INTERNATIONAL RELATIVISTIC ASTROPHYSICS PHD PROGRAM :

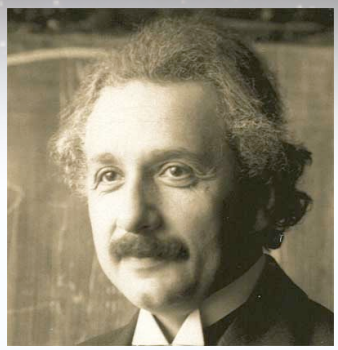
A NEW ERA IN ASTROPHYSICS

We offer for the first time in the world a high level PhD training program with a diploma delivered by thirteen Institutions residing in Europe and Asia. This diploma carries the prestigious label of "Erasmus Mundus" from the European Commission.

At the end of their curriculum the Students are awarded a joint Ph.D. title signed by the Rectors/ Presidents of the six Academic Institutions of the IRAP PhD consortium.

The IRAP PhD program intends to create conditions for high-level education in Astrophysics mainly in Europe to create a new generation of leading scientists in this field. No single university in Europe today has the expertise required to attain this ambitious goal by itself. For this reason we have identified universities which offer a very large complementarity expertise.

Each student admitted to the Ph.D. program will be part of a team inside one of the laboratories of the consortium. Each year they will have the opportunity to visit the other laboratories of the consortium and enlighten themselves with new topics in the forefront research from world leading experts. In this way the students will come into direct contact with some of the leading scientists in the world working in General Relativity, Relativistic Astrophysics, Cosmology and Quantum Field Theory..



Albert Einstein:

«Imagination is more important than knowledge.

Knowledge is limited. Imagination encircles the world.»

European Commission
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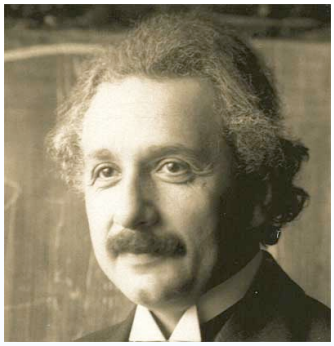
IRAP PHD PROGRAM

CYCLE I (2010-2013)

BARANOV ANDREY (RU)
BENEDETTI ALBERTO (IT)
DUTTA PARIKSHIT (IN)
FLEIG PHILIPP (DE)
FRAGA BERNARDO (BR)
GRUBER CHRISTINE (AT)
LICCARDO VINCENZO (IT)
MARTINS DE CARVALHO (BR)
PENACCHIONI ANA (AR)
VALSAN VINEETH (IN)



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European Commission
ERASMUS MUNDUS

STUDENTS' REPORTS- 2010-2013

Research Activities

The title of my thesis is "Pair instability supernovae explosion and gamma-ray bursts". Gamma-Ray Bursts (GRBs) are very high energetic bursts of gamma emission that last for a few seconds and come from very distant parts of the Universe. They are already known from 1960s, but until now there is no self-consistent description of this phenomenon. Still there is no definite answer on the question "Which objects are the source of GRBs?". The purpose of my work with prof. Chardonnet is to check if GRBs could be explained as a result of explosion of a very massive star. This kind of stars undergoes specific kind of instability which is called "pair instability". This instability could lead to an explosion of a whole star and then this star becomes "pair-instability supernova". Recently this type of supernova was only theoretical model but a few years ago observational evidences of existence of these phenomena were obtained.

To analyze these complex phenomena we need to make numerical simulations. To do these simulations I developed computer code for spherically symmetrical model of explosion. This simple spatial model allowed us to concentrate on microphysical processes inside the star and to understand which of them should be introduced inside our computational model. At this moment we obtained first results which were presented on Erasmus Mundus Workshop in Les Houches, France. And now we are working under the complication of our computational model and introducing more physics inside it. It will help us to perform further analysis and to compute spectra and time-variability of emission – the quantities that could be compared with observational data.

Why I recommend this PhD Program

« IRAP PhD program is great opportunity to start or continue scientific work in astrophysics. First of all it provides interesting topics of research from different fields of astrophysics. And it is already great, because modern astrophysics is very wide area of science. Despite research activity, it provides great collaboration activity, which is very important. We have schools twice a year, workshops and meetings, where we meet experts from various fields of astrophysics. All this helps to make new connections within scientific community.»

Программа IRAP PhD является отличной возможностью для начала или продолжения научной работы в астрофизике. Прежде всего, она предоставляет интересные темы исследований в различных областях астрофизики. Это очень важно, потому что современная астрофизика являет собой очень обширную область науки. Кроме научно-исследовательской деятельности, IRAP PhD обеспечивает необходимый опыт сотрудничества. Два раза в год проводятся научные школы, также организовываются семинары и различные конференции, где есть возможность встретиться с экспертами из различных областей астрофизики. Все это помогает создавать новые связи внутри научного общества.

Andrey BARANOV
(Russian)
Thesis: «Pair Instability Supernovae Explosion and Gamma-Ray Bursts»
Supervisor:
Prof. Pascal Chardonnet
University of Savoie

STUDENTS' REPORTS- 2010-2013

Research Activities

The title of my thesis is: "Emission from the photosphere of Gamma-Ray Bursts (GRBs): kinetic approach". GRBs are high energy astrophysical phenomena that happen in a short time, from a few to tens of seconds. All the informations about them come from the photons we can observe with our instruments. The goal of my research is to explain the features of the light produced and emitted from the photosphere. The photosphere is a surface where photons are scattered for the last time before starting to propagate toward the observer; besides it is expanding with a speed close to the speed of light. Within the kinetic approach we adopt, the microphysical interactions can be taken into account in detail, allowing us to calculate the physical quantities related to the light detected by the instruments.

At the beginning of my PhD I moved to Rome at the University of La Sapienza where I began to study the Relativistic Kinetic Theory, as the necessary theoretical background of my research topic, and I followed the lectures of prof. Ruffini on General Relativity. In parallel to that and in collaboration with my tutor Dr. Vereshchagin, I started a work related to the behavior of the electron- positron pairs when they are produced in a strong electric field; the result of this work has been published on the Physics Letters B Journal. Then I started to work out the set of equations we need for our model. However, due to the complexity of the problem, a numerical code is essential. For this reason part of my activity has been devoted to the understanding and improvement of the code provided my Dr. Aksenov with whom I collaborate as well.

Why I recommend this PhD Program

«We have the opportunity to interact with professors and students experienced not only in the field of relativistic astrophysics but also in a wide range of other related topics. This gives us the chance to study and work deeply on a specific subject but also understanding what is happening around it. The relativistic astrophysics is in a continuously evolving state, therefore an overall point of view can help us understanding our future perspectives.
The program is just started and we have the possibility to improve it presenting our suggestions and ideas: a good possibility to collaborate all together in order the make it more advantageous and fruitful for everybody.»

