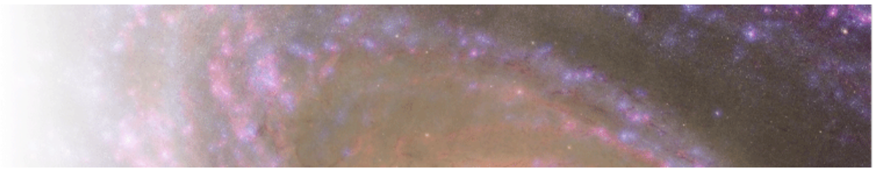
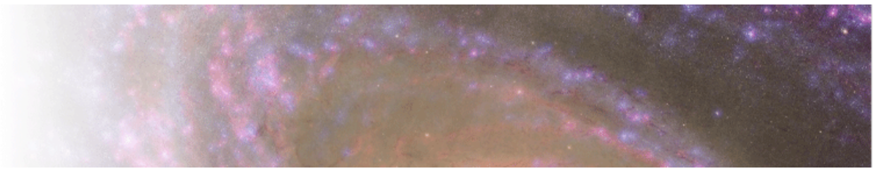


January 09 – January 13, 2023



FINAL SCIENTIFIC PROGRAM

Monday January 9 – **High redshift GRBs**

08:30 – 09:15 Registration

09:15 – 10:00 Piran: *High Energy emissision from GRBs*

10:00 – 10:45 Ghirlanda: *High redshift GRB population studies: clues on their cosmic evolution*

10:45 – 11:30 Bernardini: *Gamma-Ray Bursts central engine in the multi-messenger era*

11:30 – 16:00 Lunch Break

16:00 – 16:30 Coffee Break

16:30 – 17:15 Tsvetkova: *Cosmic GRB formation rate studied on the largest homogeneous sample of bursts detected over a broad energy band*

17:15 – 18:00 Palmerio: *The rate and production efficiency of high redshift long GRBs from modelling and observations*

18:00 – 18:45 Amati: *Shedding light on "Dark Energy" and Universe expansion history with Gamma-Ray Bursts*

Tuesday January 10 **Observations of GRBs at High redshift**

09:15 – 10:00 Vergani: *High redshift Gamma-Ray-Bursts in the JWST era*

10:00 – 10:45 Amati: *Shedding light on the early universe with next generation GRB missions*

10:45 – 11:30 Piro: *Probing high-z GRB progenitors with X-ray spectroscopy*

11:30 – 16:00 Break

16:00 – 16:30 Coffee Break

16:30 – 17:15 Fiore: *Distributed architectures for multimessenger astrophysics*

17:15 – 18:00 Behar: *Directional detection of GRBs*

18:00 – 18:45 Della Valle: *Supernova explosions in the Multi-Messenger era*

Wednesday January 11 **Short GRBs and their progenitors**

09:15 – 10:00 D'Avanzo: *Short Gamma-ray burst in the multi-messenger era: situation and perspectives*

10:00 – 10:45 Greggio: *The distribution of the delay times of binary neutron star mergers*

10:45 – 11:30 Cavallo: *On the hosts of neutron star mergers in the nearby Universe*

11:30 – 16:00 Break

16:30 – 17:15 Matteucci: *Short GRBs and production of heavy elements*

17:15 – 18:00 Molero: *Predicted rates of sGRBs in galaxies*

18:00 – 18:45 Burderi: *CubeSats and Distributed Astronomy: from the HERMES fleet to the flight of the ALBATROS, surfing the waves of quantum space-time*

Thursday January 12 **High redshift**

09:15 – 10:00 Tanvir: *Exploring the reionization era with GRBs*

10:00 – 10:45 Feruglio: *ALMA view of high z galaxies*

10:45 – 11:30 Behar: *X-ray Absorption of High-z GRBs*.

