Abstracts of the Workshop "Gamma-Ray Bursts: Probing the Science, Progenitors and their Environment"

Cosmic gamma-ray bursts and soft gamma-repeaters studies with Ioffe Institute Konus experiments

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The short review of gamma-ray bursts (GRBs) and soft gamma repeaters (SGRs) studies performed for many years by Ioffe Institute is presented. An important breakthrough in GRBs studies became available owing to four Konus experiments carried out by Ioffe Institute onboard the Venera 11 to 14 interplanetary missions from 1978 to 1983. The various observational properties of GRBs were firstly obtained and new rare astrophysical objects was discovered late named soft gamma-repeaters. The joint Russian-American Konus-Wind experiment, which has already been operating for more than 17 years, provides important and often unique data regarding GRB characteristics in 20 keV - 15 MeV energy range. These investigations were complemented by several Konus and Helicon experiments onboard Russian near the Earth spacecraft. A short description of future Konus-UF experiment in the frame Spektr-UF project is also given.

Nuclear Gamma-Ray Astronomy – the next step

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Despite having studied the nuclear gamma-ray sky for almost five decades with balloon and satellite experiments, many fundamental questions still wait for answers from gamma-ray observation : How do supernovae explode? What is the origin of Galactic cosmic rays? How are particles accelerated to extreme energies in the strongest magnetic fields? Also, the origin and propagation of the galactic positrons has remained as enigmatic as ever. Setting out from what we presently know about the gamma-ray sky, requirements for future space-based telescope are drawn up, and a scenario for a DUAL mission is outlined. The DUAL mission concept is composed of an All-Sky Compton Imager (ASCI), and two optical modules, the Laue-Lens Optic (LLO) and the Coded-Mask Optic (CMO). The ASCI serves dual roles simultaneously, both as an optimal focal-plane sensor for deep observations with the optical modules and as a sensitive true all-sky telescope in its own right for all-sky surveys and monitoring. For the first time in this energy range, DUAL features gamma-ray polarimetry. Broadband spectroscopy combined with measurement of the polarization of the gamma-rays emitted during the prompt Gamma-Ray Burst emission will be crucial diagnostics for solving the prompt emission mechanism issue. DUAL will provide the long awaited leap of a factor of 30, both for the 56Co and 56Ni (812 keV) lines of SN Ia, during focused pointings (10^6 sec) of its Laue lens, and for the long-lived radioactivity, e+e- annihilation radiation, nuclear excitation lines, etc. during its all-sky survey, through a very deep exposure (~10^10 cm2 s) of every source in the entire sky!

Observation of Bright High-Energy GRBs with Fermi

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We present the analysis of a sample of bright Gamma-Ray Bursts detected by Fermi GBM up to more than 1 MeV, which were collected during the first 3 years of Fermi operations. We derive GRB durations in various energy bands up to 10 MeV, thus expanding the duration–energy relationship in the GRB light curves to high energies. With the addition of Fermi LAT data, we can further extend the energy range up to 1 GeV. Finally we compare our analysis with previous results. For several bursts we notice evidence of a possible cutoff or break at higher energies and investigate this behavior by relating it with the spectral properties of GRBs.

Afterglow from the interaction of gamma radiation with dense gaseous cloud

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Re-radiation of the gamma ray emission by a nearby dense molecular clouds leads to the extended optical and UV afterglows, which light curve depends strongly on the properties of these clouds. Results of numerical simulations are presented.

Hyper-Supernovae produced by shocks

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Extremely luminous supernovae are being discovered currently e.g. in the Palomar Transient Factory survey. Their luminosity is higher than for famous "Hypernovae" like SN1998bw: they are 10 times more powerful in visible light than standard supernovae used for cosmology and they shine for a longer time. The source of their emission is still puzzling. We show that most probably they are produced by shocks in circumstellar medium. In general, bursts of light from shocks are the first observable events after the neutrino and gravitational wave bursts in core-collapsing supernovae. Here the light may be produced without collapse by pulsational pair-instability explosions of very massive stars. The brightest supernova shocks may become a new tool for measuring cosmological parameters which has some advantages in comparison with standard techniques.