Alberto BENEDETTI
(Italian)
Thesis: «Emission from the photosphere of Gamma-Ray Bursts: kinetic approach»
Supervisor:
Prof. Remo Ruffini
University of Roma

STUDENTS' REPORTS- 2010-2013

Research Activities

The title of my thesis is "N=4 SuperSymmetric Yang Mills Theory". I work under the supervision of Prof. Hermann Nicolai at the Albert Einstein Institute in Potsdam. We look at the N=4 SuperSymmetric Yang Mills Lagrangian in 4 dimensions, which is special as it is finite, i.e. it is free from ultraviolet divergenges and needs no renormalization unlike most other field theory models. In this case we try to write down DeWitt equation for this Lagrangian which is basically the functional field derivative of the effective action, from which we can generate the Schwinger-Dyson equations, and an infinite tower of equations relating the correlation functions, i.e. the 2 point correlation function with the three point, and hence forth. Our current goal is to write the DeWitt equation for the case and show that it is well defined, meaning it is free from ultraviolet divergences. This happens because in our theory we have same number of fermions and bosons, and their divergences occur with opposite signs, thus they cancel each other. As in all SuperSymmetric theories, there are cancellation of these divergences, some complete and some incomplete, luckily in our case it is complete. In this context we also look at the much simpler model of N=1 Wess Zumino model in 2 dimensions, to understand the cancellation of bosonic and fermionic divergences in this case. Form these correlation functions we intend to do non-perturbative calculations for our theory in the future.

Why I recommend this PhD Program

«I recommend this program because it gives us a great working atmosphere. The institutes which are in the consortium are really well renowned and one can easily collaborate with many good people here. It also provides an oppurtunity for such an informal interaction with everybody, which is really nice. The half yearly workshops are also unique in a sense all the students meet up and discuss their work and listen to latest breakthroughs in the field of astrophysics, which is really motivating.»

Parikshit DUTTA

(Indian)

Thesis: «N=4 SuperSymmetric Yang Mills Theory»

Supervisor:

Prof. Hermann Nicolai

Albert-Einstein-Institute

STUDENTS' REPORTS- 2010-2013

Research Activities

The title of my thesis is "Quantum Gravity and Automorphic Functions". Today, the two great pillars on which our modern understanding of physics rests are the theory of General Relativity on the one hand and Quantum Theory on the other hand. The further is a theory which describes phenomena happening on a very large scale, e.g. the scale of our Galaxy, and the latter is a theory describing things on a very small scale, e.g. the structure of atoms. Both theories have had remarkable success in their respective range of validity and have been proven experimentally up to very high accuracies. However there seem to be certain physical situations, e.g. Black Holes or the Big Bang, in our universe where one cannot just use one of the two theories to describe the physics that is happening, but one has to use a different kind of theory, which incorporates both, General Relativity and Quantum Theory at the same time. This theory generally goes by the suggestive name "Quantum Gravity".

There are currently several different views on what the theory of Quantum Gravity should be and no clear picture has yet emerged. One version of Quantum Gravity, which is being discussed goes by the name "Arithmetic Quantum Gravity". It is a rather young theory and has mainly been developed within the last 10 years. In this theory a central idea is that the behaviour of a point in space-time (the space that we live in) can be described as if it was a small ball moving on a billiard table. The precise shape of the billiard table determines how exactly the ball moves and therefore determines the dynamics of space-time.

In a recent publication, done in collaboration with H. Nicolai and M. Köhn, we have managed to give a complete, geometric description of the billiard table mentioned above, as well as to calculate its volume. My current work is concerned with the symmetries, which arise in Arithmetic Quantum Gravity. I am working on this in collaboration with H. Nicolai and V. Belinski.

Why I recommend this PhD Program

«The field of relativistic Astrophysics has become an extremely diverse field, which in itself contains a wealth of different areas that one can work on and think about. Due to their complexity each area in itself has become highly specialized. The IRAP PhD program puts together people from the various areas of relativistic Astrophysics and gets them to talk to each other, always with the goal in mind that learning from each other is the best and fastest way of making progress. Despite from learning a whole lot of new physics, this also teaches one how to communicate and explain ideas to people with a different background in physics.Since the program includes people with different nationalities from all over the world, it is also a great opportunity for cross-cultural exchange.»

Philipp FLEIG

(German)

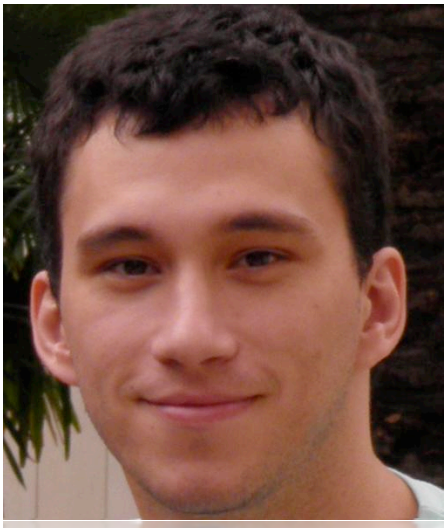
Thesis: «Quantum Gravity and Automorphic Functions»

Supervisor:

Prof. Hermann Nicolai

Albert-Einstein Institute

STUDENTS' REPORTS- 2010-2013



Research Activities

The title of my thesis is " ". The classic work of Prof. Ruffini works over a wide range of subjects, one of which is the Theory of Dark Matter. Since the beginning of the 1930s, there were already observations that reported a disagreement between the total mass of galaxies and clusters of galaxies as measured by the rotation of such, and the mass inferred from the luminosity. This implied that there was some "missing" mass that do not emit light but interacts gravitationally. This remained somewhat obscure until the 1970s, when after a long work on rotation curves of galaxies, it was agreed that this curves were incompatible with galaxies composed only by baryonic matter (luminous matter). At first, it was believed that the dark matter was present on individual galaxies as a halo, with baryonic matter on the center. However, recent observations suggest that this is not right, and there may be a substantial amount of dark matter also in the center of the galaxies and in the galactic plane. Due to the fact that the dark matter does not emit light, its nature is so far not understood and we do not know which particle it is. There are different density profiles obtained with simulations and observations, and no model as of today can account fully for the different features of dark matter in different objects (individual galaxies, clusters and dwarf galaxies). We are working on a model of dark matter composed by fermions, particles with half-integer spin (like the proton, neutron), with no charge and a mass on the keV range, as proposed by Prof. Ruffini and others in 1990. This model could explain the halos of dark matter, but also is a potential explanation for what lies in the center of the galaxies, since the strongest candidate is a black hole, which could not explain some recent observations of the galactic center.

Why I recommend this PhD Program

« Cooperation is one of the keys to scientific progress, and in this program we have the possibility to be in contact with different researchers in different areas of astrophysics, thus not only working on our field, but also seeing how our work can affect other areas of astrophysics. This helps greatly in understanding astrophysics as a whole, and not be confined to our areas of research.»

Bernardo FRAGA
(Brazilian)
Thesis: « Cosmology and Galaxy Formation»
Supervisor:
Prof. Remo Ruffini
University of Roma

STUDENTS' REPORTS- 2010-2013

Research Activities

My thesis will enclose two applications of quantum phenomena in the large-scale framework of cosmology and astrophysics. One part will deal with the so-called dark energy problem of cosmology ñ i.e. the observation that the universe is expanding in an accelerated way. Among the abundance of models trying to explain this kinematic feature of the universe, one of them is to consider the vacuum fluctuations of quantum fields, an energy density constant in space, to cause the expansion. The vacuum energy is a divergent quantity though, and is thus usually discarded as a possible candidate for dark energy. However, by balancing contributions of different quantum fields, a finite value can be achieved, which can correctly account for the expansion of the universe.

