Introduction to Workshop

Reuven Opher

In this introductory talk, I will discuss briefly what I consider to be some of the major challenges, both theoretical and observational of new physics in space.

I. BLACK HOLES (BHs)

- How were the BHs at the center of galaxies formed?
- Did primordial BHs form?
- Can we observe the primordial BHs?
- Can we observe BHs at the center of galaxies?
- Can we observe the spin of a BH?
- Can we extract energy from a rotating BH?
- Does BH evaporation cease when the mass of an evaporating BH approaches the Planck mass?
- Can we observe the BHs and gravitons, predicted by extra dimension theories?

II. EVOLUTION OF GALAXIES

- What is the explanation for the close correlation between:
  1-the central BH mass;
  2-the bulge mass;
  3-the central virial velocity; and
  4-the bulge luminosity?
- What is the explanation for the observed intensive stellar formation near central BHs?
- Mergers imply the creation of galaxies that have two BHs at an average separation ~ pc at their centers. Can we observe the predicted ejection of stars in the region < pc?

III. THE PRIMORDIAL UNIVERSE AND DARK ENERGY (DE)

- Are the primordial and present accelerations of the Universe both due to the vacuum energy produced by one-loop quantum fluctuations?
- Is the primordial and present acceleration of the Universe due to the Casimir vacuum energy of a compactified extra dimension $\leq 100\ \mu$?

IV. DARK MATTER (DM)

- What is the distribution of sub-halos of DM in the halo of our galaxy?
- What is the large scale distribution of DM?
- The galaxy distribution fluctuation spectrum should follow the DM fluctuation spectrum. What is the ratio of the two specta?
- Do we now have definite evidence that DM is not simply baryon matter with a modified law of gravity?

V. ASTROPARTICLES – UHECR

- Are UHE photons ($E \sim 10^{20}$ eV) damped by strong galactic and extragalactic magnetic fields (~ μG)?
- Are UHECR produced by rapidly rotating BHs?

VI. GRAVITATIONAL WAVES (GWs)

- How close are we to detecting directly GWs?
- Can we use GWs to study fundamental physics, such as:
  1-QCD (quantum chromodynamics) in the cores of neutron stars; and
  2-DE with GW standard candles?
- Can we increase the sensitivity of GW detectors from GRBs (gamma ray bursts), using the coincidence of the GWs with the emitted gamma rays?

VII. COSMIC MICROWAVE BACKGROUND (CMB)

- Can we determine accurately the primordial GWs in the CMB (B-Mode) and, therefore, the ratio of GW tensor modes to density fluctuation scalar modes?
- Can we detect primordial magnetic fields with the CMB?

VIII. PLASMA ASTROPHYSICS

- How are highly collimated jets from AGNs formed?
- Is the origin of the reionization of the Universe at z~10 due to
  1-radiation from first stars; or
  2-primordial magnetic fields?
- Can we determine the intergalactic magnetic field from the UHECR scattering data?

IX. THE TOPOLOGY OF THE UNIVERSE

- Is there a connection between:
  1-the north-south asymmetry of the CMB;
  2-alignmente of the low multipoles of the CMB; and
  3-the topology of the Universe?

SESSION I

Dark Matters

Joseph Silk
University of Oxford

One of the greatest mysteries in the cosmos is that it is mostly dark. That is, not only is the night sky dark, but also most of the matter in the universe is dark. For every atom visible in planets, stars and galaxies today there exists at least five or six times as much "Dark Matter" in the universe. Astronomers and particle physicists today are seeking to unravel the nature of this mysterious, but pervasive dark matter which has profoundly influenced the formation of structure in the universe. After discussing the evidence for dark matter in the universe, I will review attempts to detect and measure dark matter by direct and indirect techniques. The role of space experiments will be discussed, with emphasis on gamma ray and cosmic ray signatures of dark matter. I will describe some recent hints of a possible particle dark matter annihilation signal, and will review the astrophysical alternatives

Dark Matter and Dark Energy as Interacting Fields

Élcio Abdalla
IF/USP

I consider observational constraints on Dark Matter and Dark Energy. We have tried to modelate them in terms of interacting fluids and further as interacting fields. Observations lead to our confidence on a nonvanishing interaction which, in the worst possibility is one sigma away from vanishing, while in the optimistic cases is more than three standard deviations from the cosmological constant case. We discuss the consequences as well as the motivations for such claims.

Dark Energy Fluctuations and Structure Formation

Rogério Rosenfeld
IFT/UNESP

One of the most important open problems in Cosmology is to find the cause for the apparent accelerated expansion of the universe. A leading candidate to explain this phenomenum is a class of models that goes under the name dynamical dark energy (DDE) models. A given DDE model can be specified by a equation-of-state parameter that relates the background density and pressure and by an effective speed of sound that relates perturbations in density and pressure. There are many observables that are only sensitive to background quantities, such as distance measures (e.g., SNIa, BAO) and hence can be used to put constraints on equation-of-state parameter. However, to get a handle on the effective speed of sound of DDE one must study its effects on the formation of dark matter haloes. To determine the impact of the DDE effective speed of sound on the number of dark matter haloes in future experiments is the Challenge I will discuss.

Nature Versus Nurture: A Challenge for Galaxy Evolution

Abilio Mateus
IAG/USP

The overall scenario of galaxy formation and evolution is far from being complete, but recent advances provided by large redshift surveys and simulations of structure growth has helped us to improve our understanding about this hot topic. Some of the main issues related to galaxy evolution are the role played by the environment in driving galaxy properties, the downsizing observed in star formation in galaxies and the bimodality of the galaxy populations. In this work we review some results on these subjects obtained by analysis of observational and simulated data. We investigate the star formation history of galaxies through a paleontological perspective, applying a spectral synthesis method to retrieve physical properties of galaxies from the Sloan Digital Sky Survey. From these data, we present some clues on the origin of galaxy bimodality and downsizing, as well as relations between galaxy properties and environment. Additionally, we analyze the model universes obtained from the implementation of semi-analytical galaxy formation models into the Millennium Simulation of structure growth. The importance of mergers in galaxy evolution is well determined from this simulation through the recovering of complete merger trees and mass assembly histories of model galaxies. Finally, we discuss some implications of our results.

