS (the spectrograph/imager at NTT) and we are ready for the commissioning, this year at ESO La-Silla.

Gamma-Ray Bursts and Binary-Driven Hypernovae

1. *Probing Electromagnetic Gravitational-wave Emission Coincidence in a Type I Binary-driven Hypernova Family of Long Gamma-Ray Bursts at Very High Redshift,* Bianco et al. 2024, ApJ, 966, 219

This paper investigates the early X-ray afterglow emissions in long gamma-ray bursts (GRBs), focusing on the cosmological time dilation of observational signals. The authors analyze the vNS (new neutron star) formed in a type I binary-driven hypernova (BdHN) scenario, examining the spin evolution of these objects and their associated gravitational wave (GW) emissions. This study emphasizes the importance of BdHNs in understanding long GRBs at very high redshifts and links them to vNS dynamics, exploring how these systems could serve as probes for both electromagnetic and GW emissions. The implications for vNS formation and interactions within the BdHN model are particularly noteworthy.

GRB 241025A: The discovery of a BdHN I from data of Swift, Fermi, SVOM and Einstein Probe telescopes Ruffini et al. 2024, GCN 37964, 1

GRB 240825A: The nature of the afterglow motivates the search of the associated supernova Ruffini et al. 2024, GCN 37536, 1

2. *Varying Linear Polarisation in the Dust-Free Gamma-Ray Burst 210610B,* Agüí Fernández, J. F. 2024, A&A, 690, 216

The authors explore the time evolution of polarisation in the afterglow of GRB 210610B, one of the rare GRBs with minimal line-of-sight extinction, which provides a pristine view of the system. Observations reveal that the linear polarisation degree and position angles evolve significantly over time, hinting at complex magnetic field structures or varying jet geometries. This paper enhances the understanding of polarimetric behavior in GRBs and offers a window into their central engines and jet dynamics, using GRB 210610B as a key example of a "dust-free" system.

Type Ia Supernovae and Progenitor Mechanisms

3. *Cosmic Type Ia Supernova Rate and Constraints on Supernova Ia Progenitors,* Palicio, P. A. et al. 2024, A&A, 689, 203

This work delves into one of the most debated issues in astrophysics: the origin of Type Ia supernovae (SNe Ia). By comparing observed cosmic SN Ia rates with theoretical delay-time distributions (DTDs), the authors address the contributions of the two main progenitor models: the single-degenerate channel (a white dwarf accreting from a companion) and the double-degenerate channel (merging of two white dwarfs). The findings strongly suggest that both channels are active, with the single-degenerate mechanism playing a more substantial role than previously estimated, contributing at least ~34% of all SNe Ia. This study provides valuable insights into the lifetimes and environments of SN Ia progenitors and their role as cosmic distance markers and contributors to galactic chemical evolution.

Supernovae and Circumstellar Interactions

4. *The Carbon-rich Type Ic Supernova 2016adj in the Iconic Dust Lane of Centaurus A,* Stritzinger, M. D. et al. 2024, A&A, 686, 79

This paper examines SN 2016adj, a rare carbon-rich Type Ic supernova embedded within the dense dust lane of the elliptical galaxy Centaurus A. Early observations reveal a carbon-monoxide-rich spectrum, while late-time hydrogen emission suggests interaction with circumstellar material (CSI). The detailed study of its spectral evolution hints at a progenitor that might have undergone significant mass loss before the explosion. The estimated ejecta mass and the synthesized 56Ni point to a massive star origin, adding to the understanding of Type Ic SNe in complex environments. This work underscores the role of CSIs in shaping the observed features of supernovae, especially in galaxies with challenging observational conditions.

Nova Studies and Potential Supernova Progenitors

5. *The Physical Properties of T Pyx as Measured by MUSE*, Izzo et al. 2024, 2024, A&A, 686, 72

This study investigates the recurrent nova T Pyx, a system of interest due to its potential as a Type Ia supernova progenitor. Using data from MUSE, the authors construct a detailed 3D model of the nova ejecta, which reveals a tilted ring structure accompanied by bipolar outflows. The estimated distance to T Pyx and its ejecta mass are critically evaluated, leading to questions about its ability to reach the Chandrasekhar mass required for a SN Ia explosion. While the results do not definitively confirm T Pyx as a viable progenitor, they provide valuable constraints on its evolutionary path, shedding light on the complex relationship between recurrent novae and their supernova outcomes.

6. *Jet-Induced Enhancement of the Nova Rate in M87*, Della Valle, M., Shafter, A., Starrfield, S. 2024, RNAAS, 8, 195

In this paper, Della Valle, Shafter, and Starrfield revisit the nova production rate in the vicinity of the relativistic jet of the M87 galaxy. By applying the Bondi accretion model, they demonstrate that the density enhancement around the jet can significantly increase the nova rate. This jet-induced mechanism provides an explanation for the observed excess of novae, deepening our understanding of how relativistic jets influence surrounding stellar populations and interstellar environments.