To compare this model with data, a cosmographic analysis of supernova luminosities as a function of redshift is carried out in order to estimate the kinematic parameters of the expansion of the universe.

Another part of the thesis research deals with the occurrence of Bose-Einstein condensates (BECs) in astrophysical contexts, i.e. in compact objects such as neutron stars and white dwarfs. As unlikely as it may seem, conditions in such environments allow for the formation of BECs due to a favourable combination of temperature and density, and thus it is of interest to investigate the condensation of bosonic particles under the influence of gravitational interactions in the framework of a Hartree-Fock theory. Results can be compared to observations through the predicted density profiles and masses of the objects.

Why I recommend this PhD Program

«I think one very essential aspect of science is networking – to know what's being done in a field, to connect with other groups and to collaborate. And this is what the program is offering – there is a faculty of people working in all kinds of topics of Cosmology and Astrophysics, from which the students can choose, we can benefit from many meetings and schools and have opportunities to be trained in a broad range of subjects and collaborate with people within the network. It's important, besides studying intensely the own subject, also to have a broad overview of the general field, and the program supports both of those claims.»

Ich denke, ein sehr wichtiger Aspekt der Arbeit in der Forschung ist es, Netzwerke aufzubauen, zu wissen, in welche Richtungen und in welchen Zusammenh‰ngen andere Gruppen und Forscher an einem Thema arbeiten, und sich mit Kollegen auszutauschen und eventuell Kollaborationen zu formen - und diesem Gedanken gibt das Erasmus Mundus IRAP PhD-Programm einen groflen Stellenwert. Es bietet eine grofle Anzahl an Forschern an verschiedenen Universit‰ten und Instituten, und eine grofle Auswahl an vielen verschiedenen Themengebieten, von Astrophysik, ¸ber Kosmologie, bis hin zu sehr theoretischen Richtungen wie Quantengravitation, und dadurch haben wir Studenten eine Reihe von M^glichkeiten, unsere Forschungsinteressen zu verwirklichen. Dar¸ber hinaus wird durch den intensiven Kontakt zwischen Studenten und Lehrenden und vielen gemeinsamen Vorlesungsaktivit‰ten auch eine breite Ausbildung in all diesen Themen erm^glicht und ein guter ‹berblick ¸ber den aktuellen Stand

Christine GRUBER

(Austrian)

Thesis: « Quantum phenomena in the realm of Cosmology»

Supervisor:

Prof. Hagen Kleinert

Free University of Berlin

STUDENTS' REPORTS- 2010-2013

Research Activities

The title of my thesis is "Gama-ray lens development and test". The main goal of the thesis concerns the development and test of a broad band (70/100 -600 keV) Laue Lens prototype for opening a new window for the deep exploration of the Galactic and extragalactic sky. No focusing instruments in this band are available till now. It is the first time that the development of a Laue lens for astrophysics is faced with a great effort. To this end, the doctoral student is being involved in a large national project, LAUE, scientifically led by the High Energy Astrophysics (HEA) group(PI: the doctoral candidate supervisor) of the Physics department of the University of Ferrara. The project is supported by the Italian Space Agency. The project is now in the design phase and is fully consistent with the timeline of the thesis preparation. The lens is based on the use of mosaic/curved crystals, that are being developed for this project, while the technology for properly positioning the crystals in the lens is the result of the experience gained with another project now concluded. The student will face several issues related to the LAUE project: the choice of the best crystals to be used for the lens, the data analysis of the imager/spectrometer data in the focal plane of the lens for establishing the best orientation of the crystals in the lens, the correction of the systematic errors, like the effect of the gamma-ray beam divergence, the measurement of the built lens petal optical properties and so on.The doctoral candidate will be part of a larger team, making possible a strict direct supervision. Results, also at intermediate level, will be presented in international conferences, like SPIE Symposia.

Why I recommend this PhD Program

«I think that the main difference between our program and the normal PhDs is the opportunity to travel, hence broad your mind, and to attend many meetings in which you have the possibility to know other scientists of the field who work in cosmology, general relativity, quantum field theory, and confronting your ideas with them. The schools in Nice are given by some of the leading experts on all the topics of the relativistic astrophysics, both experimental and theoretical.
Moreover, you have the opportunity to meet the other students of the program, and be part of a group, so that you may have a general overview of all fields involved in the network, trying to find a link between different topics which could lead to a common goal.
Finally, the Erasmus Mundus Program provides you a complete education in the high energy astrophysics.»

Vincenzo LICCARDO
(Italian)
Thesis: « Gamma-ray lens development and test.»

Supervisor:
Prof. Filippo Frontera

University of Ferrara

STUDENTS' REPORTS- 2010-2013

Research Activities

The title of my thesis is " Electrodynamics of Neutrons Stars". The classic work of Oppenheimer and Volkoff (1939) addresses the problem of the construction of configurations of equilibrium of neutron stars composed only by neutrons, within the Einstein theory of relativity. For the more general case when protons and electrons are also present in neutron star interiors, in nearly all of the scientific literature it is assumed that the condition of local charge neutrality applies inside the neutron star, namely, no electromagnetic interactions between protons and electrons are considered at all. Consequently, the corresponding solutions of the Einstein equations for a non-rotating neutron star, following the work of Tolman (1939) and of Oppenheimer and Volkoff (1939), have been systematically adopted.

In our research work we prove that this approach is conceptually inconsistent as soon as a self-gravitating system of neutrons, protons and electrons is considered. Therefore, we work on a self-consistent theory of neutron stars in the framework of general relativity, including all the interactions between particles with particular emphasis on the electromagnetic interactions between protons and electrons. The analysis of the properties of the new neutron star equilibrium configurations and their consequence on the process of gravitational collapse to a black hole is one the main goals of our research project.

The observation of the late X-ray emission of the Gamma-Ray Bursts (GRBs) associated to Supernova explosions within the so-called GRB-Supernova connection problem has evidenced the possibility of witnessing the thermal evolution of neo-neutron stars: neutron stars just formed in the Supernova event with expected very large temperatures of tens of billion degrees. Therefore, we are exploring the effects of very large temperatures on the equation of state of nuclear matter at high densities important for neutron stars as well as on the different emission mechanisms leading to the cooling of such newly-born neutron stars.

Why I recommend this PhD Program

« I think the most important aspect of IRAP PhD is the opportunity to interact with teachers and students of all different themes of astrophysics and the participation in schools and meetings. Be present where discuss the new physics and all that scientific exchange, are essential for study and understanding of our topics and our research, as well as astrophysics in general.»

Sheyse MARTINS

(Brazilian)

Thesis: «Electrodynamics of Neutron Stars»

Supervisor:

Prof. Remo Ruffini

University of Roma

STUDENTS' REPORTS- 2010-2013

Research Activities

The title of my thesis is "Multiwavelength analysis of Gamma Ray Bursts emission". My thesis work is based mainly on the study of GRBs. I work both on the experimental and theoretical aspects. I am learning to reduce the data of many satellites like Fermi, Swift and BATSE, and then build their light curves and spectra through specific tools and codes. Then, by means of theoretical models and applying all the knowledge of physics I have, I try to explain the observed behavior and arrive to any conclusion.