Magnetic Fields and the Formation of Galaxies

Rafael da Silva de Souza, Reuven Opher
IAG/USP

Magnetic Fields are important in various astrophysical environments, in particular, there is evidence that moderately strong magnetic fields exist at the beginning of the formation of a galaxy. The origin of these intense magnetic fields is an important and challenging question in astrophysics. We review possible mechanisms that are able to create these fields. Dynamo mechanisms that can amplify these fields are also discussed.

Creating Inflation with a Trans-Planckian Dispersion Relation

Ulisses Machado & Reuven Opher
IAG/USP

This work is based on the suggestion that some trans-planckian physics could be modeled by a non-Lorentz invariant dispersion relation. For example, the dispersion relation asumes that the Planck length is independent of the observer, which is incompatible with Lorentz symmetry. That the Planck length could be associated with the uncertainty principle in spatial coordinates, used in non-commutative space-time, is also incompatible. Based on this suggestion, we investigate a primordial inflation period that does not include an unknown scalar field (inflaton) and also does not have a gracious exit problem.

SESSION II

Dark Energy and New Cosmology

Luca Amendola
Osservatorio Astronomico di Roma

Just as physicist look for "new physics" at high energy, astrophysicist look for "new cosmology" at large scales and at deep redshifts. The evidence for cosmic acceleration is probably the first hint that something beyond standard cosmology is needed to explain our universe. Even if the simplest explanation, the cosmological constant, might be the correct one, in the last decade we have learned how little we know about cosmic history and about gravity. We have some knowledge of cosmic dynamics only at very small redshifts and, in an integrated form, also at very large redshifts. Gravity itself, the main player in the cosmic playground, is known with an acceptable precision only within our solar system. In my talk I will review the theoretical motivations for observing deeper and wider and for searching for new effects. After classifying the current models of Dark Energy, I will review the most interesting observational phenomena related to dark energy and to modifications of gravity.

Gravitational Waves: Challenges and New Physics

Odylio D. Aguiar
National Institute for Space Research
(INPE - Instituto Nacional de Pesquisas Espaciais)

The quest for gravitational wave detection has been one of the toughest technological challenges ever faced by experimental physicists and engineers. Despite the null results to date, after four decades of research, the community involved in this area is continuously growing. One of the main reasons for this is because the first gravitational wave detection and the regular observation of gravitational waves are among the most important scientific goals for the beginning of this millennium. They will test one of the foundations of physics, Einstein's theory of general relativity, and will open a new window for the observation of the universe, which certainly will cause a revolution in our knowledge of physics and astrophysics. In this talk, it will be discussed both the challenges we need to overcome in order to realize gravitational wave detection and the topics where new physics have high probability to be revealed.

Absorption Cross Sections of Static Black Holes and Analogues

Luís Carlos Bassalo Crispino and Ednilton Santos de Oliveira
Universidade Federal do Pará

After a brief historical review on the subject, we present the Schwarzschild and Reissner-Nordström black hole absorption cross sections for the massless scalar and the electromagnetic waves with arbitrary frequencies, as well as the canonical acoustic hole absorption cross section for sound waves with arbitrary frequencies. We point out their differences and similarities, comparing these absorption cross sections with the ones obtained for massless waves with spin 1/2 and 2 in Schwarzschild spacetime.

Cosmological Perturbations and Running Cosmological Constant

Alan Toribio
UFJF

In this paper we determine for the running Cosmological constant model the perturbations of matter density using the longitudinal gauge and determine the critical density of collapse. Also we predict the mass function of the model for a given scale.

Dark Energy Constraints Using Matter Density Fluctuations

Ana Pelinson
Departamento de Astronomia, IAG/USP

One of the biggest challenges in Cosmology for the next decade is related to "dark energy", the unknown repulsive force that recently accelerates the Universe, as confirmed by SNIa data. Much effort is concentrated in determining the dark energy (DE) equation of state using observational data. We investigated the matter density fluctuations in the running Lambda CDM and Lambda XCDM models, which have a variable equation of state. The latter was proposed as an interesting solution to the cosmic coincidence problem. It includes an extra dynamical component, the "cosmon" X, which interacts with the running Lambda, but not with matter. We adopted a DE "picture" in which the total DE and matter components are conserved separately and the growth of density fluctuations can be written in terms of the effective EOS. We made use of the galaxy fluctuation power spectrum predicted by the 2dFGRSsurvey, in which the linear bias parameter was obtained within a 10% accuracy for the standard Lambda CDM model. Adopting this limit we constrained the fundamental parameter of the running Lambda CDM model, which is in agreement with previous estimates obtained by a number of different methods and authors. This provided a good test of the procedure, which we then applied to the Lambda XCDM model in order to put constraints on the physical region of the Lambda XCDM parameter space. However, one should take the DE density perturbations into account, since the DE density is not constant. We put strong constraints on the region of the parameter space in which DE perturbations can be consistently defined and the growth of the matter density fluctuations of the Lambda XCDM is in agreement with the Lambda CDM model and 2dFGRS data. Finally, we found only quintessence

behavior for the DE effective EOS of the model which could be confronted by observations, for example, by the next generation of supernovae experiments.

Gamma-Ray Bursts and a Transplanckian Dispersion Relation

Gustavo Rocha da Silva, Reuven Opher, Ulisses Diego Machado
IAG/USP

Several authors have proposed that the comparison of the time of arrival of photons with diferent energies from GRBs could be used to measure a possible Lorentz invariance violation that leads to deviations from a constant speed of light at high photon energies. Models of quantum gravity lead to a dispersion relation of the photon that depends on energy. Recently, data from the FERMI and MAGIC telescopes suggest that these deviations were, in fact, observed. We discuss these recent observations and analyze them, based on a Transplanckian dispersion relation. Possible astrophysical e_ects are discussed. 1

SPECIAL SESSION

Our Miserable Future

Lawrence Krauss
University of Arizona

In this talk, I will ruminate on the future of the Universe itself, and also on the future of life within it, using as my starting point recent observations in cosmology. I will first discuss why the Universe we appear to inhabit is the worst of all possible universes, as far as considerations of the quality and quantity of life is concerned. I will then address several fascinating questions that have arisen as a result of our discovery that the dominant energy of the universe resides in empty space: Can life be eternal in an eternally expanding universe,? Are the laws of physics tailored for the existence of life? What will science in the far future tell us about the universe?