11:30 – 16:00 Break

16:00 – 16:30 Coffe break

16:30 – 17:15 Saccardi: *Dissecting the interstellar medium of a z=6.3 galaxy. X-shooter spectroscopy and HST imaging of the afterglow and environment of the Swift GRB 210905A*

17:15 – 18:00 Tripodi: *Cold gas and dust properties of the first QSOs*

20:00 Social Dinner

Friday January 13 **High energy observations of GRBs**

09:15 – 10:00 Bissaldi: *Towards 15-years of Gamma-Ray Burst observations with Fermi*

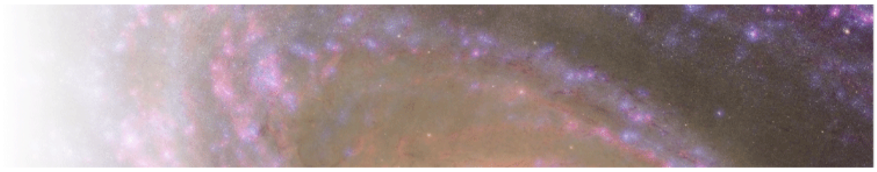
10:00 – 10:45 Longo: *GRBs at the highest energies*

10:45 – 11:30 Citossi: *Nano-Spazio INAF FVG outreach program*

11:30 – 12:00 Matteucci: *Concluding remarks*

High redshift Gamma Ray Bursts

High energy emission from GRBs
Tsvi Piran



High redshift GRB population studies: clues on their cosmic evolution
Giancarlo Ghirlanda

I will present a review of the current knowledge of the cosmic evolution of GRBs. In particular, population studies highlight the possible evolution of their rate related to the global metallicity evolution but also some intrinsic possible change in the population properties. I will discuss what we know and how we can better understand how GRBs and their progenitors evolve with redshift owing to the change of the progenitor population and/or of the possible central engine and relativistic outflow properties.

Gamma-Ray Bursts central engine in the multi-messenger era
Maria Grazia Bernardini

Multi-messenger Astronomy opened a new discovery window, providing the long-sought smoking gun for short gamma-ray burst (GRB) progenitors, almost 20 years after the discovery that long GRBs are originated in the collapse of massive stars. Despite these many advancements in the field, the nature of the remnant compact object that powers both long and short GRBs is still unsettled. Currently, newly-born millisecond magnetars are competing with black holes as source of the GRB power, mainly with their rotational energy reservoir. In this talk we review the main observational evidences supporting the two scenarios, and we discuss how the combined information provided by both the electromagnetic and gravitational signals are the most promising way to unveil the nature of the central engine, that is one of the major breakthrough achievable with the next generation gravitational wave detectors.

Cosmic GRB formation rate studied on the largest homogeneous sample of bursts detected over a broad energy band

Anastasia Tsvetkova

The set of the GRBs detected by Konus-Wind in the triggered and waiting mode (simultaneously with Swift/BAT) comprises ~350 events. This sample is the largest one detected by the same instrument over a broad energy band. For this set of GRBs, we study the cosmic GRB formation rate (GRBFR) along with the luminosity and energy-release functions (LF and EF) using the non-parametric technique suggested by D. Lynden-Bell and further developed by B. Efron and V. Petrosian, which allows to take into account the instrumental bias. The derived GRBFR nearly traces the star formation rate (SFR) at $z>1$, while at $z<1$ it features a relative excess over the SFR that cannot be attributed to the analysis artifact. The shape of the derived LF is better described by a broken PL, while the EF is better described by an exponentially cutoff PL.