There are currently many models which are the leading ones and most of the scientists use for their research work, but at the same time there are many controversies about which is the one to use. The main objective of my work is to reach their complete understanding so that I can make my own way through this field, taking the best part of each one and merging them in a single improved approach.

Why I recommend this PhD Program

« There is a very important feature of this PhD program, and is the fact that you are continuously traveling all around the world. This way you meet important scientists and have the opportunity to interact with them, not only to exchange your opinion but also to learn from them all the small but fundamental things that make you grow as a scientist. By the way, you start to become known in the scientific community from the very beginning, which represents a great advantage over the other programs.»

Ana PENACCHIONI

(Argentinian)

Thesis: «Multiwavelenght analysis of Gamma Ray Bursts emission»

Supervisor:

Prof. Remo Ruffini

University of Roma

STUDENTS' REPORTS- 2010-2013

Research Activities

The title of my thesis is "Laue lens configuration studies for highly sensitive broad band X-/ Gamma-ray astronomy missions". The main goal of the thesis is the study of a broad band (1-600 keV) multi-optics focusing telescope configuration for unprecedented observations of Galactic and extragalactic objects. While at energies below 70/100 keV, the technology for building focusing optics (based on multilayers) is already mature, focusing optics at higher energies are still lacking. Motivated by the astrophysical importance of extending the focusing band up to 600 keV, with the support of the Italian Space Agency, the development of a broad band (70/100 -600 keV) Laue Lens is being performed in Italy, under the scientific PI-ship of Filippo Frontera, at the Physics Department of the University of Ferrara. I am involved in this project, with the goal of developing a code that simulates a Laue lens made of mosaic curved crystals, like that foreseen to be developed. With this code we can, first, establish the best crystal and lens parameters of the lens prototype we want to build, later, we can compare the experimental results of the developed prototype with expectations.

At first, I made a study of X-/ gamma-ray detectors and their theoretical principles. After having made measurements in the LARIX laboratory, I started with simulations and modelling of different parameters and functions that are necessary to get the best results practically for a Laue lens made of different types of crystals.I also modelled the basic petal structure of the proposed Laue project, with single material crystals. The minimum and maximum energy that this structure will provide with these cystals was also modelled.

Why I recommend this PhD Program

« Through this program we have the unprecedented opportunity to meet and interact with one of the pioneer group of high energy astrophysics. This is a very good platform to gain knowledge in the related areas also. The Instrumentation aspects of high energy astrophysics in University of Ferrara is one among the best in this area. It is the first time that the development of a Laue lens for astrophysics is faced with a great effort.»

Vineeth VALSAN

(Indian)

Thesis: «Extending the band of focusing X-ray telescopes beyong 100 keV: motivations and proposed solutions»

Supervisor:

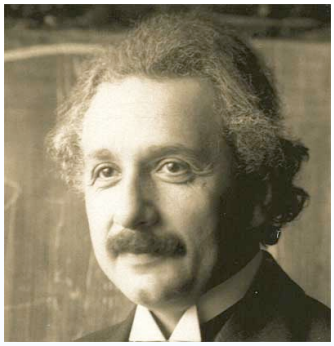
Prof. Filippo Frontera

University of Ferrara

IRAP PHD PROGRAM

CYCLE II (2011-2014)

BEGUE DAMIEN	(FR)
DERELI HUSNE	(TR)
IYYANI SHABNAM	(IN)
PEREIRA JONAS	(BR)
PISANI GIOVANNI	(IT)
GREGORIS DANIELE	(IT)
RAKSHIT SUVENDU	(IN)
BRUNO SVERSUT ARSIOLI	(BR)
WU YUANBIN	(CN)



Albert Einstein:

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Knowledge is limited. Imagination encircles the world.»

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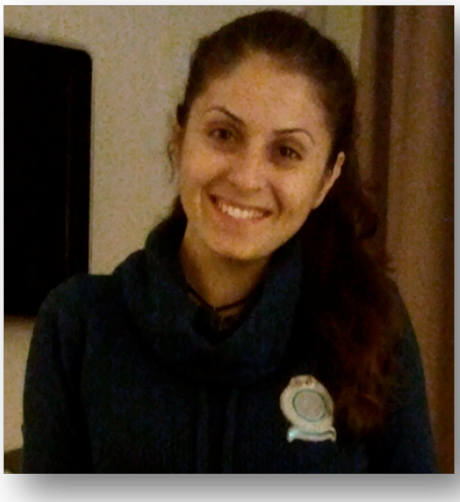
STUDENTS' REPORTS- 2011-2014



Research Activities

The title of my thesis is **"Supernovae and Gamma-Ray Burst"**. Gamma-ray burst (GRBs) are the most luminous events (with 10^{49} - 10^{52} erg/s) in the Universe with the luminosity comparable to the one of Active Galactic Nuclei (AGNs) (L= 10^{48} erg/s) and Supernovae (SNe) (L= 10^{45} erg/s). Both GRBs and SNe events are due to the last evolution step of stars. The association GRB-SNe is intrinsically rare (<5% of SNe-Ibc) and certain conditions must be fulfilled for an exploding progenitor, beside being a massive and stripped star, to simultaneously produce a GRB. The most direct proof of the connection between long GRBs and SNe-Ibc comes from spectroscopic observations of the GRB afterglows. Spectra obtained days/weeks after the initial gamma-ray burst (also called prompt emission) show broad-lines which are typical features of SNe Ib/c events.
The aim of this project is to investigate the relation between stripped supernovae (SNe Ib/c) that result from the cataclysmic death of massive stars and long-duration GRBs with optical data. I collaborated with the SNe group in Naples and in Padua as well as with the GRBs group in Rome, Italy. We worked out on the photometric and spectroscopic data from one specific Supernova source to understand the mechanism of this kind of sources. Besides, we created one template for the relation between long-duration GRBs and stripped SNe Ib/c for the fireshell model developed by the group in Rome.

Now, I am working on very long GRBs with the M. Boer in Nice. This may be a new element in the classification of GRBs. Our goal is to get a statistically meaningful sample to be able to characterize this new class, using optical, X-ray and gamma-ray data from different satellites and telescopes. Then we should be able to study how this class is connected to the others and supernovae.

Why I recommend this PhD Program

« In this program, the most important thing for PhD students is the connection with a large number of scientists to make collaborations for future works. The other important thing for students are the common meetings to exchange information and opinions. Because they have a different background (theory, numerical simulation or observational analysis) and different topics, the exchange of idea is always fruitful.

The last but not least good thing of this program is the exchange between different cultures.»

Hüsne DERELI
(Turkish)
Thesis: «Supernovae and Gamma Ray Bursts»
Supervisor:
Prof. Michel Boer
University of Nice

STUDENTS' REPORTS- 2011-2014

Research Activities

The title of my thesis is ' Observational study of the prompt emission in Gamma ray bursts with the Fermi telescope: The role of photosphere of the relativistic jet'.
Gamma ray bursts are the largest known explosions in the universe. Due to their huge brightness we are able to detect them from very large distances, thereby viewing the very early universe. Most of the observable energy in a GRB is released in the gamma-rays. In spite of this fact we do not yet know how it arises. This problem is therefore one of the most fundamental in high energy astrophysics today, and much attention has been devoted to it both observationally and theoretically.