SESSION III

Formation of the Galaxies

Joseph Silk
University of Oxford

The origin of the galaxies represents an important focus of current cosmological research, both observational and theoretical. Its resolution involves a comprehensive understanding of star formation, galaxy dynamics and the cosmology of the very early universe. It is a field that is largely driven by a phenomenology that depends on our accumulating data taken with the largest available telescopes, both terrestrial and in space, both on the most distant objects in the observable universe and on fossil signatures from the oldest stars in our own Milky Way Galaxy. Progress has been made in understanding the origin of spiral galaxies, but elliptical galaxy formation continues to pose unresolved problems. In both cases, feedback seems to be a central issue. Why do both quiescent and star-forming disk galaxies lie on the Schmidt- Kennicutt relation? What is the role of AGN in massive galaxy formation? I will review our current understanding of galaxy formation and summarize the challenges that lie ahead.

Quantum Information and Relativity Theory

André Gustavo Scagliusi Landulfo
IFT/UNESP

I present some general issues about the interplay between quantum information theory and relativity, like the non invariance of Von Neumann theory, Bell inequalities and The Black Hole information Paradox.

Analytical considerations about the cosmological constant and dark energy

Everton M. C. Abreu, Leonardo P. G. De Assis e Carlos M. L. dos Reis

The accelerated expansion of the Universe has now been confirmed by several independent observations including those of high redshift type Ia supernovae, and the cosmic microwave background combined with the large scale structure of the Universe. Another way of presenting this kinematic property of the Universe is to postulate the existence of a new and exotic entity, with negative pressure, the dark energy (DE). In spite of observationally well established, no single theoretical model provides an entirely compelling framework within which cosmic acceleration or DE can be understood. At present all existing observational data are in agreement with the simplest possibility that the cosmological constant be a candidate for DE. This case is internally self-consistent and non-contradictory. The extreme smallness of the cosmological constant expressed in either Planck, or even atomic units means only that its origin is not related to strong, electromagnetic and weak interactions. Although in this case DE reduces to only a single fundamental constant we still have no derivation from any underlying quantum field theory for its small value. From the principles of quantum cosmologies, for example, it is possible to obtain the reason for an inverse-square law for the cosmological constant with no conflict with observations. Despite the fact that this general expression is well known, in this work we introduce families of analytical solutions for the scale factor different from the current literature. The knowledge of the scale factor behavior might shed some light on these questions mentioned above since the entire evolution of a homogeneous isotropic Universe is contained in the scale factor. We use different parameters for these solutions and with these parameters we stablish a connection with the equation of state for different dark energy scenarios.

One of the Challenges for Millimetric Interferometry: Observations of the Formation of Galactic Bulges at Redshifts Larger than z=6

Jacques Lépine
IAG/USP

Argentina and Brazil are starting a project of installation of one or two milllimetric antennas in the Andes - the LLAMA project -, at about 180 km from the core of the ALMA interferometer, so that in future it will be possible to perform VLBI observations using the two instruments, reaching an angular resolution of the order of 2 milliseconds of arc. Among other incredible possibilities offered by such a resolution, one will be to investigate what is probably the formation of bulges of galaxies, as is suggested in a recent paper in Nature, which reports observations of a kiloparsec-scale hyper-starbursts in a quasar host galaxy. In that experiment, made with the IRAM interferometer of the Plateau de Bures, the redshift [CII] line (at 158 microns in th erest frame) was observed at 1.3 mm. We shall discuss the new possibilities offered by this type of observations.

Are Galaxy Clusters Suggesting an Accelerating Universe Independent of SNe Type Ia?

J. A. S. Lima, R. F. L. Holanda and J. V. Cunha
IAG/USP

We present a kinematic analysis of the universal expansion by using 38 angular diameter distances from galaxy clusters in the redshift range $0.14 < z < 0.89$ as measured via the Sunyaev-Zel'dovich effect and X-ray surface brightness data. Similarly to what happens in the supernova type Ia observations, we find that the present accelerating stage of the Universe is supported by this galaxy clusters sample. Our kinematic description is based on two different parameterizations of the deceleration parameter for flat Universe and it is entirely independent on the validity of general relativity or the matter-energy contents of the Universe. The ability of the Planck satellite mission to obtain more constrained limits on the cosmic universal expansion history is also discussed.

SESSION IV

Dumb Holes – Analogs to Black Holes (Part I)

William Unruh
Univ. of British Columbia

Understanding black hole evaporation suffers from an apparent problem of ultra high energies (the Planck Scale problem) and lack of a theory of quantum gravity. The existance of analogs to this process in condensed matter systems gives us the opportunity to understand it better both theoretically and experimentally. My talks will cover the theory of dumb holes and pointing out the way they can be used to understand even the entropy of black holes, and the prospects for carrying out experiments which could test our understanding of the approximations used in predicting black hole evaporation.

Interaction of the Fulling-Davies-Unruh Thermal Bath of the Proca Field with a Uniformly Accelerated Charge in the Rindler Wedge

Jorge Castiñeiras, Luis Carlos Bassalo Crispino, Emerson Benedito Sousa Corrêa
Universidade Federal do Pará

George Emanuel Avraam Matsas
Instituto de Física Teórica - UNESP

We compute the total response of a uniformly accelerated source in Rindler spacetime interacting with the zero energy massive vector particle of the Fulling-Davies-Unruh (FDU) thermal bath. This is done in order to compare the result with the response of a static source with the same proper acceleration outside a Schwarzschild black hole interacting with the massive vector particles of the Hawking thermal radiation. Surprisingly, as it was already shown, these responses would be identical if a massless scalar field is consider instead of the Proca field.