Gamma-ray spectrometer BDRG onboard "Lomonosov": design, characteristics and test results

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BDRG gamma-ray spectrometer for "Lomonosov" mission is designed to obtain temporal and spectral information about GRBs in energy range 10-3000 keV as well as to produce GRB trigger at several time scales (20 ms, 1 s and 20 s). BDRG instrument consists of 3 identical detector boxes with axes shifted by 90° from each other. Such design allows to provide coordinates of GRB sources with accuracy ~2°.

Each BDRG box is a phosvich NaI(Tl)/CsJ(Tl) scintillator detector. Considerably thick CsI(Tl) crystal (∅130 x 17 mm) placed behind NaI(Tl) is used as an active shield in soft energy range and as the main detector in hard one. The ratio between the rates of NaI(Tl) and CsI(Tl) events with different energy release can be used as a self-criterion for separation of GRBs and their imitations by near-Earth electrons.

The data from 3 detectors are collected in BA BDRG information box producing GRB trigger and forming a set of output data frames. Day amount of scientific data ~100 Mb contains ~50 Mb continuous part (1 s timing in 16 channels, detailed energy spectra) and sets of frames with detailed information for burst-like events (~2 Mb for a burst). A number of tests provided with BDRG confirmed its reliability, calibration and trigger production algorithm.

All-Sky Monitor in Hard X-Rays and Soft Gamma-Rays with Wide-Field Gamma-Ray Telescope "Gammascope"

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The main purpose is study of astrophysical transient phenomena such as cosmic gamma-ray bursts (GRBs), supernovas and novas, outbursts in X-ray binaries and pulsars, active galactic nuclei variability during simultaneous all-sky observations in hard X-rays and soft gamma-rays (0.02 – 2.0 MeV) and optics. Study of these phenomena is actual in view of fundamental problems of modern natural history such as origin and evolution of the Universe, the nature of dark matter and dark energy, the space-time structure and matter properties in very high electromagnetic and gravitation fields. In particular, the GRBs study is one of the main goals of modern astrophysics. Being one of the most powerful events in the Universe, GRBs are not studied well up to know because we do not understand adequately its central engine. From the other hand GRBs give as the independent cosmological test and could be used for study the stages of very early Universe.

Besides, the proposed experiment allows realisation of some applied researches including the monitoring of dangerous asteroids and meteorites, space debris and also the artificial objects in the near-Earth space with fissile materials.

The experiment main feature is the possibility of simultaneous observations of GRBs in the gamma-rays and optics. Hitherto mainly the so-called afterglow, i.e. the response of the medium on an explosion in the GRB source, was observed in optics. The Gammascope project is supposed to detect at the same time the optical and gamma emission just in the moment of explosion. From this point it continues the line of Lomonosov mission, which assumes the multi-wave study of GRB prompt emission. However the Gammascope is quality new step because as expected to obtain the gamma-ray images of the sky large areas it significantly improves the accuracy of GRB localisation in the gamma range.

Type IIn supernovae

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Type IIn supernovae are highly heterogeneous class of supernovae showing evidence of a energetic interaction with a dense circumstellar medium. Current understanding of these phenomena will be reviewed.

Afterglow observations with GROND

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Gamma-Ray Bursts are brief flashes of gamma-rays on the sky, and they produce so-called afterglow emission, from X-ray to radio, which lasts for days to weeks. While many details of the origin of the burst and afterglow emission are still open, the afterglow emission can be used as beacon to probe the distant Universe. I will report on both, an instrument (GROND) specifically developed for ground-based afterglow observations, and some results obtained since its commissioning in 2007: (i) chasing high-redshift bursts, (ii) determining the origin of dark bursts, (iii) investigating the surprising wealth of light curve variability.