The aim of my project is to address this problem by studying the photosphere in the relativistic jet in GRBs, in combination with studies of the spectral and temporal data available from the Fermi Gamma-ray Space Telescope. I study the second (pair) photosphere which is expected to be formed if there is energy dissipation below or close to the original photosphere. The conditions under which such a photosphere can be produced is studied. This will allow a calculation of the dynamics of the flow based on observables, such as the temperature and fluxes. These results will be applied on Fermi bursts.

Why I recommend this PhD Program

« I strongly recommend this PhD program as it gives one of the best exposures to current scientific work done in relativistic astrophysics. It gives a platform to interact with people all around the world not only scientifically but also socially. It helps you to grow both intellectually as well as emotionally as a person.»

ഞാന് ഈ പി എച് ഡി ോ,പാ,ഗാം വളെര ശ4് മായി സുഭാര്ഷ െചയു;ു കാരണം ന>ു?് ഇ;ു റീെലടിവിസEിക് അേസ,G ാഫി്സിJില് നട?ു; എKാ നൂതനമായ ഗേവഷണെN കുറിO് അറിയാനും പഠി?ാനും ഉR അവസരം ഇതു വഴി ലഭി?ു;ു. അത് കൂടാെത ന>ു?് ോലാകെമമTാടും നി;് വരു; ശാ,UഞV ാെരയും ഗേവഷണ വിദ ാരXികRുമായും ശാ,Uിയമായതും, സാമൂഹികമായതുമായ കാരIZെള?ുറിO് ആശയ വിനമയം നടNാനുR അവസേരാം ലഭി?ു;ു. ഇത് ന>െള ബു]ിപരമായും മാനസികമായും വളരാന് സഹായി?ു;ു.

Shabnam IYYANI
(India)

Thesis: «Observational study of the prompt emission in gamma-ray bursts with the Fermi telescope»

Supervisor:
Prof. Felix Ryde

University of Stockholm

STUDENTS' REPORTS- 2011-2014

Research Activities

The title of my research is "General Relativistic Electrodynamical Processes in Neutron Stars and Black Holes", under the guidance of Prof. Remo Ruffini and Dr. Jorge Rueda. The most general black hole is believed to be described by its mass (or total energy) M, its charge Q and its angular momentum L. For this general description, one relies on the Maxwellian Lagrangian on the electromagnetic sector minimally coupled to the Einstein-Hilbert action. Although Maxwell's Lagrangian leads to numerous successes concerning physical processes on terrestrial laboratories, it possess some undesirable consequences, such as the existence of singularities for pointlike charged particles, a singular universe when applied to Cosmology, among others. It seems the simplest way to address these difficulties is by the so-called "effective Lagrangians", generally nonlinear theories dependent upon the invariants of the electromagnetism, until a more fundamental theory for nature does not rise. Such effective Lagrangians take into account desirable aspects one would like to insert into a description of a given system at the classical level. In our project we are interested in applying some effective Lagrangians into the description of black holes and neutron stars for seeing their role into these systems. First of all, efforts are being put into understanding the decomposition of the total energy M of a given black hole in this scenario. This is of fundamental importance, because it would allow one to investigate the essential issue concerned with "naked singularities", black holes bereft of an event horizon. Perturbative analyses should also be addressed for black holes and neutron stars described electromagnetically by some nonlinear Lagrangians, for investigating their subtleties and stability as well as for enhancing our understanding of the gravitational collapse from the later to the former entities aforementioned.

Why I recommend this PhD Program

« I would recommend the EMJD Program on Relativistic Astrophysics by its intrinsic multicultural aspect, in which knowledge and life experiences are enhanced by views coming from very different perspectives; by its challenge, in the sense that very exciting and contemporary areas are proposed for investigation; by the independence given by the PhD students in the course of their research and finally by its dynamical nature concerning the miscellaneous congresses, schools, seminars, lectures, etc that the students could participate, either by attending or by presenting works, inasmuch as the large set of universities composing the consortium in various countries in which students are allowed spend a while, allowing them additional scientific interactions and cooperation, broadening even more their erudition.»

Eu recomendaria o Programa EMJD em Astrofísica Relativística pelo seu aspecto multicultural intrínseco, onde conhecimentos e experiências de vida são enriquecidos por perspectivas vindas de diferentes pontos de vista; pelo desafio, no que tange as áreas de pesquisa atuais e empolgantes que nos são oferecidas; pela independência dada ao doutorando no decorrer do sua pesquisa e também pela dinamicidade do programa, presente nos vários congressos, escolas, seminários, aulas, etc, os quais os estudantes podem participar, tanto como ouvintes quanto como palestrantes, bem como as várias universidades que compõem o consórcio onde os estudantes podem ficar um certo tempo, permitindo-os cooperações e interações científicas adicionais, que aumentam ainda mais seus conhecimentos.

Jonas PEREIRA
(Brazil)
Thesis: «General Relativistic Electrodynamical Processes in Neutron Stars and Black Hokes»
Supervisor:
Prof. Remo Ruffini
University of Roma Sapienza

STUDENTS' REPORTS- 2011-2014

Research Activities

My research topic is Neutron stars and Black holes, a topic works over a wide range of subjects. Our research mainly concerns the effects of strong, weak, and electromagnetic interactions on the properties of Neutron stars and Black holes. When taking into account strong, weak, electromagnetic, and gravitational interactions and fulfilling the global charge neutrality of the system, a transition layer will happen between the core and crust of neutron stars, at the nuclear saturation density. This is different from the results from traditional Tolman-Oppenheimer-Volkoff equations imposing local charge neutrality; new neutron star equilibrium configurations are constructed. This result gives us a new concept and a better understanding of neutron stars. Using the Relativistic Mean Field Theory together with the Thomas-Fermi approximation, we study the detailed structure of this transition layer and its surface tension, near the saturation density of nuclear matter. We analyze the stability of this structure. The results will help us to understand the new neutron star equilibrium configurations better.

Extracting energy from a black hole has been an interesting topic for many decades. At the same time, Quantum Electrodynamics (QED) is the fundamental theory who gives the elegance description of electromagnetic interaction. QED has gained remarkable successes in both theoretical and experimental aspects. Taking into account one loop nonperturbative QED effects, we construct the Einstein-Maxwell-Eular-Heisenberg theory. We find out the solution of the field equations of this theory in both weak field and strong field cases. We study the entropy of black holes and the maximal energy that can be extracted from a black hole.

Why I recommend this PhD Program

«The most important aspect of IRAP PhD is that it provides an opportunity to interact with professors and students of all different themes of astrophysics. It provides interesting topics of research from different fields of astrophysics, and one can easily collaborate with many good people. Also you are continuously traveling all around the world. In this way, one can meet many important scientists and have the opportunity to interact with them, which can make you grow as a scientist. »

交流是IRAP PhD最重要的特点。这个项目能给我们提供很多的有趣的课题，而且我们能容易地和很多优秀的科研人员合作。在这个项目中，我们不断地在世界各地参加学术活动。这样，我们能和很多优秀的科学家交流，这会有助于我们成为合格的科研工作者。

Yuanbin WU

(Chinese)

Thesis: «Soliton solutions and Neutron Stars»

Supervisor:

Prof. She-Sheng Xue

ICRANet

STUDENTS' REPORTS- 2011-2014

Research Activities

The title of my thesis is "Fermi Data from Active Galactic Nuclei" supervised by Paolo Giommi. We are dealing with data coming from sky surveys covering a vast range of energies, from radio to TeV photons, as an attempt to identify new blazars and describe their spectral energy distribution (SED).

