1st. Padova – Buenos Aires Workshop on Massive stars and Interacting Binaries

Institute for Astronomy and Space Physics, Buenos Aires, Argentina

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Abstract Book

SEVN and its friends: present and future of population synthesis codes

Giuliano Iorio
Università degli studi di Padova, Italia

Binary population-synthesis codes are fundamental tools for studying the evolution of large samples of stars and binaries. They can be used for a large variety of purposes from populating cosmological simulations with realistic stellar populations to studying rare and peculiar objects such as progenitors of binary compact objects (black holes and neutron stars). Their role is also crucial in making predictions for next-generation instruments (e.g. LISA/Einstein Telescope). In this talk, I will give a brief overview of the different population synthesis codes available nowadays and their peculiarities and differences. In particular, I will present a new fully revised version of the population synthesis code SEVN (Stellar EVolution for N-body codes, Iorio et al., 2023). SEVN is currently the only publicly available population synthesis code that is flexible enough to allow the exploration of different stellar evolution models. I will show how using SEVN, we found how significant can be the impact of stellar evolution models in the study of stellar populations and binary compact objects. Finally, I will conclude my talk by discussing the improvements required to enhance the modelling and predictive capabilities of population synthesis codes.

Demography of binary compact objects with SEVN

Gastón J. Escobar
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The currently-growing LIGO-Virgo data provides an excellent opportunity to investigate the demography of gravitational-wave sources and their production channels. Gravitational waves detected by LIGO-Virgo are originated in the coalescence of two compact objects, as black holes or neutron stars. The compact-object binaries that merge in less than a Hubble time may arise as the last evolutionary stage of binary stars evolved in isolation. In this talk we will show our results on the demography of binary compact objects by means of population-synthesis simulations with SEVN, and confront them with those which use past stellar-evolution prescriptions. SEVN uses a set of pre-computed stellar tracks to interpolate the evolution of star properties on the fly. This is a change of paradigm in the field, since most population-synthesis codes rely on fitting formulas to stellar evolution tracks run more than 20 years ago.

X-ray binary feedback over the interstellar and intergalactic media

Leonardo J. Pellizza
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The properties of the first generations of stars formed at the Cosmic Dawn ($10^8 - 10^9$ yr after the Big Bang) and their influence on the subsequent evolution of galaxies are fundamental research topics in extragalactic astrophysics. Several authors have suggested that X-ray binaries (XRBs) may have contributed significantly to the energy feedback into their environment at that epoch, participating in the regulation of the cosmic star formation and the ionization state of the intergalactic medium. The determination of the properties of XRB populations in the Early Universe is therefore important. This can be done by exploring XRB populations in low-metallicity galaxies at redshift zero, which are assumed to be the local analogs of those prevailing at Cosmic Dawn. To this aim, we investigated the correlations between X-ray luminosity, star formation rate, mass and metallicity of a sample of local galaxies in which XRBs have been detected. We compared them with the general sample of local galaxies, finding a bias towards low metallicity in the former. After homogenizing the data we discarded the possibility of the bias being caused by some systematics. We modelled XRB populations using cosmological hydrodynamical numerical simulations of galaxy formation and evolution [8, 9], coupled to our XRB population synthesis model, to determine the origin of this bias. In this poster we show our preliminary results which suggest that the bias may arise in the effect of the metallicity dependence of XRB evolution on the properties of the population, in agreement with previous results.

Cosmic rays at the epoch of reionization

Lautaro Carvalho
Instituto de Astronomía y Física del Espacio, Buenos Aires, Argentina

One of the most important open problems in modern cosmology is that of the sources responsible for the ionization and heating of the intergalactic medium (IGM) during the Cosmic Dawn. Radiation from early galaxies would not have been enough to maintain the ionization of the IGM on a large scale. For this reason different complementary ionizing agents have been proposed, such as the cosmic rays produced by those galaxies. In this work we present our first results on the ionization of the IGM produced by electron-initiated electromagnetic cascades, for a standard reionization scenario. Using numerical methods we simulated the transport of the particles that compose the cascades. Then, we calculated the ionization rate and the energy distribution among the particles and the IGM as the cascades propagate through the latter. Our results reinforce and extend those of other authors, in the sense that the contribution of the electronic component of the cosmic rays to the ionization of the IGM occurs in two stages. Electrons with energies below 10 keV cool down completely within a distance to the source on the order of thousands of kiloparsecs, ionizing the medium in the process. On the other hand, electrons with energies above 100 keV transport most of their energy to distances beyond the megaparsec. Also, we show for the first time that secondary photons originated in cascades initiated by high-energy electrons could contribute significantly to the ionization of the IGM. This result implies a sizable ionization rate in the deep IGM that is yet to be explored in detail.