The rate and production efficiency of high redshift long GRBs from modelling and observations

Jesse Palmerio

Long gamma-ray bursts (LGRBs) have been shown to be associated with the core-collapse of some massive stars and thus have been suggested as promising tracers of star formation up to the earliest epochs of the Universe. However, not all massive star core-collapses give rise to LGRBs as these are rare events, requiring particular conditions to form. Two crucial ingredients for using LGRBs as tracers of star formation are their rate and their efficiency, defined as the fraction of core-collapses that form an LGRB. In this talk, I present two complementary approaches to tackle the question of the LGRB efficiency and to estimate their rate at high redshift. Frist, based on a set of carefully selected high-energy observational constraints, we developed a statistical population model that allows us to constrain the intrinsic LGRB population. We discuss the implications regarding the LGRB efficiency, the LGRB luminisity function, and their rate evolution with redshift. The second part of the talk will be devoted to our observational study which aims to identify the factors affecting the LGRB efficiency by studying the host galaxies of a complete, unbiased sample of LGRBs at $1 < z < 2$. We infer information on the environments in which LGRBs form by studying different properties of their hosts and carefully comparing them with typical star-forming galaxies. We discuss these results in the context of the production efficiency and the rate of LGRBs at high redshift.

Shedding light on "Dark Energy" and Universe expansion history with Gamma-Ray Bursts

Lorenzo Amati

The huge luminosity, the redshift distribution extending at least up to z~10 and the association with the explosive death of very massive stars make long GRBs (i.e., those lasting up to a few minutes) potentially extremely powerful probes for modern cosmology. In addition to the exploration of the early Universe (star formation rate evolution up to the first generation of stars, cosmic reionization, luminosity function and metallicity evolution of primordial galaxies) the discovery and intensive study of the Ep,i - Eiso correlation ("Amati relation") and other empirical correlations between distance-dependent quantities and rest-frame observables has opened to us the possibility of standardizing these sources and thus extend the Hubble diagram substantially beyond the redshift range of Type-Ia SNe and even BAO, in a regime where only high-z AGNs can partly compete. As demonstrated by analysis and simulations, this redshift extension is fundamental for testing "Dark Energy" models and, more in general, cosmological scenarios alternative to the standard Lambda-CDM.

Observation of GRBs at high redshift

High redshift Gamma-Ray-Bursts in the JWST era
Susanna Vergani

Shedding light on the early universe with next generation GRB missions
Lorenzo Amati

The huge luminosity, the redshift distribution extending at least up to z~10 and the association with the explosive death of very massive stars make long GRBs (i.e., those lasting up to a few minutes) potentially extremely powerful probes for investigating the early Universe (pop-III stars, cosmic re-ionization, SFR and metallicity evolution up to the “cosmic dawn”) and measuring cosmological parameters. I will review the status, concepts and expected performances of space mission projects (e.g, THESEUS) aiming at fully exploiting these unique potentialities of the GRB phenomenon, thus providing an ideal synergy with the large e.m. facilities of the future like LSST, ELT, TMT, SKA, CTA, ATHENA in the e.m. domain, advanced second generation (2G++) and third generation (3G) GW detectors and future large neutrino detectors (e.g., Km3NET).

Probing high-z GRB progenitors with X-ray spectroscopy
Luigi Piro

Gamma-Ray Bursts as a unique probe to study the cosmic history of baryons and the metal enrichment from the first stars to the present Universe. At the epoch of Cosmic Dawn the first star populations exploded, enriching their environment with heavy elements.

The properties of the circumburst and host-galaxy environment of GRBs can be effectively assessed with high resolution X-ray spectroscopy. Because of the high ionizing flux, only X-ray observations can effectively probe the highly ionized close environment and enable us to characterize the region where the progenitor formed and eventually exploded as a GRB. We discuss the case relevant to high-z GRBs, where a pristine or Pop-III enriched medium is expected and compare it with an environment enriched by PoP-II population in a typical star forming region at lower redshift. We expect many narrow X-ray lines by ionized metals, that would allow us to determine the density and metal abundances of the GRB environment. To properly derive such fundamental information, the time-variable effect of the pho-ionizing flux by the GRB on the close medium is required. This effect is accounted by our newly developed time evolving photo-ionization code. We show that single-zone, time equilibrium photoionized model are not adequate to describe even present X-ray low-resolution spectra. We will present some results with present satellites and discuss the capability of Athena XIFU to determine the key parameters of the absorption medium subject to the GRB ionizing photons, in particular redshift and metal abundances.