Usually, the activity in the central regions of elliptical galaxies generates powerful jets of particles that can be pointing towards us. As a result, relativistic effects may boost the luminosity of the jet, which can overcome the whole thermal luminosity of the galaxy. Basically, two main physical processes are assumed to describe the shape of the observed SEDs from blazars: the synchrotron radiation coming from relativistic electrons moving in a feeble magnetic field, and the inverse Compton process where low energy photons can be scattered to higher energies by the interaction with relativistic electrons.

We have been developing methods for selecting extreme AGNs, where the flux density peak associated with the synchrotron radiation reaches the X-ray band. This sample of objects may enclose bright sources of TeV photons, being responsible for the majority of the TeV background radiation.

During the research we shall give attention to time variability of the photon flux in different frequencies, looking for correlations and trying to uncover physical mechanisms that may be generating them.

Open questions in this field are very thought provoking, inviting us to think about the physical nature of the central engines and how they could produce such high energy TeV photons.

Why I recommend this PhD Program

«I recommend the IRAP Erasmus Mundus PhD program especially for those who aim to experience the European culture on science and daily life. It is a fruitful opportunity to get in touch with students from all over the world, and it offers a dynamic environment where one can learn the very essential concepts on General Relativity and Quantum Mechanics. From the beginning the whole atmosphere motivates the students to conceive new ideas and share the lessons each one has learned so far . »

Bruno SVERSUT ARSIOLI

(Brazilian)

Thesis: «Fermi Data from Active Galactic Nuclei»

Supervisor:

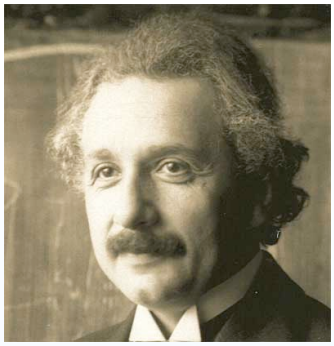
Prof. Paolo Giommi

ICRANet

IRAP PHD PROGRAM

CYCLE III (2012-2015)

BARDHO ONELDA (AL)
ENDERLI MAXIME (FR)
FILINA ANASTASIA (RU)
GALSTYAN IRINA (AR)
GOMES FERNANDA (BR)
KHORRAMI ZEINAB (IR)
LUDWIG HENDRIK (DE)
STROBEL ECKHARD (DE)
SAWANT DISHA (IN)



Albert Einstein:

«Imagination is more important than knowledge.

Knowledge is limited. Imagination encircles the world.»

European Commission
ERASMUS MUNDUS

STUDENTS' REPORTS- 2012-2015

Research Activities

The title of my thesis is "**Understanding the physics behind the correlations in Gamma-Ray Bursts data**". My subject deals with the understanding of high energy transients and gamma-ray bursts. The goal is to explore the relations that exists between different quantities in GRBs, at X-ray but also at different wavelengths. Gamma-Ray Bursts are enigmatic sources which can be either the sign of the end of the life of a very massive star in the distant universe, or the coalescence of 2 compact binary star loosing energy through gravitational radiation. In both cases this is important since the first origin provides clues on the first generations of stars, and the second might lead to the first direct detection of elusive gravitational waves.

Though the precise scenario that leads to the very energetic explosion we observe has yet to be written, we observe various correlations between several measured quantities from GRBs, such as the energy of the peak emission, the luminosity, the decaying of the afterglow, etc. Some other correlations remain to be confirmed, but the main problem is to evaluate how these correlations are produced from the physical processes at work in GRBs, and whether they are connected to the way we get the measurements or to the physics. One of the work will be to continue the catalog of X-ray afterglow since many sources have been observed now. Finally, the correlations which are/will be established have to be interpreted in terms of the physics of the objects..

Why I recommend this PhD Program

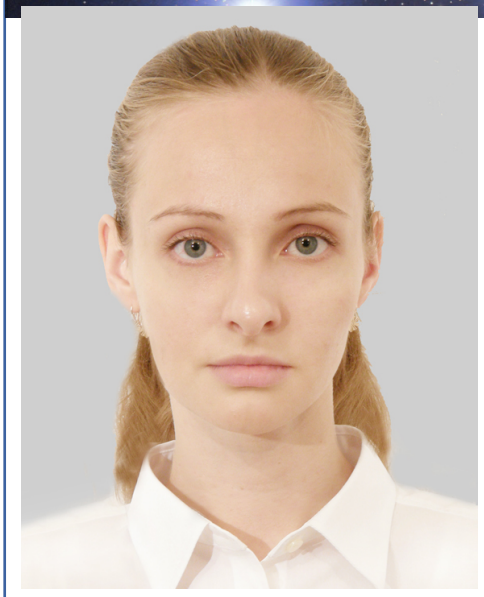
« IRAP PhD program is the best opportunity for any young person who wants to start his/her scientific work in astrophysics. Given the fact that the relativistic astrophysics is in a continuous evolving process, IRAP PhD program gives us the opportunity through schools, meetings, seminars and workshops to meet with the most important scientists and to learn from them the newest breakthroughs in all fields of astrophysics, makes it possible for us to broaden our knowledge. It will prepare and enable us to join the group of the future scientists in the field of relativistic astrophysics and to be able to share our knowledge with other scientists. Isn't this awesome!»

Pse e rekomandojë këtë PhD program

Programi IRAP PhD është mundësia më e mirë për çdo të ri që kërkon të fillojë punën e tij shkencore në astrofizikë. Duke qenë se astrofizika relativiste është në proces të vazhdueshëm evoluimi/zhvillimi, programi IRAP PhD na jep mundësinë nëpërmjet shkollave, takimeve, seminareve dhe workshope-ve të takojmë shkencëtarët më të rëndësishëm dhe të mësojmë të rejat më të fundit në të gjitha fushat e astrofizikës, na jep mundësinë të zgjerojmë njohuritë tona në këtë fushë. Ai do të na përgatisë dhe mundësojë të bashkohemi në grupin e shkencëtarëve të së ardhmes në fushën e astrofizikës relativiste dhe që të jemi në gjendje të shkëmbejmë njohuritë tona me shkencëtarë të tjerë. A nuk është kjo një mbrekulli!

Onelda BARDHO
(Albania)
Thesis: «Undrstanding the physics behind the correlations in Gamma-Ray Bursts Data»
Supervisor:
Prof. Michel Boer
University of Nice

STUDENTS' REPORTS- 2012-2015



Research Activities

The title of my thesis is "**Astrophysics and Cosmology with Gamma-Ray Bursts**". When the satellite BeppoSAX detected the afterglow (fading X-ray emission after a gamma-ray burst), it was proven that the GRBs have cosmological nature. With new satellites it becomes possible to detect GRBs with higher values of redshifts and these observations could give us better understanding of the era of the first stars. For GRBs with known redshift it is possible to construct the distribution of observed GRBs per redshift. This statistical analysis is necessary for understanding the nature of GRB phenomena. We should compare the predictions of theory about progenitors of GRBs with observational data. This requires consideration of the various models, like different explanations of GRB rate, different form of luminosity function of GRBs

Why I recommend this PhD Program

IRAP Ph.D. program has interested me by its unique possibility to work on the problems of modern astrophysics inside big consortium of universities. It gives an opportunity to receive PhD degree in one of leading world centers of science. This program provides necessary conditions for a fruitful work with very interesting people and gives great experience of international communication.