Search for a Low-Energy Quantum Gravity Effect

George Matsas
IFT/UNESP

The formulation of a consistent theory for space, time, gravity and quantum mechanics is one of the longstanding fundamental physics challenges and would possibly(?) give a meaning to questions as "what is the big bang?". The main impediment to accomplish this goal is that typical quantum gravity effects would be obvious only at the Planck scale, which is much beyond our present technological capabilities. This does not rule out, however, the search for subtle low-energy quantum gravity effects, which should shed new light about what a quantum gravity theory must look like. Using past precendents we shall argue that looking carefully at "old physics

on earth" may lead to significant advances in this program. In this vein, we will eventually make a conjecture on the cosmic censorship issue and a raise a thought-provoking prediction about the Higgs boson to be seen at the LHC.

Observations of Black Holes with MIRAX

João Braga
INPE

One of the main science drivers of the MIRAX (Monitor e Imageador de Raios X) mission is its capability for quasi-continuous observations of several Galactic binary systems harboring a black hole. These systems have been shown to possess distinct states which are characterized by conspicuous differences both in X-ray spectra and light curve power spectra. This phenomenology is not yet fully understood. The MIRAX cameras will be especially suited for the study of these systems due to their combination of wide field-of-view (~1000 square degrees), broadband energy range (1 to 200 keV) and observational strategy, which will be based on simultaneous observations of a large number of objects for extended periods of time (timescales of ~months). This will provide ample coverage of the discovery space. In this talk I will comment on the expected MIRAX contributions to the characterization of black holes in Galactic stellar systems.

Anisotropic Correlation Function

Thiago dos Santos Pereira (IF/USP), Raul Abramo (IF/USP), Armando Bernui (INPE)

Careful examination of temperature maps of the cosmic microwave background radiation (CMB) indicate the existence of several statistical anomalies which are not compatible with the standard gaussian/isotropic model of the universe. In this standard scenario the temperature correlation function is assumed to be a function of the angle between any two given vectors in the sky. In this work we extend this hypoteses and construct a correlation function which depend also on the overall orientation of the plane defined by these vectors. We test the robustness of the 5-year WMAP data against this new correlation function.

Simulating SN Ia Surveys

B. L. Lago, E. E. O. Ishida, R. R. R. Reis, M. O. Calvão & I. Waga
Institute of Physics
Federal University of Rio de Janeiro
Rio de Janeiro, Brazil

We build up a simulation pipeline for the estimation of cosmological parameters (energy densities and equation of state parameters), for some general classes of dark energy models (Chevallier-Polarsky-Linder, Chaplygin, WMAP), solely from type Ia supernova data. We are particularly interested in the role played by the characteristics of the survey (area, limiting magnitude, flux measurement technique, filters) and the systematic errors (dust, K-correction, different progenitors/populations, zero point calibrations).

Up to now we implemented, for the CPL equation of state $w(a)=w_0+w_a(1-a)$, the estimation of w_0 and w_a for some survey configurations.

We have already obtained some results for a preliminary version of the DES survey and intend to extend this analysis for LSST or JDEM/Euclid.

SESSION V

Observing Dark Energy

Luca Amendola
Osservatorio Astronomico di Roma

The astrophysical observables that contain relevant cosmological information are not many: essentially, position, brightness, spectrum and shape of distant sources. Dark energy research exploits all of them. I will review the main observational tools to map the dynamics of the expansion and of perturbations: supernovae, cosmic shear, power spectrum, galaxy clusters, cosmic microwave background. I will also discuss some other proposed tests, from gamma-ray bursts to the Sandage effect, and present some of the current observational projects.

Clumps and Cusps: How Small Scale Structure Challenges the Current Dark Matter Paradigm

Luiz Felippe S. Rodrigues, Reuven Opher
IAG/USP

Although very successful in the description of large scale structure, the standard ΛCDM model faces difficulties when one tries to make predictions about smaller objects. We review the so-called "missing satellites" problem, the difference of orders of magnitude in the number dwarf galaxies of Local Group and the number of dark matter haloes of similar masses which occur in simulations. We also review the so-called "cusps vs cores" problem, the incompatibility between the dark matter halo density profiles which are obtained from simulations and the observed dwarf galaxy density profiles. We briefly discuss some tentative solutions to those problems, namely: truncations of the primordial power spectrum, Bose-Einstein condensate dark matter and baryonic astrophysical processes.

Scalar-Tensor Theories of Gravity and the Inflationary Universe

Marcos Brum and Ioav Waga
IF/UFRJ

A model of Cosmic Inflation recently proposed by Di Marco and Notari [1] attempts to solve some of the problems of Guth's original scenario [2]. In their model, the phase transition that drives the inflationary expansion is completed, and it is attractive because it is based on a minimum of extra hypothesis to those of the original work. Gravitation is considered to be described by a Scalar-Tensor theory, whose action is

$$S = \int d^4x\sqrt{-g}\left[\frac{1}{2}(M^2 + \beta\phi^2)R - \frac{1}{2}\partial_\mu\phi\partial^\mu\phi - \Lambda\right].$$

In the proposed model, the inflationary expansion occurs in two stages: the first, de Sitter, is driven by the constant energy of the false vacuum (Λ). In the second, the dynamics is dominated by the scalar field ϕ, and the scale factor evolves as a power-law. This second stage, in which the Hubble parameter decreases, is of great importance for the completion of the phase transition. The relevant perturbations of the scalar field's energy density are generated during the de Sitter stage, though their spectral index is in disagreement with observations. We investigate the changes that occur if these perturbations are generated during the second stage of the inflationary evolution and obtain the necessary conditions for the spectral index to be in accordance with the observations. Another proposal for Inflation, similar in spirit to [1], was made by Biswas and Notari [3]. Though similar in spirit, it opens extra possibilities that will be explored here. It considers a Scalar-Tensor theory with a generic power of the scalar field. We also investigate the bootstrap tests recently proposed by Latham Boyle and Paul Steinhardt [4], and adapt it to the Scalar-Tensor Inflationary Universe.