Distributed architectures for multimessenger astrophysics

Fabrizio Fiore

While the GW/GRB170817 event hinted at the enormous potential of the multi-messenger astrophysics, it remained, so far, unique. The situation will change in the next few years when Advanced LIGO/VIRGO and KAGRA will reach their nominal sensitivity. In the electromagnetic domain the Vera C. Rubin Observatory will soon revolutionize the investigation of transient sources in the optical band. An efficient X-ray all-sky monitor with good localisation capabilities will thus have a pivotal role in providing the high-energy counterparts of the GW interferometers and Rubin Observatory sources. To gain the required precision in localisation for unpredictable events in time and space requires a sensor distribution covering the full sky. We discuss the potential and the programmatic implications of large-scale –small platform distributed architectures.

Directional detection of GRBs
Ehud Behar

We will present the recent progress in our GRB detector, named GALI for GAmma-ray burst Localizing Instrument. We are in the final stages of assembling a GALI experiment for the ISS. The talk will present its prospects and challenges

Supernova explosions in the Multi-Messenger era

Massimo Della Valle

I will briefly review some of the observational facts of Supernovae from the perspective of multi-messenger astronomy, such as neutrino and GW emissions. Current neutrinos and GWs observatories have the capability to detect CC-SN explosions inside the Milky Way. The obvious drawback is represented by the low rate of events (~1-2 per century). Future GWs detectors (e.g. ET and CE) can detect GWs emission from CC-SNe forming BHs occurring in the Virgo Cluster within the time-frame of a few years. Future HyperKamiokande observations of neutrinos should solve the problem of missing SNe in terms of dust effect or direct collapse of massive progenitors into BHs within times scale of ~ 10 yrs

Short GRBs and their progenitors

Short Gamma-ray burst in the multi-messenger era: situation and perspectives.

Paolo D'Avanzo

The knowledge of short gamma-ray bursts (SGRBs) experienced an impressive boost in the past two decades. After the recent major breakthroughs, we now have direct evidence for: the NS-NS / SGRB association, the existence of NS-BH systems, SGRB outflows shaped as structured jets, off-axis afterglow emission, the existence of r process kilonovae and their association with SGRBs. The majority of the studies on SGRB properties reported in the literature are based over the sample of events with measured redshift (z). Although this approach has the advantage of describing the SGRB intrinsic properties, it can be affected by biases, given that almost 3/4 of SGRBs are lacking z. With the aim of overcoming this issue, in 2014 we presented a sub-sample of Swift SGRBs with favorable observing conditions for z determination and bright in in the 15–150 keV Swift-BAT energy band. Although relatively small (16 events up to Jun 2013), this sample (S-BAT4) is complete in flux with a high completeness in z (70%), providing a useful bench to study the SGRB properties. The sample has recently been extended, being now more than double in size (42 events up to Dec 2021), keeping high completeness in z (60%). In this talk I will review the situation and perspectives of our understanding of SGRBs, their progenitors and their association with kilonovae and GWs, and will discuss how the S-BAT4 sample can represent a robust base for SGRB studies.

The distribution of the delay times of binary neutron star mergers

Laura Greggio

I will discuss the main characteristics of the distribution of the delay times of binary neutron stars mergers. I will first present general features of models based on binary population synthesis codes, and then I will describe in detail the derivation of semi-analytic delay times distributions meant to capture their major properties.

On the hosts of neutron star mergers in the nearby Universe

Lorenzo Cavallo

In the last years, with the advent of multi-messenger astrophysics, the characterisation of binary systems of neutron stars has become central in various fields such as gravitational waves, gramma-ray bursts (GRBs), and the chemical evolution of galaxies. In this work, we explore possible observational proxies that can be used to infer some characteristics of the delay time distribution (DTD) of neutron star mergers (NSMs). To do that, we construct a sample of model galaxies that fulfils the observed mass distribution function, star formation rate versus mass relation, and the cosmic star formation rate density. The star formation history of these galaxies is described with a log-normal function characterised by the logarithmic delay time (t0) and the width of the function itself (τ). For the NSMs, we assume a theoretical DTD that mainly depends on the lower limit and the slope of the distribution of separation of the binary neutron stars systems at birth. We find that the current present rate of NSMs (R=320+490−240 Gpc−3yr−1) requires that ~0.3 per cent of neutron star progenitors lives in binary systems with the right characteristics to lead to a NSM within a Hubble time. The fraction of short-GRBs observed in late-type galaxies favours DTDs with a fair fraction of prompt events, along the lines suggested by chemical evolution models.