Программа IRAP Ph.D дает уникальную возможность работать над проблемами современной астрофизики внутри большого сообщества университетов. Она дает возможность получить степень PhD в одном из ведущих мировых научных центров. Эта программа предоставляет необходимые условия для плодотворной работы с очень интересными людьми и обеспечивает большой опыт международного общения.

Anastasia FILINA
(Russian)
Thesis: «Cosmology with Gamma-Ray Bursts»

Supervisor:
Prof. Pascal Chardonnet

University of Savoie

STUDENTS' REPORTS- 2012-2015

Research Activities

The title of my thesis is "**Induced Gravitational Collapse, GRB-SN connection, Neo Neutron Stars**". The project is devoted to study both theoretical and observational details of the induce gravitational collapse (IGC) scenario for the gamma-ray burst-supernova (GRB-SN) events. In the IGC paradigm the GRB-SN is the outcome of the final stage of the evolution of a very tight binary system composed of an evolved star and a neutron star (NS) companion. The early stages of the SN event of the evolved star is characterized by the expansion of its outer layers. This material reaches rapidly the gravitational capture region of the NS due to the tightness of the binary and therefore establishes a fast and high accretion rate onto the NS. The NS reaches in short time of seconds its critical mass and gravitationally collapses to a black hole (BH), emitting a GRB. The optical bump of the SN is then observed a few days later, hence superposed to the GRB afterglow. The natural outcome of this system is thus represented a NS, from the SN event, and a BH, from the GRB. I will investigate the subsequent emission both of the NS and the BH, which can be identify in the late X-ray emission observed in the GRB-SN events. The cooling of the newly-born NS, the enhanced thermonuclear reactions occurring in there, and possible fallback accretion processes both on the NS and the BH will be analyzed in detail. The radiation going in gravitational waves in these systems as well as in NS binaries relevant for short GRBs will be also investigated.

Why I recommend this PhD Program

« I am motivated to gain new experiences with IRAP PhD and in my opinion this program is the best way to explore the maximum of my potential. Its international aspect and very high standard of education of the professors and the interaction at different students from various countries is very enriching and exactly what I looked for. I am positive that the IRAP PhD program is an excellent start for an ambitious academic career..»

Estou motivada para ganhar novas experiências com o programa de doutorado IRAP e na minha opinião este programa é a melhor maneira para explorar o máximo do meu potencial. Seu aspecto internacional, o alto padrão de ensino dos professores e a interação com diferentes alunos de vários países, é muito enriquecedor e exatamente o que eu estava procurando. Estou certo de que o IRAP doutorado é um excelente começo para uma carreira acadêmica ambiciosa.

Fernanda GOMES DE OLIVEIRA

(Brazilian)

Thesis: «Induced Grabitational Collapse, GRB-SN Connection, Neo NEutron Stars»

Supervisor:

Prof. Remo Ruffini

University of Roma, Sapienza

STUDENTS' REPORTS- 2012-2015

Research Activities

The title of my Thesis is "**Initial Mass Function and Kinematics of Star Burst Region in 30 Doradus with VLT adaptive Optics**". I work under the supervision of Prof. Farrokh Vakili and Dr. Olivier Chesneau.

R136 is a massive compact star cluster near the center of 30 Doradus in Large Magellanic Cloud with stellar ages for the most massive stars in the range of 1-2Myr and a total stellar mass in the range of $\sim 0.35-1\times10^{5}$ *solar masses*. The aim of my project is to observe this cluster with the new instrument SPHERE. SPHERE will be installed on the Nasmyth platform of the Very Large Telescope (VLT) based on extreme adaptive optics correction and high contrast coronagraphic imaging. In this way we will be able to get more information about the kinematics and the star members of R136.

This object may provide key answers to many fundamental questions regarding the physics of the formation of stars, stellar clusters and their role in the cosmos.

I started my work with analysing the HST image of R136 in different wavelengths (336, 555 and 814 μm) with the help of IDL photometry program.

Why I recommend this PhD Program

« In IRAP PhD program the student have the opportunity to participate in different schools and meetings and this provides the possibility for them to interact with other scientists and learn more about different aspects of Astrophysics.

The OCA institute is particularly suitable to carrying research for the PhD program. Specialists of Adaptive Optics, inverse problems, gravitational wave detection and stellar interferometry work together with theoreticians in cosmology and galactic stellar evolution at OCA.»

چرا این برنامه را پیشنهاد میکنم؟

در برنامه ی دکتری برای دانشجویان این فرصت فراهم است تا در مدرسه ها و نشست های علمی شرکت کنند و با دانشمندان ارتباط برقرار کنند و در زمینه های مختلف ستاره شناسی علم بیاموزند. موسسسه ی مکان مناسبی برای پژوهش در دوره ی دکتری است. متخصصان اپتیک تطبیقی و امواج گرانشی و تداخل ستاره ای همراه با نظریه پردازان در کیهان شناسی و تکامل ستاره ای باهم کار می کنند. م

Zeinab KHORRAMI

(Iranian)

Thesis: «Initial mass function and kinemativcs of starburst region R136 in 30 Doradus using VLTI adaptive optics»

Supervisor:

Prof. Farrokh Vakili

Observatoire de la Côte d'Azur

Research Activities

The IRAP PhD Program is very international and covers almost all areas of astrophysics, from compact objects, gamma ray bursts and active galactic nuclei to gravitational waves and cosmology, and from mathematical and theoretical physics to data analysis and satellite instrument development. This diversity leads to very interesting conversations, and the international atmosphere at the schools in Niece and on convivial evenings is very inspiring.

Why I recommend this PhD Program

The IRAP PhD programm gives the possibility to do research in astrophysics in a very good environment. Through the collaboration between different countries one has the possibility to easily cowork with many scientist in the same field. The schools organized by the program give the possibility to communicate with other students as well as learn about recent developments in the field of astrophysics from distinguished scientist. Furthermore the travel funds allow the attendance of conferences which is especially important for young scientists.

Why I recommend this PhD Program

Das IRAP PhD Programm ist sehr international und deckt beinahe alle Bereiche der Astrophysik ab, von Kompakten Objekten, Gamma Ray Bursts und Active Galactic Nuclei zu Gravitationswellen und Kosmologie, und von Mathematischer und Theoretischer Physik über Datenanalyse bis zur Entwicklung von Satelliteninstrumenten. Durch diese Diversität kommen sehr interessante Gespräche zustande, und auch so ist die internationale Atmosphäre auf den Schulen in Nizza und an gemeinsamen Abenden sehr inspirierend.