Supermassive black holes approaching merger

Gustavo E. Romero
Instituto Argentino de Radioastronomía

I will discuss the electromagnetic signatures of supermassive black hole binaries that are approaching their final merger. I will present results of detailed 3D-GRMHD simulations of gas around these systems and the result of calculations of the different radiative processes that take place in such a complex environment. The various patterns presented by this radiation can be used in the future to identify systems that might be observed with gravitational wave detectors such as LISA and pulsar timing arrays.

On the nature of ultraluminous X-ray sources

Leandro Abaroa
Instituto Argentino de Radioastronomía

Ultraluminous X-ray sources (ULXs) are extragalactic point-like objects where the X-ray luminosity appears to be higher than the Eddington luminosity. ULXs are thought to be X-ray binaries with a compact stellar-mass object accreting at super-Eddington rates, where the accretion disk launches powerful winds. A beaming effect could be responsible for the observed X-ray luminosity: the radiation emitted from the inner part of the accretion disk is geometrically collimated by the ejected wind, which is optically thick except for a narrow region around the black hole axis, forming a cone-shaped funnel. Furthermore, in some ULXs the emission extends to energies higher than 10 keV that cannot be produced in the disk, and the hard X-rays require an additional component. Such a component could be a hot plasma of relativistic electrons in the funnel above the black hole that Comptonize the softer photons from the disk, producing the non thermal tail. In this talk we will present the state-of-the-art on ULXs from a theoretical approach and show some recent results, focusing in particular on their super-Eddington nature.

Massive stars and related studies

Paula Benaglia
FRINGE, Instituto Argentino de Radioastronomía

The Instituto Argentino de Radioastromía has been carrying out in-depth research on massive stars and their environments for the last decades. In particular, the work of the FRINGE (Formation in Radio INterferometry - arGEntina) research group is based on top-level dedicated observations, obtained with the main radio interferometers around the world. The data analysis is complemented by the development of models to understand the measured emission and to describe the radiating source. Radio data are a unique tool to probe scenarios such as stellar wind collisions, interactions between stellar winds and the stellar environment, and to further explore the radio-gamma connection. In this talk I will present some of the most important results obtained at the IAR in the mentioned field.

TBD

Lucas A. Bignone
Instituto de Astronomía y Física del Espacio, Buenos Aires, Argentina

TBD

TBD

Marina B. Badaracco
Instituto de Astronomía y Física del Espacio, Buenos Aires, Argentina

TBD

The final fates of Extreme Massive Stars: as black holes (BHs), BH-HMXBs and Binary BHs (GWs)

I. Félix Mirabel
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Extreme massive stars of up to 120 solar masses may end as black holes (BHs) in two different ways: Either the massive star directly collapses as a BH with no supernova (SN), or a failed SN occurs with too low energy to unbind completely the stellar envelope, leading to the delayed formation of a BH. Theoretical models set stellar progenitor masses and metallicities for BH formation by implosion, namely, by complete or almost complete collapse, but observational evidences have been elusive. In this talk, I will present the observational evidences for BH formation by implosion based on: (1) the kinematics of BH X-ray binaries (BH-XRBs) with no BH natal kicks, (2) the optical and infrared observations of massive stars that collapse in the dark, with no luminous SN, and (3) the properties of BH binary sources of gravitational waves (GWs).

Prospecting stellar winds of massive stars with an X-ray lens

F. Fogantini
Instituto Argentino de Radioastronomía

The presence of a compact object orbiting a massive star can give great insights on the properties of the stellar wind, as it interacts with its surroundings while orbiting its companion. In this talk I will present two case studies, IGR J16320-4751 and IGR J18027-2016, two high mass X-ray binaries consisting of a pulsating Neutron Star orbiting an early OB type star. By analyzing X-ray light curves and spectra of these objects one can determine several properties of the binary system, as well as properties and large scale structures of the stellar wind of the companion star.