Short GRBs and production of heavy elements

Francesca Matteucci

I will review the last papers concerning the role of merging neutron stars in the production of heavy elements, in particular Europium. I will discuss the crucial parameters necessary to compute the evolution of Eu abundance in the Milky Way, such as the fraction of binary massive stars giving rise to binary neutron stars, the delay time distribution of the coalescence time and the stellar yields. The role of core-collapse SNe versus merging neutron stars as Eu producers will be highlighted. The observational constraints will be discussed, such as the rate of merging neutron stars, as derived from the GW170817 event, and the cosmic short GRB (SGRB) rate. From the comparison between model results and observations I will derive constraints on the origin of SGRBs.

Predicted rates of sGRBs in galaxies

Marta Molero

With the aim of providing predictions of kilonova rates for future observations both at low and high redshift, I will present our computation for the rates of merging neutron stars (MNS) in different galaxies, as well as the cosmic MNS rate in different cosmological scenarios. To compute the MNS rates, we adopt either a constant total time delay for merging (10 Myr) or a distribution function of such delays. In both cases we were able to reproduce the observed present time rate in our Galaxy. For the cosmic rate we concluded that spiral galaxies are the major contributors at all redshifts in hierarchical scenarios, while in a pure luminosity evolution scenario the spirals are the major contributors locally, whereas at high redshift ellipticals dominate. A comparison between our predicted cosmic MNS rate with the cosmic rate of short Gamma Ray Bursts has also been done. Our predictions well agree with observations if the distribution function of delays is adopted in a cosmological hierarchical scenario observationally derived. However, future observations of Kilonovae in ellipticals will allow us to disentangle among constant or a distribution of time delays as well as among different cosmological scenarios.

CubeSats and Distributed Astronomy: from the HERMES fleet to the flight of the ALBATROS, surfing the waves of quantum space-time
Luciano Burderi

ALBATROS (Astonishingly Long Baseline Array Transients Reconnaissance Observatory in Space) is an ambitious astro- physical mission concept that uses a fleet of three small satellites to create an high-energy all-sky monitor with excellent localisation capabilities. The proposed orbits for the spacecrafts are three independent Earth-trailing heliocentric orbits, that will form a nearly equilateral triangular formation with 2.5 106 km arm length: the so-called cart-wheel formation. Each satellite is equipped with two opposite facing ~ 500 cm2 effective area detectors each consisting of a segmented array of crystal scintillators (GAGG) with a half-sky Field of View, keV-MeV energy band, and temporal resolution better than one microsecond. Thanks to the million km baselines, temporal triangulation techniques allow unprecedented location accuracies, few arc-second/few arc-minutes, for bright/faint transients in a wide energy band, few keV-few MeV crucial for hunting the elusive electromagnetic counterparts of Gravitational Waves, that will play a paramount role in the future of Multi-messenger Astronomy.
This project is an example of high-energy distributed astronomy: a new concept of modular observatory consisting of a fleet of small satellites displaced over a large array, with sub-microsecond time resolution and wide energy band (keV-MeV). A pathfinder of ALBATROS is already under development through the HERMES (High Energy Rapid Modular Ensemble of Satellites) and SpIRIT (Space Industry Responsive Intelligent Thermal Nanosatellite) projects: a fleet of six 3U cube-sats (HERMES) to be launched by the end of 2023 plus one 12U cube-sat (SpIRIT) to be launched by the end of 2022.
ALBATROS will furnish the golden sample of GRBs needed to test the dispersion law theorised by some Quantum Gravity theories, which predict relative discrepancies of the speed of photons w.r.t. the speed of light proportional to the ratio of the photon energy to the Planck energy. This effect is extremely small, and GRBs occurring at cosmological distances represent the ideal target to explore it. We describe a compelling approach to this problem that statistically combines a large number of GRBs for which light-curves of the prompt emission over a wide energy band (keV-MeV) are available, and distances are known. We discuss how a golden sample of ~ 1000 GRBs with known redshift is sufficient to effectively constrain this dispersion law.