High-Energy Gamma-Ray Astronomy

7. *Prospects for a Survey of the Galactic Plane with the Cherenkov Telescope Array,* Abe, S. 2024, JCAP, 10, 081

This paper outlines the ambitious plan for a Galactic Plane Survey (GPS) using the upcoming Cherenkov Telescope Array Observatory (CTAO). Currently, about 100 very-high-energy (VHE) gamma-ray sources have been identified in the Milky Way. The proposed GPS aims to systematically map the Galactic plane in the energy range of a few tens of GeV to several hundred TeV, leveraging CTAO's superior sensitivity and resolution.

The authors present a sky model that integrates observational data from known VHE sources—such as pulsar wind nebulae (PWNe), young and interacting supernova remnants (SNRs), and compact binary systems—with cutting-edge simulations of cosmic-ray interactions within the Milky Way. Using an optimized observation strategy spanning 1620 hours over ten years, they simulate the survey's potential results.

The findings suggest that the GPS could quintuple the number of known Galactic VHE emitters, identifying over 200 PWNe and numerous SNRs at flux levels ten times lower than previously detected. The survey also has the potential to unveil gamma-ray pulsars with novel TeV emission components, discover PeVatrons (sources capable of accelerating particles to PeV energies), and enhance population studies of VHE sources.

Additionally, the GPS is expected to contribute to understanding diffuse interstellar gamma-ray emissions, offering insights into unresolved source populations and cosmic-ray propagation. These advancements will not only enrich our knowledge of Galactic high-energy astrophysics but also lay the groundwork for future targeted observations.

Intermediate Luminosity Red Transients (ILRTs)

8. *A Study in Scarlet – I. Photometric Properties of a Sample of Intermediate Luminosity Red Transients,* Valerin et al. 2024, A&A, in press

This paper explores the photometric characteristics of ILRTs, a class of transients with luminosities between classical novae and supernovae. Using a sample of objects identified through multiple surveys, the authors analyze light curves to understand the physical mechanisms driving their evolution. Key insights include variability patterns, peak luminosities, and correlations with progenitor properties, providing a foundation for deeper investigation into this enigmatic group.

9. *A Study in Scarlet – II. Spectroscopic Properties of a Sample of Intermediate Luminosity Red Transients,* Valerin et al. 2024, A&A, in press

Focusing on spectroscopic observations of the same ILRT sample, this study investigates the spectral features that distinguish ILRTs from other transient types. The authors identify elements and ionization states present during different phases of the events, linking these observations to their underlying progenitors. The findings point to possible connections with massive stars in binary systems or electron-capture supernovae, offering new perspectives on ILRT origins and diversity.

SOXS at NTT

Walking with SOXS towards the transient sky, Schipani, P.; Campana, S.; Claudi, R. et al. 2024, SPIE, 13096E.1T

SOXS NIR: optomechanical integration and alignment, optical performance verification before full instrument assembly, Genoni, M.; Aliverti, M.; Pariani, G.et al. 2024, SPIE, 13096E 2T

Characterisation and assessment of the SOXS Spectrograph UV-VIS detector system, Cosentino, Rosario; Hernandez, Marcos; Ventura, Hector et al. 2024, SPIE, 13096E, 2U

The status of the NIR arm of the SOXS Instrument toward the PAE, Vitali, Fabrizio; Genoni, Matteo; Aliverti, Matteo et al. 2024, SPIE,13096E, 2V

The integration of the SOXS control electronics towards the PAE, Colapietro, M.; D'Orsi, S.; Capasso, G. et al. 2024, SPIE, 13096E, 2W

Final alignment and image quality test for the acquisition and guiding system of SOXS, Araiza-Durán, José A.; Pignata, Giuliano; Brucalassi, Anna et al. 2024, SPIE, 13096E, 72

What is your favorite transient event? SOXS is almost ready to observe! Radhakrishnan Santhakumari, Kalyan Kumar; Battaini, Federico; Di Filippo, Simone et al. 2024, SPIE, 13096E, 73

Automated scheduler for the SOXS instrument: design and performance, Asquini, Laura; Landoni, Marco; Young, Dave et al. 2024, SPIE, 13101E, 2F

The SOXS instrument control software approaching the PAE, Ricci, Davide; Salasnich, Bernardo; Baruffolo, Andrea et al. 2024, SPIE, 13101E, 2G

End-to-end simulation framework for astronomical spectrographs: SOXS, CUBES, and ANDES, Scaudo, A.; Genoni, M.; Li Causi, G. et al. 2024, SPIE13099E, 1N

SOXS system engineering from design to installation: challenges and results, Claudi, Riccardo; Radhakrishnan, Kalyan; Battaini, Federico et al. 2024, SPIE, 13099E, 1N