X-ray polarimetry of X-ray binaries with IXPE

Francesco Ursini
University of Roma Tre, Italy

This talk reviews the first X-ray polarimetric measurements of X-ray binaries with the Imaging X-ray Polarimetry Explorer (IXPE). Since its launch in 2021, IXPE has observed a number of X-ray binaries containing neutron stars and black holes. The X-ray polarization signal yields unprecedented constraints to the geometry of the X-ray emitting accretion disc/corona. The IXPE results provide a significant advancement in the physical understanding of these binary systems, and often challenge simplistic accretion geometries.

High-Mass X-ray Binaries in Milky way/Andromeda-Type Galaxies

Felipe Vivanco Cadiz
Universidad Andres Bello, Chile

High-Mass X-ray Binaries (HMXBs) are systems composed of a massive star and a compact object (neutron star or black hole). Understanding their properties in the context of their host galaxies is crucial for unraveling their evolutionary history and contribution as potential progenitors of gravitational wave sources. Here we combine the stellar evolution synthesis code SEVN with the Milky way/Andromeda type galaxies catalogues from IllustrisTNG50 to model the formation and evolution of HMXBs within their host galaxies. We describe the methodology and present our first results on the HMXB population properties, such as the mass of the compact object and companion star and their X-ray luminosity distributions. We discuss our results in the context of the most recent observations of HMXBs in the Galaxy.

TBD

P.B. Tissera
Pontificia Universidad Católica de Chile

TBD

Cosmological simulations of the formation of the Milky Way and the Local Group

C. Scannapieco
Departamento de Física, Universidad de Buenos Aires, Argentina

S.E. Nuza
Instituto de Astronomía y Física del Espacio, Buenos Aires, Argentina

In this talk we will present the current work of our group, focused on studies of the formation and evolution of galaxies similar to our Milky Way. We use numerical, hydrodynamical simulations in cosmological context with two different types of initial conditions: on one side, galaxies that are relatively isolated at the present day and, on the other hand, a system of galaxies similar to Andromeda-Milky Way, the two main constituents of our Local Group. For this, we use constrained initial conditions which reproduce the local distribution and kinematics within the Local Volume. In the talk we will describe results on the formation of galaxy discs, the effects of gas accretion on their formation, and on the properties of the Local Group.

Close binary evolution: a brief review, some results, and future perspectives

María Alejandra De Vito
GESBI Grupo de Evolución en Sistemas Binarios
IALP Instituto de Astrofísica de La Plata
FCAGLP Facultad de Ciencias Astronómicas y Geofísicas - UNLP, Argentina

Stars are usually in pairs. These configurations allow us to obtain from observations, in some cases, one of a star's most important characteristic parameters: its mass. Among binaries in general, there is a particular group: close binary systems. In this kind of pairs, the stars are close enough that, in one or more stages of their evolution, the components may fill its Roche lobe. From there on, the evolution of the stars in the system is completely different since each component was alone. Various interesting astrophysical events such as pulsar recycling, ultracompact X-ray binary systems, cataclysmic variables, and type Ia supernovae can be found within the framework of close binary systems. On the other hand, many objects can form in close binaries, such as low-mass helium white dwarfs, blue dwarfs, and blue stragglers. Since the 1970s, many researchers have modeled stellar evolution in this type of systems. In particular, our research group has been performing detailed binary evolution calculations for more than two decades. In this talk, we briefly review the modeling of close binary systems, present some of our most recent results, and discuss the possibility of using our models in population synthesis studies.

Spinning into the Void: Black Holes in Low-mass Interactive Binaries

Leandro Bartolomeo Koninckx
Instituto de Astrofisica de La Plata, Argentina

Both the mass and spin parameters can fully characterize a rotating black hole. In binary systems where these objects interact with stars, observational estimates of these parameters can occasionally be made. Within such systems, the spin of a black hole intensifies as it accretes material from its companion. Consequently, increased accretion leads to a higher spin rate. In this presentation, I present findings concerning two Low-Mass Interacting binary systems, specifically V404 Cyg and XTE J1550-564, where the dimensionless spin parameter of the black hole has been observationally determined. Utilizing our binary evolution code, we established a progenitor for each system, a crucial step toward deciphering the episodes of mass accretion onto the black hole. By assuming an initially non-rotating black hole and incorporating data from mass transfer episodes for our best models, we investigated the evolution of the black hole's spin parameter. Our analysis suggests that there may be aspects of the black hole formation process that elude our current understanding.