High redshift

Exploring the reionization era with GRBs
Nial Tanvir

Long-duration GRBs are bright enough to be detected in and before the reionization era, and both pinpoint massive star production an provide backlights to explore material along the line of sight through spectroscopy. I will discuss various ways in which GRBs shed light on the process of reionization, its timeline and causes.

ALMA view of high z galaxies

Chiara Feruglio

X-ray Absorption of HIgh-z GRBs.

Ehud Behar

The talk will present the analysis of large scale structure cosmological simulations, confronting them with the rich data of X-ray absorption of GRB afterglows. The hypothesis of intergalactic absorption will be tested.

Dissecting the interstellar medium of a z=6.3 galaxy. X-shooter spectroscopy and HST imaging of the afterglow and environment of the Swift GRB 210905A

Andrea Saccardi

Long gamma-ray bursts (LGRBs) are unique tools to probe first galaxies. Afterglow spectroscopy allows detailed studies of the properties of the ISM of star-forming galaxies up to the highest redshift. In this talk, I will show the results obtained with VLT/X-shooter observation of the afterglow of GRB210905A at z=6.3118. We detect neutral-hydrogen, low-ionization, high-ionization and fine-structure absorption lines, as well as a tentative Lyman-α emission at velocity > 1000km/s from the absorbing gas. We were able to determine the metallicity, kinematics and chemical abundance pattern, dust depletion and dust-to-metal ratio of the ISM at z=6.3118. We also obtained HST/F140W observations of the GRB field, that allowed us to detect the GRB host galaxy as well as a complex of four objects in the proximity of the GRB afterglow position. These results show the powerful potential of GRBs to access detailed information on the properties of high-redshift galaxies.

SEXTEN CENTER FOR ASTROPHYSICS

Cold gas and dust properties of the first QSOs
Roberta Tripodi

High energy observations of GRBs

Towards 15-years of Gamma-Ray Burst observations with Fermi
Elisabetta Bissaldi

I will review the main obseravtions of Gamma-Ray Bursts made by the Fermi instruments, the Gamma-Ray Burst Monitor (GBM) and the Large Area Telescope (LAT), over the past years, placing these results in a multiwavelength and multimessenger context, also in view of the present and future ground-based and space experiments.

GRBs at the highest energies

Francesco Longo

GRBs are intense flashes of gamma-rays in the keV-MeV band. In their prompt emission phase they are characterised by a broad band spectrum that extend up to tens of GeV as measured by Fermi-LAT. In their afterglow phase they have been detected up to tens of TeV. This contribution will review the observations of GRB at the highest energies and the theories proposed to explain such emission component.

Nano-Spazio INAF FVG outreach program
Marco Citossi

Nano-Spazio INAF FVG is an outreach program carried out by INAF-OATs in close collaboration with the "Istituto Malignani" high school of Udine. INAF-OATs participates to the so-called 'Alternanza Scuola-Lavoro' (i.e. 'school-work synergy') outreach project promoted by the Italian government, with the primary aim of bringing students closer to space-related activities before choosing their university studies. The outreach program is split into three parts: one with frontal lessons, which present and discuss relevant topic of astrophysics, and one practical, consisting of hands-on activities aimed to replicate scientific analysis of real space data. The last part of the program includes the assembly of nano-satellite payload to launch in a stratospheric balloon, developed in collaboration with the HERMES-SP project.