References

[1] Fabrizio Di Marco and Alessio Notari, Phys. Rev. D **73**, 063514 (2006)
[2] A. H. Guth, Phys. Rev. D **23**, 347 (1981).
[3] Thirtabir Biswas and Alessio Notari, Phys. Rev. D **74**, 043508 (2006)
[4] Latham Boyle and Paul Steinhardt, astro-ph/08102787v1 (2008)

Looking for the Nature of Dark Energy in Counts of Galaxy Clusters

Raul Abramo
IF/USP

The effect of dark energy is commonly parametrized in terms an equation of state with a simple dependence on redshift, and substantial efforts are being made to determine these parameters. But nailing this dependence to even excellent precision would still tell us nothing about the nature of dark energy. To answer that question we must try to find evidence of dark energy perturbations in cosmological observables - which must exist if dark energy is anything but the Cosmological Constant. I will discuss how these perturbations should be manifested in the Universe, in particular on galaxy cluster counts. I will show that structure formation is affected by dark energy perturbations to a level that could be detected by near-future surveys such as the South Pole Telescope. Furthermore, future surveys such as the LSST and EUCLID may be able to constrain the effective sound speed of the dark energy perturbations. Using the Fisher matrix method we derive what are these constraints on the effective sound speed, and how this new parameter affects the forecast of the more basic parameters, such as Ω_m, σ_8, etc.

Interplay between Particle Physics Experiments and Physics in Space?

Oscar Éboli
IF/USP

Particle physics experiments are continously expanding our knowledge of the inner layers of matter. In the last decades we witness a large accumulation of data in neutrino physics and in the next years the CERN Large Hadron Collider will start to produce data. We review the interplay between particle physics and physics in space to expand our knowledge of the universe we live.

The Challenges of Gravitation

Marcos Maia
Universidade de Brasília

Three major challenges of the new physics in space: The accelerated expansion of the universe, the formation of structures in the early universe and the cosmological constant problem, are seen as different symptoms indicating the necessity of a new gravitational theory. After a judicious analysis of Einstein's equations, it is shown that the new gravitational theory may be derived from a generalization of the brane-world program.

SESSION VI

Dumb Holes – Analogs to Black Holes (Part II)

William Unruh
Univ. of British Columbia

Understanding black hole evaporation suffers from an apparent problem of ultra high energies (the Planck Scale problem) and lack of a theory of quantum gravity. The existance of analogs to this process in condensed matter systems gives us the opportunity to understand it better both theoretically and experimentally. My talks will cover the theory of dumb holes and pointing out the way they can be used to understand even the entropy of black holes, and the prospects for carrying out experiments which could test our understanding of the approximations used in predicting black hole evaporation.

Type Ia Supernovae Surveys and Cosmology

Maurício O. Calvão
IF/UFRJ

Type Ia supernovae (SNIa) constitute the main pillar, though not the only one at all, upon which the present universe is established to be accelerating; this, in turn, usually, entails either the existence of dark energy or the modification of effective gravity. It is all too natural to expect that they will still play a dominant role in the final understanding and explanation of the acceleration phenomenon. The analysis and interpretation of SNIa survey data, however, is, or will soon be, no longer limited by sample size, but rather by systematic errors. I will draw attention to some cosmologically relevant issues related to the latter, such as low-redshift consistent calibration, *K*-correction, extinction, evolution, and inhomogeneity of data sets. The Brazilian astrophysical community has already manifested interest to participate in two future surveys (ground-based LSST and space-borne Euclid/JDEM) which will sure shed important light on these issues.

Some Challenges in Cosmic Topology

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Cosmologists assume that the Universe can be described by a space-time manifold $\mathcal{M}_4 = \mathbb{R} \times M$ with a locally homogeneous and isotropic spatial geometry. Mathematicians characterize manifolds in terms of their geometry and topology. Thus, two fundamental questions regarding our description of the Universe concerns its spatial geometry and topology. Geometry is a local quantity that gives the curvature of the *3*-space. Topology is a global feature that characterizes its shape and size. The spatial section M is usually taken to be one of the simply-connected spaces, namely, Euclidean $\mathbb{R}^3$, spherical $\mathbb{S}^3$, or hyperbolic $\mathbb{H}^3$. However, this is an assumption which has led to a common misconception that the curvature *k* of *M* is all one needs to decide whether the spatial section is finite or not. The spatial geometry constrains but does not dictate the topology of the 3-space *M*, and although the spatial section *M* is usually taken to be one of these simply-connected spaces it is a mathematical result that great majority of locally homogeneous and isotropic 3-spaces *M* are multiply-connected quotient manifolds of the form $\mathbb{R}^3/\Gamma$, $\mathbb{S}^3/\Gamma$, and $\mathbb{H}^3/\Gamma$, where Γ is a fixed-point free group of isometries of the corresponding covering space. Thus, for example, for the Euclidean geometry ($k=0$) besides $\mathbb{R}^3$ there are 6 classes of topologically distinct compact orientable spaces *M* that can be endowed with this geometry, while for both the spherical ($k=1$) and hyperbolic ($k=-1$) geometries there are an infinite number of topologically inequivalent manifolds with non-trivial topology that can be endowed with each one of these geometries. Geometry does not dictate the topology of the spatial sections. What is the topology of the spatial section of the Universe, whether it is finite and what is its size and shape may be are among the fundamental open problems that high precision modern cosmology can potentially resolve. These questions have become particularly topical, given the wealth of increasingly accurate cosmological observations, especially the recent observations of the cosmic microwave background radiation. Despite our present-day inability to *predict* the topology of the Universe we should be able to devise strategies and methods to *detect* it by using observational data. In this talk I shall present a brief overview of the basic features of cosmic topology, examine some recent results in the field, and discuss some of the challenges in the search for a possible nontrivial topology of the Universe.

Can Primordial Cosmological Models be Tested by Future Observations?

Nelson Pinto Neto
CBPF

In this talk I will make a critical comparison among viable inflationary, pre-Big Bang and bouncing models for the primordial Universe which I will describe, and discuss how the usual problems and features of the standard cosmological model are addressed by them in order to investigate if they can be distinguished by future observations.