Massive binary black hole mergers from Population II and III stars

Guglielmo Costa
Centre de Recherche Astrophysique de Lyon, France

Population III (Pop III) stars are almost metal-free stars, born from the primordial gas in the Universe. The almost total absence of metals impacts their initial mass function distribution (predicted to be top-heavy), their evolutionary path, and their final fate. Moreover, they lose a negligible fraction of their mass via stellar winds during their life. Such properties make them ideal massive black hole progenitors. In this talk, I will present the new models of Pop III stars computed with the PARSEC stellar evolutionary code. Then, I will show the large sets of Pop III and Population II binary populations we computed with the SEVN code used to study the main formation channel of binary black hole mergers. We find only mild differences between binary BH (BBH) mergers properties born from Pop III and II stars, especially if we adopt the same initial mass function and orbital properties. Most BBH mergers born from Pop III and II stars have the primary BH mass below the pair-instability gap, and the maximum secondary BH mass is < 50 Msun. Moreover, we find that, unlike metal-rich binary stars, the main formation channel of BBH mergers from Pop III and II stars involves only stable mass transfer episodes in our fiducial model. Studies like this are fundamental in advancing our understanding of binary black hole merger formation scenarios and enhancing our interpretation capabilities of data from gravitational wave detections from current and next-gen observing facilities.

Computing Stellar Evolution in Binary Systems

Omar G. Benvenuto
GESBI Group of Study of Stellar Evolution in Binary Systems
IALP Institute for Astrophysics of La Plata
FCAG Faculty of Astronomy and Geophysics of La Plata, Argentina

We describe the numerical scheme we employ for calculating stellar evolution in binary systems in which the components of the pair are close enough to allow for the occurrence of Roche Lobe OverFlow (RLOF) and mass transfer between them. The method is based on a generalization of the standard Henyey method in which we consider the mass transfer rate as a variable to be relaxed simultaneously with those corresponding to the internal structure of the donor star. In the standard treatment, the big linear system to be solved for the corrections in luminosity, pressure, radius, and temperature has a particular sparse structure: a diagonal of blocks of matrices of four files and eight columns while the rest of the elements are zero. Considering the mass transfer rate also adds a non-zero column for the entire matrix, it is still possible to solve it with a particular algorithm tailored for this purpose. Ist is also necessary to evolve the system's orbit during the evolution. In particular, it is necessary to consider the main sources and sinks of angular momentum: gravitational radiation, (the still uncertain) magnetic braking, and the angular momentum advected away by the mass lost from the system. In the original version of the code, we assumed a circularized orbit and the components of the pair to rotate synchronized. In a more recent version, we have relaxed synchronization, allowing the occurrence of tidal evolution. Still, we plan to add the presence of an accretion disk. With this tool, we have studied the evolution of low-mass X-ray binaries with and without irradiation feedback, with any class of compact companion (white dwarf, neutron star, or black hole), for low and intermediate-mass donors. Furthermore, we have applied it to study the structure of pre-supernovae objects.

Exploring the origin of the short-period Blue Straggler Stars in Collinder 261: A binary evolution approach