Gamma-ray Bursts in the Fermi Era

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After a brief overview of GRBs the talk will focus of recent developments in our understanding of gamma-ray burst prompt emission mechanisms. Properties of high energy emission (>100 MeV) detected by Fermi from a number of bursts and their possible origin will be described, and the recent announcement by the ICECUBE collaboration regarding upper limit on neutrino flux from GRBs will be discussed.

The report will also include data on recent measurements of magnetic fields in highly relativistic shocks associated with GRBs.

Past, present and future of hard X-ray/γ-ray measurements of Gamma-Ray Bursts polarization

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Polarization measurements provide a direct insight into the nature of astrophysical processes. Unfortunately, only a few instruments are available for this kind of measurement at γ -ray energies, and the sources need to be very bright. Gamma-ray bursts (GRBs) are ideal candidates due to their large flux over limited time intervals, maximizing the available signal-to-noise ratio. Polarization measurements of the prompt phase of GRBs can shed new light on the strength and scale of magnetic fields, as well as on the radiative mechanisms at work. To date a few polarization measurements have been reported, claiming a high degree of polarization in the prompt emission of GRBs but with low statistical evidence. We will describe these observations and then focus on the recent polarization measurements of the long and bright GRB 041219A completed with the IBIS telescope on board the *INTEGRAL* satellite, which lead to the derivation of strong constraints on possible Lorentz Invariance Violating phenomena. We will describe also the recent results obtained by the IKAROS/GAP experiment and sketch the future prospects for hard X-ray/γ-ray polarization measurement in space.

Global MASTER-Net

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The results of optical transient observations at the unique russian global robotic telescope network MASTER are presented.

Magnetorotational Supernovae and Gamma-Ray bursts

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We discuss results of 2D simulations of magnetorotational mechanism of core-collapse supernovae. The supernova explosion initiated due to the transformation of part of rotational energy to the rtadial kinetic energy by magnetic field. The influence of different initial configurations of the magnetic field, different initial masses and different initial rotational rates of pre-supernovae are considered.
We show that due to the magnetorotational instability the magnetic field can reach values up to 10(15)Gauss. The supernova explosion energy in our simulations is up tp 2.5x10(51)erg.

Aspherical Supernova Explosion and Gamma-Ray Bursts

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I would like to present our study on aspherical supernova explosion and gamma-ray bursts. I would like to show our study on explosive nucleosynthesis in aspherical explosions to explain many observations of SN1987A and Cassiopeia A. We would like to show that our aspherical explosion model can be applied to hypernovae that are associated with gamma-ray bursts. I also present numerical simulations of the central engine of gamma-ray bursts using our general relativistic MHD code. I will show that Blandford-Znajek process can be an important one to drive a gamma-ray burst jet. I would like to show some our recent study on supernova remnants and particle acceleration and emission there. I would like to show that our model can explain RXJ1713.

Bulk Lorentz factors and comoving properties of GRBs

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External shocks between the fireball and the surrounding medium are thought to be responsible for the afterglow emission in GRBs. I consider the hydrodynamic evolution of a relativistic semi-radiative blast wave interacting with the ambient medium. I derive the temporal evolution of the bulk Lorentz factor, from the initial coasting phase to the non-relativistic regime. The relation between the peak time of the afterglow bolometric light curve and the initial Lorentz factor is investigated and an approximated equation is proposed. I apply this equation to estimate the Lorentz factor of a sample of 27 GRBs, with the peak time measured from their optical light curves. Typical values are between 138 and 66, depending on the density structure of the external medium (homogeneous and wind-like, respectively). The measure of the initial Lorentz factor allows to estimate the properties of the prompt emission in the comoving frame (i.e. in the frame at rest with the relativistic fluid). I show that the comoving energetics, spectral peak energy and luminosity of GRBs have quite narrow distributions. These results provide a general explanation for the existence of the spectral-energy correlations.