SESSION VII

Supersymmetric Dark Matter and Non-Standard Cosmologies

Athanasios Lahanas
University of Athens

We discuss some phenomenological aspects of supersymmetric field theories. Supersymmetry (SUSY), an indispensable ingredient of String Theories, will be tested in the near future at very high energy accellerators starting with the Large Hadron Collider (LHC). This will probe for new physics laws at distances as small as of one billionth of a billionth of a centimeter. Among its virtues SUSY predicts for the existence of Weakly Interacting Massive Particles (WIMPs), providing an explanation for Dark Matter one of the biggest mysteries of modern Astrophysics. On going studies of supersymmetry, both at the theoretical and phenomenological level, when combined with new physics ideas, especially those advocating the existence of extra space-time dimensions, may help towards resolving long standing problems in Particle Physics and Cosmology.

Viable Singularity-Free f(R) Gravity

Ioav Waga
IF/UFRJ

Since the discovery of cosmic acceleration, more than a decade ago, considerable effort has been devoted to understand what is its underlying physical mechanism. The two possibilities most widely investigated are: the existence ofan exotic component with negative pressure (dark energy) and proper modifications of Einstein's gravity theory at cosmological scales (modified gravity). In the last five years increased interest has been given to theformer approach. In particular, f(R) gravity theory, due to its simplicity, has received the main attention. In this theory the Lagrangian density is not alinear but a general function of the Ricci scalar R. Although a great deal of effort has been employed to develop this formulation, it appeared to be a difficult challenge to build a new f(R) gravity theory that does not spoil the successes of General Relativity – one that passes solar system tests, describes the early universe, allows a matter-dominated phase followed by an accelerated attractor and, at the same time, do not suffer from curvature singularities. Recently, some authors have argued that self-consistent f(R) gravity models distinct from LCDM are almost ruled out. Confronting such claims, we present a particular two-parameter f(R) model that: (a) is cosmologically viable and distinguishable from LCDM; (b) is compatible with the existence of relativistic stars; (c) is free of singularities of the Ricci scalar during the cosmological evolution and (d) allows the addition of high curvature corrections that could be relevant for inflation.

Teleparalelism and Quantum Mechanics

Raissa F. P. Mendes e Vanessa C. de Andrade

Since the advent of Quantum Field Theory, great effort has been made in order to apply it to the gravitational field, as part of the search for a consistent theory of Gravitation. However, the attempts to connect Gravitation and Quantum Mechanics have faced many challenges, from a conceptual as well as technical point of view. On the other hand, aiming to describe Gravitation so it could approach the other interactions, the Teleparallelism or Teleparallel Equivalent of GR (TEGR) has been formulated, which is an equivalent and alternative gauge theory of Gravitation. This work's objective is to analyze the compatibility between Teleparallel Gravity and Quantum Mechanics, following the construction of TEGR's hamiltonian formulation and focusing on the conceptual advantages of this theory.

Investigating Galaxy Evolution with Spectral Synthesis

Laerte Sodré
IAG/USP

The main objective of spectral synthesis, as implemented by our group, is to investigate the star-formation history of galaxies in the local universe from the analysis of their optical spectra. The study of more than half a million SDSS galaxy spectra has already allowed to analyze the evolution of stellar mass and metallicity, the relation between nebular and stellar extinction, the role of environment on galaxy evolution, the role of stellar populations in nuclear activity, as well as general properties of the galaxy population, like their bimodality and downsizing. In this talk I will review our approach to spectral synthesis and present the main results so far.

Semiclassical Corrections to GR and their Gravitational Implications

Ilya Shapiro
UFJF

We report on some recent results on the evaluation of quantum corrections to classical gravity and their applications, mainly to cosmology.

Searching for Monochromatic Signals in the ALLEGRO Gravitational Wave Detector Data

Fernanda G. Oliveira (ITA), *Rubens Marinho Jr* (ITA), Nadja S.Magalhães (UNIFESP), Ricardo Pires (CEFET), Odylio D. Aguiar (INPE)

The present work is devoted to the detection of continuous GW signals within ALLEGRO's data. It is based on a method tailored for the detection of monochromatic signals in the middle of strong, white noise, which basically makes power spectrum estimates using averaged modified periodograms developed by P. D. Welch. By using this method it is possible to obtain a power spectrum for the data which preserves peaks due to monochromatic signals. Then an analysis is performed on the peak called Mistery Mode, the analysis has been done for the observation time of 1200 s and we have tracked this peak during 100 days of the year 1997, searching for frequency drifts that might present a similar pattern to the one due to Doppler shifts.

SESSION VIII

Connecting Energy to Geometry: The Case of Regular Black Holes in an Asymptotically de Sitter Universe

Irina Radinschi[1] and Th. Grammenos[2]
[1]Department of Physics, "Gh. Asachi" Technical University, Iasi, 700050, Romania
[2]Department of Mechanical & Industrial Engineering, University of Thessaly, 383 34 Volos, Greece

The study of the energy localization of black holes is one of the most important issues in present-day gravitational studies and provides an interesting challenge to our understanding of space-time. We present an overview of some recent developments in energy localization for black hole solutions. We focus on 2 issues: (1) the review of the main aspects of the problem of energy localization and the ways of dealing with it up today, which has implied the use of efficient and accurate tools like superenergy-tensors, energy-momentum complexes, quasi-local expressions and the tele-parallel theory of gravitation, and (2) the study of the energy of strong gravitational fields giving as a specific example the case of regular black holes in an asymptotically de Sitter Universe.

Modified Gravity and its Mapping to Scalar-Tensor Theories

Sergio Jorás
IF-UFRJ

When the observational data is analysed from the point of view of General Relativity (GR), we arrive at the astonishing conclusion that about 95% of the content of the universe is unknow and is called of dark matter and dark energy.

An interesting and reasonable alternative is to suppose that GR is not valid at any length scale and that the required modifications are (erroneously?) interpreted as exotic fluids.

In this seminar we will focus on the current approach to this so-called modified gravity theories including the mapping onto scalar-tensor theories and its shortcomings.