Maite Echeveste
Instituto de Astrofisica de La Plata, Argentina

Blue-straggler stars (BSS) are peculiar objects found in various stellar systems. They exhibit characteristics of youth, higher temperature, and greater mass than expected according to standard stellar evolution. Moreover, they occupy a position above and to the left of the main sequence turn-off point in the optical color-magnitude diagrams (CMDs). The prevailing consensus is that BSS were originally main sequence stars that acquired additional mass via mass transfer from an evolving primary star through Roche lobe overflow, and/or via collisions involving single, binary, or triple stars. Based on the recent publication of a fresh catalog of BSS in Galactic Open Clusters (OC) using Gaia DR2 data (Gaia Collaboration et al. 2018), we conducted a study focusing specifically on the short-period BSS found in the OC Collinder 261. Our investigation delved into the potential of mass transfer in binary systems in accounting for the presence and properties of these stars. We use an adaptation of the binary evolution code presented in Benvenuto & De Vito (2003), which allow us to perform comprehensive calculations on the structure of both stars within the binary system, as well as the orbital evolution and mass transfer rate simultaneously. Our investigation includes the study of several parameters, such as the initial mass of both stars, the initial orbital period, and the efficiency of mass transfer. The aim is to identify potential progenitor candidates matching CMD observations at the same age as that determined for Collinder 261. The first result of this investigation is that binary evolution serves as a viable mechanism for producing these BSS and that the efficiency of mass transfer plays a key role in accurately matching the fainter objects.

Exploring the effects of magnetic braking on the evolution of low-mass binary systems

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Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata
Instituto de Astrofísica de La Plata (CONICET-UNLP), Argentina

We investigate the evolution of low-mass close binary systems under different magnetic braking prescriptions. Specifically, we focus on systems where the accretor compact object is a neutron star and the companion is a low-mass solar-type star. During mass transfer episodes, these systems emit X-rays and are known as Low Mass X-ray Binaries (LMXBs). When mass transfer stops, they can be observed as binary pulsars. If any of these systems undergo another mass transfer episode when the orbital period is less than 1 hour, they are referred to as ultracompact X-ray binaries (UCXBs). Several angular momentum loss mechanisms influence the evolution of these systems, with magnetic braking being one of the most significant, although with some uncertainties. The standard prescription presents certain issues, e.g. the fine-tuning problem in the formation of UCXBs. Therefore, we investigate the effect of three new prescriptions on the evolution of these binary systems using our stellar code.

Nebular emission from young stellar populations including binary stars

Marie Lecroq
Institut d'Astrophysique de Paris, Sorbonne Université, France

We investigate the nebular emission produced by young stellar populations using the new GALSEVN model based on the combination of the SEVN population-synthesis code including binary-star processes and the GALAXEV code for the spectral evolution of stellar populations. Photoionization calculations performed with the CLOUDY code confirm that accounting for binary-star processes strongly influences the predicted emission-line properties of young galaxies. In particular, we find that our model naturally reproduces the strong He II λ4686/Hβ ratios commonly observed at high Hβ equivalent widths in metal-poor, actively star-forming galaxies, which have proven challenging to reproduce using previous models. Including bursty star formation histories broadens the agreement with observations, while the most extreme He II λ1640 equivalent widths can be reproduced by models dominated by massive stars. GALSEVN also enables us to compute, for the first time in a way physically consistent with stellar emission, the emission from accretion discs of X-ray binaries (XRBs) and radiative shocks driven by stellar winds and supernova explosions. We find that these contributions are unlikely to prominently affect the predicted He ii λ4686/Hβ ratio, and that previous claims of a significant contribution by XRBs to the luminosities of high-ionization lines are based on models predicting improbably high ratios of X-ray luminosity to star formation rate, inconsistent with the observed average luminosity function of XRBs in nearby galaxies. The results presented here provide a solid basis for a more comprehensive investigation of the physical properties of observed galaxies with GALSEVN using Bayesian inference.

TBD

Michela Mapelli
Institut für Theoretische Astrophysik, Universität Heidelberg, Deutschland

TBD

The ones that got away: formation and evolution of intermediate-mass black holes in massive star clusters

Benedetta Mestichelli
Gran Sasso Science Institute, Italy

Repeated stellar collisions and hierarchical mergers in dense and massive star clusters are among the most straightforward mechanisms to produce intermediate-mass black holes (IMBHs). In my talk, I will investigate the formation of IMBHs in globular clusters up to 10^6 Msun. To do this, I will rely on an extensive set of accurate N-body models run with the recently-developed PeTar-MOBSE, which is uniquely conceived to integrate both stellar interactions and long-term dynamical evolution in massive and long-lived stellar clusters. I will explore the role of repeated stellar mergers on the formation of very massive stars, and how their efficiency depends on the globular cluster birth properties. Also, I will discuss the properties of binary-black hole mergers and the peculiar impact of hierarchical mergers on the growth of massive compact objects.