What spectral lag can tell us about Gamma-Ray Burst

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It is known that GRB time profile in lower energy band lags the higher energy bands. We investigated dependence of the spectral lag of a prompt emission against energy band in several cases in gamma, x-ray and even optic. It is found that for simple structures such as separate pulses, the energy-dependent lag can be approximated by a simple law, and lag parameter correlates with pulse duration. We also have not found any negative lag in well separated pulses. We discuss what spectral lag can tell us the about emission region.

Properties of galaxies hosting gamma-ray bursts

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Due to their extreme luminosities, gamma-ray bursts (GRBs) are routinely detected in hostile regions of galaxies, nearby and at very high redshift. Thus, they are important cosmological probes. During recent years, the investigation of galaxies hosting GRBs demonstrated their connection with star-formation activity. However, the link to the total galaxy population is still poorly understood, due to the small-number statistics: less than 50 hosts have been studied in detail over a total of 250 GRBs with spectroscopically measured redshifts. Moreover, at present, mainly low-redshift (z2, where some hosts are massive, show high metallicities and are red due to high dust content. Understanding the reasons for these apparently contradicting results is the goal of on-going projects.

Development of electron tracking Compton camera for both balloon and future satellite experiments of MeV gamma-ray astronomy

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In order to explore MeV gamma-ray astronomy, we have developed Electron Tracking Compton Camera (ETCC) consisting of a Time projection Chamber based on the micro pixel gas counter and pixel array scintillators. By measuring the track of a recoil electron in TPC event by event, ETCC measures the direction of each gamma-ray as a small arc (not circle), which also provides a good background rejection using the kinematical check for the angle between a recoil electron and a scattered gamma ray. ETCC in satellite would be a good candidate for All sky MeV gamma-ray survey of a wide band energy regions on 0.1-100MeV with several ten times better sensitivities of COMPTEL. Already we carried out the balloon experiment with a small 10cm cube ETCC (Sub-MeV gamma ray Imaging Loaded-on-balloon Experiment: SMILE-I) in 2006, and obtained diffuse cosmic and atmosphere gamma-ray spectra in the sub-MeV region. We are now constructing a 30cm cube ETCC to catch gamma-rays from the Crab and terrestrial gamma-ray bursts in the Polar region using a long duration balloon flight around North Pole since 2013 (SMILE-II project). Terrestrial gamma-ray bursts are generated by relativistic electron precipitation from the radiation belt in the Polar region. Recently performance of the tracking of the recoil electron has been dramatically improved by developing both new electronics and reconstruction method of the TPC, which may enable us to come near the ideal efficiency expected in the gas detector. Also the result of the measurement of the angular resolution for the pair creation in 10-20MeV is presented.
In addition, I mention about the unique capability to find a high-z Gamma-Ray Bursts beyond z>10 by ETCC, in particular long duration GRBs over 1000 sec, which are expected for Population-III stars.

Dimensionless scaling of magnetic fields in the Metagalaxy

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The group of dimensionless physical parameters is considered in attempts to constrain and evaluate the role of magnetic fields by scaling laws and orders of magnitudes. Admissible combinations are numerous and include the binary interplay of independent parameter combinations of magnetic fields with local and global plasma density, velocity, temperature, composition, ionization degree, radiation and other quantities including kinetic distribution function details in different space-time scales. It makes the overall situation very diversified and not obeying any a priori general scenario and model. The role of magnetic fields in the visible Universe is varying from primary to negligible for many known astrophysical objects and phenomena. The question about the bulk role of magnetic fields in the Universe is ill posed and has no definite answer because of not known boundary conditions in space and time. Available observations are not sufficient to quantify magnetic fields in several instances and for the whole visible Universe in the same manner as the 'critical density of matter' in the homogeneous model.