Exact Foldy-Wouthuysen transformation for gravitational waves and magnetic field background

Bruno Goncalves, Yuri N. Obukhov, Ilya L. Shapiro

We consider an exact Foldy-Wouthuysen transformation for the Dirac spinor field on the combined background of a gravitational wave and constant uniform magnetic field. By taking the classical limit of the spinor field Hamiltonian we arrive at the equations of motion for the non-relativistic spinning particle. Two different kinds of the gravitational fields are consid- ered and in both cases the effect of the gravitational wave on the spinor field and on the corresponding

spinning particle may be enforced by the sufficiently strong magnetic field. This result can be relevant for the astro- physical applications and, in principle, useful for creating the gravitational wave detectors based on atomic physics and precise interferometry.

Gravitational Wave Background from a Neutron Star Phase Transition

J.C.N. de Araujo & G.F. Marranghello
Instituto Nacional de Pesquisas Espaciais - Divisão de Astrofísica

We study the generation of a stochastic gravitational wave (GW) background produced from a population of neutron stars which go over a hadron-quark phase transition in its inner shells. In particular, we take into account in the present study the history of star formation derived by Springel & Hernquist, who employed hydrodynamic simulations of structure formation in a LCDM cosmology. We study the possibility of detection of this GW background by correlating signals of a pair of advanced LIGO observatories. We discuss what astrophysical information could be obtained from a positive (or even a negative) detection of such a GW background generated in scenarios such as those studied here.

Swimming in Cosmological Spacetimes

Adriano Contini Torres, George Emanuel Avraam Matsas
IFT/UNESP

In 2003, Jack Wisdom unveiled a new general relativity effect, a geometric phase phenomenon in which, contrary to the tradicional result for newtonian mechanics in euclidian spaces, particle systems in curved ambient spaces are able to rigidly move themselves without neither external thrust nor matter ejection. Stating it in a more precise fashion, constrained systems which compose quasi-rigid bodies can achieve translation on curved manifolds with intrinsic curvature, including relativistic spacetimes, by means of cyclic changes in their shapes provided by exclusively internal strains, much like in an usual swimming process. Such an effect, besides its undeniable own conceptual merit, seems to open a new vein in the intricate study of rigid bodies in general relativity, in addition to representing an uncommon mechanism for self-propulsion. In this communication, we present the extension of Wisdom's original results on Schwarzschild geometry to the cosmological solutions of Friedmann-Robertson-Walker, in whose context the effect may, at first, turn out to be more significative.

Modeling Nonlinear Dark Energy Fluctuations

Ronaldo Carlotto Batista, Raul Abramo, Rogério Rosenfeld

In the near future, galaxy clusters surveys will become a valuable tool to probe the dark energy properties. As well as its equation of state, dark energy fluctuations can modify the halo mass functions. Neglecting these fluctuations can introduce systematic errors on dark energy and other cosmological parameters that will be derived from the future data. To size the influence of dark energy fluctuations, one must know how to describe their evolution in the nonlinear regime. However, the present models of structure formation can only treat fluctuations associated to very particular dark energy models. In order to study this problem in a more general basis, we derive a system of equations capable to evolve both dark matter and dark energy fluctuations in the nonlinear regime, where the latter can be described by a scalar field or a perfect fluid; we also present some preliminary results.

The Fundamental Importance of the Reciprocity Theorem for Observational Cosmology

Marcelo B. Ribeiro
Physics Institute, University of Brazil - UFRJ

The reciprocity theorem, also known as the reciprocity law, was originally proved by I.M.H Etherington in 1933, but then lost to later generations of cosmologists only to be rediscovered in the 1960s and made popular by G.F.R. Ellis (1971, 2007). It states the equivalence between the area distance as measured by the observer to the source from a bundle of null geodesics, and the opposite situation, that is, the area distance measured by the source to the observer. The former case defines a cosmological distance usually called as "angular diameter distance" d_A, whereas in the latter situation the distance measure is often known as "effective distance" d_G. The astronomically defined "luminosity distance "d_L" can be brought to this theorem, which is then written as $\{d_L\}^2=\{d_G\}^2\{(1+z)\}^2=\{d_A\}^2\{(1+z)\}^4$. The core of this law lies in the way solid angles transform under velocity transformations and, therefore, it is absolutely general, notwithstanding how lumpy or anisotropic is the cosmological model. This law shows that d_L and d_A depend on each other, shaping the way galaxy observations are analyzed. Up until recently, both d_L and d_A of distant galaxies were obtained by means of theoretical calculations from the assumed cosmological models. However, with the dawn of the supernova cosmology era, which gave us a homogeneous class of sources capable of providing a "standard candle", we have been able to obtain d_L *independently* of a cosmological model. The *challenge* now is to find an equivalent class of cosmological sources capable of providing us with a "standard rod" such that d_A is also obtained independently of cosmological models. If we are able to do that, the reciprocity law tell us that the ratio between d_L and d_A $\{(1+z)^2\}$ must be one, meaning that Etherington's law is in principle testable observationally. If we find observational deviations of this result, that will certainly lead to a major crisis in observational cosmology, since galaxy observations, analyzes of cosmic blackbody radiation and gravitational lensing are dependent upon the validity of this law. That will also mean a catastrophe to theoretical cosmology.

Prospects for the Planck Satellite: Limiting the Hubble Parameter Value by SZE/X-Ray Distances

R. F. L. Holanda, L. Marassi, J. V. Cunha and J. A. S. Lima
Departamento de Astronomia (IAG-USP)

The satellite Planck is a project of the European Space Agency, its frequency channels were chosen with the thermal Sunyaev-Zeldovich effect (SZE) in mind. It has been estimated that Planck should see about 30.000 galaxy clusters over the whole sky via the SZE. The median of the cluster redshift distribution should be near 0.3 and a significant fraction of clusters will be near or beyond redshift unity. The SZE offers a powerful and unique observational tool for cosmology. When combined with other observations of galaxies clusters such as X-ray emission from the intracluster gas, it provides independent estimates of the Hubble constant (h). However, accurate angular diameter measurements (ADD) require long SZE and X-ray integrations and therefore we do not expect all discovered clusters to have accurate SZ/X-ray distance measurements. Thus, we simulate two sample of ADD by using a fiducial model to analyze the ability of the Planck satellite mission to obtain more restrictive limits on h based on the SZE/X-ray distance technique. The degeneracy on the cosmological parameters was broken using the baryon acoustic oscillations (a peak of the large-scale correlation function at 100 h^{-1} Mpc), known as BAO signature, and the angular scale of the first peak in the CMB spectrum, known as Shift Parameter. Booth BAO and the Shift Parameter signatures are independent of H_0.