Galactic HI supershells and their impact on the interstellar medium

Laura A. Suad
Instituto de Astronomía y Física del Espacio, Buenos Aires, Argentina

HI supershells are large arcs or bubble-like structures several hundred parsecs across that were first detected in HI 21cm surveys of the Milky Way and other spiral galaxies. Although they have been known for several decades, their origin and nature remain a subject of considerable debate. They play an important role in the evolution of the Galaxy, since they irreversibly perturb the interstellar medium (ISM), and are believed to induce the formation of molecular gas and provide physical conditions for generating new stars in their compressed collision zones. In this presentation, I will explain what supershells are and discuss their origin and the impact they have in the ISM. I will present a catalog of HI supershell candidates located in the outer part of the Galaxy made using both visual inspection and an automatic searching algorithm that sheds new light on supershell physics. I will show how their estimated kinetic energies allow us to analyze their possible origins and present hitherto elusive evidence that colliding HI supershells have triggered the formation of new stars and molecular gas.

Identifying Massive Stars and their H II Regions

Silvina Cárdenas
Instituto de Astronomía y Física del Espacio, Buenos Aires, Argentina

Massive stars significantly influence their surroundings, altering the local medium through powerful winds and ionizing radiation, leading to the formation of structures such as ionized (H II) regions and interstellar bubbles. The study of these structures can give us important clues about the physical properties of the stars that originated them, such as their binarity or multiplicity, spectral type, and spatial velocities. Even though there are many works related to the study of these structures, the effects that massive stars have on the ISM still have many open questions, like the fact that not all massive stars have a detected H II region nearby, or that many high-mass stars seem to be missing or are not being detected. The detection of massive stars in the optical band could be hindered if they are either located at large distances from the Sun, or are immersed in clouds of interstellar gas and dust. The search for high-mass stars using infrared data is therefore a reliable method for their identification and the study of their properties. In this presentation, we show some results from the multi-frequency analysis of Galactic H II regions and the massive stellar population associated with them. We estimate the physical properties of the regions and analyze the morphology of the emission distribution of the different components of gas and dust, with the aim to investigate their origin.

TBD

David Hendriks
University of Surrey, United Kingdom

TBD

Morphological analysis of the galaxy inner structure

Susana E. Pedrosa
Instituto de Astronomía y Física del Espacio, Buenos Aires, Argentina

The CIELO Project is one of the ongoing projects that our group is involved in. It encompasses a series of zoom-in simulations set in various environments with the objective of exploring the influence of the Cosmic Web, gas inflows and outflows, and mergers on the regulation of star formation (SF) activity and the chemical composition of galaxies. Our focus lies in studying the innermost regions of galaxies, examining the morphological components and their relationship with stellar population properties, with a special emphasis on angular momentum content.

Galaxy sizes and compactness during the epoch of reionization

Pedro A. Cataldi
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In this study, we investigate scale relations during early cosmic epochs with a redshift $z \gtrsim 6$ using the FirstLight cosmological simulation suite. This suite comprises 300 high-resolution zoom-ins and accurately depicts the reionization of the large-scale intergalactic medium while resolving galaxy properties. We observe that the half-mass radius (r_{hm}) of simulated galaxies shows a moderate increase with stellar mass at $M_* \lesssim 10^8$ M$_\odot$, followed by a rapid decrease at higher masses. This reduction in galaxy size is predominantly observed in massive galaxies ($M_* > 10^9$ M$_\odot$), which undergo a phase of rapid compaction and gas depletion. This leads to a contraction of the gaseous component into a compact star-forming phase, subsequently transitioning to central quenching of star formation and forming a compact passive stellar disc. Consequently, we identify positive correlations between galaxy sizes, specific star-formation rates, and gas abundances, marking a transition from diffuse, star-forming regions to compact, quenched structures with extended discs.

Electric charge in black holes in binaries

Nelson Padilla
Instituto de Astronomía Teórica y Experimental, Córdoba, Argentina

Black holes in binaries are able to increase their spin to near maximal values. After accretion from the binary stops and because their dynamics are expected to be different than that of the hot gas in galaxies, it is possible for these black holes to accrete a charge up to the equivalent Gibbons limit for anti-proton emission. This would impart interesting dynamics of electric current in galaxies wich we will discuss in this talk.