Hendrik LUDWIG
(German)
Thesis: «Discrete and Fractal Cosmology
Supervisor:
Prof. Remo Ruffini
University of Roma Sapienza

STUDENTS' REPORTS- 2012-2015

Research Activities

The title of my thesis is "Critical and Overcritical Electromagnetic Fields". My research activities are centered around the field of critical and overcritical electromagnetic fields. Strong electromagnetic fields play an important role in electron-positron pair production. The vacuum polarization process originally studied by Sauter, Heisenberg, Euler and Schwinger in recent years has been connected to an important astrophysical phenomenon: the gravitational collapse during the formation of a black hole. These processes are believed to be the origin of Gamma Ray Burst.

Currently laser technology gets more and more powerful and near the regime of the critical electromagnetic field. There exists the possibility that self-focussing materials such as electron-positron plasmas can be used to examine these processes.

The aim of the PhD thesis is to theoretically investigate the pair production in electromagnetic fields as well in the astrophysical as in the laboratory context.

Why I recommend this PhD Program

The IRAP PhD programm gives the possibility to do research in astrophysics in a very good environment. Through the collaboration between different countries one has the possibility to easily cowork with many scientist in the same field. The schools organized by the program give the possibility to communicate with other students as well as learn about recent developments in the field of astrophysics from distinguished scientist. Furthermore the travel funds allow the attendance of conferences which is especially important for young scientists.

Das IRAP PhD Programm ermöglicht Forschung auf dem Gebiet der Astrophysik in einer hervorragenden Umgebung. Durch die Zusammenarbeit zwischen verschiedenen Ländern hat man die Möglichkeit unproblematisch mit vielen Wissenschaftlern auf diesem Gebiet zusammenzuarbeiten. Die vom Programm organisierten Schulen geben sowohl die Möglichkeit mit anderen Studenten zu kommunizieren als auch von angesehenen Wissenschaftlern über neue Entwicklungen auf dem Gebiet der Astrophysik unterrichtet zu werden. Zudem erlauben die Reisemittel den Besuch von Konferenzen was besonders wichtig für junge Wissenschaftler ist.

Eckhard STROBEL

(German)

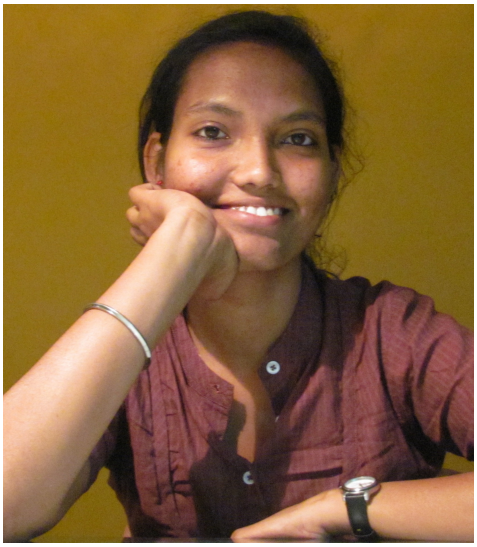
Thesis: «Critical and Overcritical Electromagnetic Fields»

Supervisor:

Prof. She-Sheng Xue

ICRANet

STUDENTS' REPORTS- 2012-2015



Research Activities

The title of my thesis is "Induced Gravitational Collapse, GRB-SN connection, Neo Neutron Stars". Description: Gamma ray bursts are the brightest cosmological sources in the Universe., with isotropic luminosities upto 1054 Erg cm-2s-1 and a redshift distribution extending atleast upto z ~ 6.3. Thus, these sources may be imperical for cosmological studies, if one can use them to provide measurements of the cosmological parameters independently of other methods, like cosmic microwave background, type Ia supernovae, baryon acoustic oscillations and galaxy clusters.
However, GRBs are not standard candels, given that their luminosities span several orders of magnitude under the assumption of both isotropic and collimated emission. In the recent years, several attempts to standardize GRBs have been made, mainly on the basis of the correlation involving intensity indicator like (1) isotropic radiated energy (Eiso) or the isotropic peak luminosity (Lp,iso) or (2) the photon energy at which the time averaged vFv spectrum peaks (peak energy) and other observables, like the break time of the afterglow light curve tb.
The thesis work will be first begun with filtering out the GRBs suitable for standardizing depending on many parameters on the basis of the Amati relation. I am still in the literature grasping phase and my data analysis work will start soon.

Why I recommend this PhD Program

About IRAP: I think IRAP program is best suited for all the young students who want to explore multidimensional Astrophysical fields in their career. Due to its member consortium, it enables the student to visit many institutes during his/ her PhD studies and helps keep himself updated with the latest work taking place about the relativistic Astrophysical fields in numerous corners of the world.
It is an excellent opportunity to make ourselves open to the open issues in various Astronomical and Astrophysical branches and helps prepares the young scientists within ourselves.
Due to its intelligently designed program, an IRAP PhD student gets opportunities to present their work in some of the highly reputed science organizations in the world and enables them to get in touch with some of the most intelligent minds working in Astrophysics. IRAP makes the student smart, independant and updated throughout the course of studies.
I firmly believe that IRAP program is the best thing happened to me in my academic life because for me, for one Indian student got a golden opportunity to come and stay in Europe and hence enjoy working with best people in the field of GRB as well as enjoying the stay to the fullest at the same time.

IRAP के बारे में: मुझे लगता है कि IRAP कार्यक्रम का सबसे अच्छा सभी युवा छात्रों को, जो अपने कैरियर में बहुआयामी Astrophysical क्षेत्रों का पता लगाने के लिए चाहते हैं के लिए अनुकूल है.उसके सदस्य संघ के कारण, यह छात्र उसकी / उसके पीएचडी की पढ़ाई के दौरान कई संस्थानों का दौरा करने के लिए सक्षम बनाता है और नवीनतम relativistic Astrophysical क्षेत्रों के बारे में दुनिया के कई कोनों में जगह लेने के काम के साथ खुद को अपडेट रखने में मदद करता है.
यह एक उत्कृष्ट बनाने के लिए खुद को विभिन्न खगोलीय और Astrophysical शाखाओं में खुला मुद्दों के लिए खुला है और मदद करता है अपने भीतर युवा वैज्ञानिकों को तैयार करने का अवसर है.
होशियारी से डिज़ाइन किया कार्यक्रम के कारण, एक IRAP पीएचडी के छात्र के अवसरों अत्यधिक प्रतिष्ठित दुनिया में विज्ञान संगठनों के कुछ में अपने काम को पेश हो जाता है और उन्हें कुछ सबसे बुद्धिमान दिमाग खगोल भौतिकी में काम के साथ संपर्क में पाने के लिए सक्षम बनाता है. IRAP छात्र स्मार्ट, स्वतंत्र और अध्ययन के पाठ्यक्रम भर में अद्यतन बनाता है.
मैं दृढ़ विश्वास है कि IRAP कार्यक्रम का सबसे अच्छा बात है क्योंकि मेरे लिए अपने शैक्षणिक जीवन में, एक भारतीय छात्र के लिए आते हैं और यूरोप में रहने इसलिए GRB के क्षेत्र में सबसे अच्छा के रूप में के रूप में अच्छी तरह से लोगों के साथ काम करने का आनंद के लिए एक सुनहरा अवसर मिल गया है मेरे लिए हुआ है एक ही समय में पूरा करने के लिए रहने का आनंद ले.

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