Participants

Foreign Speakers

Joseph SILK (Univ. of Oxford)
“Dark Matters”
“Formation of the Galaxies”

Luca AMENDOLA (Osservatorio Astron. di Roma)
“Dark Energy and New Cosmology”
“Observing Dark Energy”

Lawrence KRAUSS (Univ. of Arizona)
“Our Miserable Future”

William UNRUH (Univ. of British Columbia)
“Dumb Holes – Analogs to Black Holes” (two lectures)

Athanasios LAHANAS (Univ. of Athens)
“Supersymmetric Dark Matter and Non-Standard Cosmologies”

Irina RADINSCHI ("Gh. Asachi" Technical Univ., Romania)
“Connecting Energy to Geometry: the Case of Regular Black Holes in an Asymptotically de Sitter Universe”

Brazilian Speakers

Élcio ABDALLA (IF/USP)
“Dark Matter and Dark Energy as Interacting Fields”

Raul ABRAMO (IF/USP)
“Looking for the Nature of Dark Energy in Counts of Galaxy Clusters”

Odylio D. AGUIAR (DAS/INPE)
“Gravitational Waves: Challenges and New Physics”

José Carlos de ARAUJO (INPE)
“Gravitational Wave Background from a Neutron Star Phase Transition”

Ronaldo Carlotto BATISTA (IF/USP)
“Modeling Nonlinear Dark Energy Fluctuations"

João BRAGA (INPE)
"Observing Blacks Holes with the Satellite MIRAX"

Marcos BRUM (IF/UFRJ)
"Scalar-Tensor Theories of Gravity and the Inflationary Universe"

Maurício O. CALVÃO (IF/UFRJ)
"Type Ia Supernovae Surveys and Cosmology"

Jorge CASTIÑEIRAS (UFPA)
“Interaction of the Fulling–Davies–Unruh Thermal Both of the Proca Field with a Uniformly Accelerated Charge in the Rindler Wedge”

Roberto COLISTETE (UFES)
“Darwin and the Universe: Genetic Evolution of Cosmological Models”

Luis Carlos Bassalo CRISPINO (UFPA)
"Absorption Cross Sections of Static Black Holes and Analogues"

Gustavo Rocha DA SILVA (IAG/USP)
“Gamma-Ray Bursts and a Transplanckian Dispersion Relation”

Rafael DE SOUZA (IAG/USP)
“Magnetic Fields and the Formation of Galaxies”

Oscar ÉBOLI (IF/USP)
"Interplay between Particle Physics Experiments and Physics in Space"

Rodrigo HOLANDA (IAG/USP)
“Prospects for the Planck Satellite: Limiting the Hubble Parameter Value by SZE/X-Ray Distances”

Sergio E. JORÁS (IF/UFRJ)
“Modified Gravity and its Mapping to Scalar – Tensor Theories”

Bruno LAGO (IF/UFRJ)
"Simulating SN Ia Surveys"

André LANDULFO (IFT/UNESP)
"Quantum Information and Relativity Theory"

Jacques LÉPINE (IAG/USP)
"One of the Challenges for Millimetric Interferometry: Observations of the Formation
the Formation of Galactic Bulges at Redshifts Larger than z=6"

Jose Ademir Sales de LIMA (IAG/USP)
“Are Galaxy Clusters Suggesting an Accelerating Universe Independent of SN Type Ia?”

Ulisses MACHADO (IAG/USP)
"Creating Inflation with a Trans-Planckian Dispersion Relation"

Marcos MAIA (IF/UnB)
“The Challenges of Gravitation”

Rubens MARINHO (ITA)
“Searching for Monochromatic Signals in the ALLEGRO Gravitational Wave Detector Data”

Abilio MATEUS (IAG/USP)
“Nature Versus Nurture: A Challenge for Galaxy Evolution”

George Emanuel Avram MATSAS (IFT/UNESP)
“Search for a Low-Energy Quantum Gravity Effect”

Raissa MENDES (IFT/UNESP)
“Teleparalelism and Quantum Mechanics”

Reuven OPHER (IAG/USP)
"Introduction to the Workshop"

Ana PELINSON (IAG/USP)
“Dark Energy Constraints Using Matter Density Fluctuations”

Thiago S. PEREIRA (IF/USP)
"Anisotropic Correlation Function"

Carlos PINHEIRO (UFRRJ)
“Some Questions and Some Aspects of Time”

Nelson PINTO NETO (CBPF)
"Can Primordial Cosmological Models be Tested by Future Observations?"

Marcelo REBOUÇAS (CBPF)
“Some Challenges in Cosmic Topology”

Marcelo B. RIBEIRO (IF/UFRJ)
"The Fundamental Importance of the Reciprocity Theorem for Observational Cosmology"

Luiz Felippe S. RODRIGUES (IAG/USP)
“Clumps and Cusps: How Small Scale Structure challenges the Current Dark Matter Paradigm”

Rogério ROSENFELD (IFT/UNESP)
“Dark Energy Fluctuations and Structure Formation”

Ilya SHAPIRO (UFJF)
“Semiclassical Corrections to GR and their Gravitational Implications”

Laerte SODRÉ (IAG/USP)
“Investigating Galaxy Evolution with Spectral Synthesis”

Alan TORIBIO (UFJF)
“Cosmological Perturbations and Running Cosmological Constant”

Adriano Contini TORRES (IFT/UNESP)
"Swimming in Cosmological Spacetimes"

Ioav WAGA (IF/UFRJ)
“Viable Singularity-Free f(R) Gravity”