A study of early reionization sources

Mariano J. Domínguez
Instituto de Astronomía Teórica y Experimental, Córdoba, Argentina

Carlos A. Valotto
Instituto de Astronomía Teórica y Experimental, Córdoba, Argentina

Recent JWST observations have started to reveal the presence of a handful of AGNs in the very early universe. There are several theoretical possible formation channels for them, including heavy seed channels. We study the impact of these sources on the reionization process using 21cmFAST code, using as constraints the QSO LF, the history of reionization as inferred from the CMB data, and the 21cm dawn signal measured by the EDGES experiment. We present provisional results on this project and discuss the prospectives of including additional early sources of UV photons like population III stars, binary objects, and dark matter annihilation.

Core-Collapse Supernova Progenitors from Light Curves and Stellar-Evolution Models

Melina Bersten
Instituto de Astrofísica de La Plata, Argentina

Supernovae (SNe) are excellent laboratories for testing many aspects of stellar-evolution theory with strong implications on many various areas of astrophysics. Their light curves are extremely sensitive to the properties of their progenitor stars or systems and their environments. With the increasing amount and improved quality of current data, new types of SNe or unexpected features in normal events are being detected. These discoveries challenge our standard knowledge of how massive stars explode, as well as the mechanisms that power these events. In this talk I will focus on the modelling efforts that we have been doing in order to understand the properties of normal and some peculiar objects. In Particular, I will show our results on a large sample of hydrogen-rich SNe. Our analysis indicates that most of the SNe II come from relatively low-mass progenitors (MZAMS < 10 Msun). These results have important implications on our knowledge of massive-star evolution.

Exploring the Origins of Stellar Explosions Associated with Gamma-Ray Bursts

Lili Michelle Román Aguilar
Instituto de Astrofísica de La Plata, Argentina

A captivating yet unresolved problem in stellar astrophysics, is understanding the origin of stellar explosions linked to long-duration gamma-ray bursts. These supernovae are typically classified as type Ic, due to their lack of H and He. Also, they show broad spectral lines indicating high kinetic energies. To analyze these objects, we selected a sample of eight supernovae with gamma-ray bursts associations from the literature. We ensured the inclusion of good photometric, temporal coverage, and spectral data. For our sample, we consistently calculated their bolometric light curves in order to derive physical properties through hydrodynamical modeling. Our results revealed two possible scenarios, one of which involves massive progenitors that require stellar black hole formation. Finally, we conducted a comparative study with other SN types, unveiling distinct behaviors within the parameter space of these diverse groups. We have identified some correlations among parameters, which include a light curve decay relation. This suggests the potential for these objects to serve as “standard candles”.

Chemically-Homogeneous Evolution's Impact on Stellar Populations and Compact Binary Mergers

Marco Dall'Amico
Dipartimento di fisica e astronomia Galileo Galilei, University of Padova, Italy

Compact binary mergers mark the final stage of a complex journey that begins with massive stellar binaries. These binary systems undergo complex processes throughout their lifetime, involving phenomena such as mass transfer and tidal interactions, and ultimately culminating in the formation of neutron star or black hole pairs. Among these binary processes, chemically-homogeneous evolution notably impacts the formation of compact binary mergers by inducing rapid spin increases and subsequent alterations in stellar properties and their evolution. In my talk, I will present the effects of chemically-homogeneous evolution both on observable stellar populations and the detectability of compact binary mergers using gravitational wave interferometers. My population-synthesis simulations reveal how chemically-homogeneous evolution alters the ratio of red supergiants to Wolf-Rayet stars, dramatically affecting stellar populations potentially observable through electromagnetic surveys. Notably, Wolf-Rayet stars produced by chemically-homogeneous evolution are, on average, more massive, more numerous, and more luminous than Wolf-Rayet produced either via single or common binary evolution. The effects of chemically-homogeneous evolution are eventually inherited by the compact objects produced by these stellar progenitors: neutron star production is suppressed in favor of black holes, leading to an increased ratio of binaries composed of neutron stars and black holes or massive black holes. Conversely, chemically-homogeneous evolution strongly suppresses the production of compact binary mergers. These findings emphasize the intricate interplay between chemically-homogeneous evolution, stellar populations, and compact binary mergers.