Report of MARIO NOVELLO (2011) from ICRA-BR

List of papers and some comments on the lines of research I have been developing and the ones I shall be developing in the coming years.

1. NOVELLO, M. The gravitational mechanism to generate mass. Classical and Quantum Gravity (Print), v. 28, p. 035003, 2011.

Given the imminent possibility of proving or disproving the existence of Higss boson by experiments currently underway at CERN (European Organization for Nuclear Research), it is time to non-dogmatically examine the different proposals around the origin of the mass of all bodies. This paper looks into two of the most relevant mass generating mechanisms developed by scientists. I have emphasized the mechanism of gravitational origin for a couple of reasons. First, because Higgs's concurring mechanism has been vastly presented and described in various publications. Second, because there is a novelty in that proposal that makes it particularly attractive thanks to the discovery that the traditional difficulties presented against the gravitational mechanism have been eliminated, turning this into a most acceptable mass generating mechanism for all bodies.

2. NOVELLO, M.; E. Goulart. Beyond analog gravity: the case of exceptional dynamics. Classical and Quantum Gravity (Print), v. 28, p. 145022, 2011.

Up until recently, the idea of using scalar and/or vector fields to mimic gravitational processes was limited to kinematic issues. This meant that the propagation processes of these fields that satisfy non-linear theories may be described by a change in the geometry of space-time, mimicking gravitational effects, in terms of effective metrics. This used to be done only in issues referring to kinematics rather than dynamics.

Ever since this article I wrote with my collaborator E. Goulart, this situation has changed, for we have been able to show that there are exceptional dynamics where the very dynamics is written as a function of the effective metrics. The next step—which we have already taken—is to extend this result to other dynamics of the scalar field, and, at a second moment, to vector fields. This is one line of research I will develop.

A doctorate student, Junior Toniato, will join this study, as well as post-doctorate E. Goulart and my collaborator Felipe Tovar Falciano.

3. NOVELLO, M. ; E Bittencourt
Gaussian coordinate systems for the Kerr metric. Gravitation & Cosmology v. 17, p. 3, 2011.

Generating a most important geometry, Kerr metric is certainly one solution to equations in the field of general relativity in emptiness. It has been used hundreds of times to understand mechanisms associated with processes in Astrophysics involving non spherically symmetric black holes (with an axis of symmetry and rotation). In all of these studies and everywhere in the related scientific literature (that is, in all books on gravitation and/or astrophysics) this metric is described in various forms, always explicitly involving cross terms or terms in null coordinates. In this paper, we explicitly exhibit a class of Gaussian systems of coordinates and the different domains of its validity and extensions. Based on this description, the quasi-Maxwellian formulation of this geometry may be developed in a practical and accessible manner. Gauge's independent formalism may then be used to examine its perturbation, be it by introducing matter or by propagating gravitational waves. This is what we are doing in my student Bittencourt's doctorate thesis.

4. NOVELLO, M. ; Maria Borba . Reproducing gravity through spinor fields. Gravitation & Cosmology (Print), v. 17, p. 224-229, 2011.

Another line of investigation involves a more fundamental question, related to some aspects of the General Relativity theory, which I describe in the previous report, by the paper:

A Spinor theory of gravity and the cosmological framework.
M. Novello (Rio de Janeiro, CBPF) . Jan 2007. 10pp.
Published in **JCAP 0706:018,2007**.
e-Print: **gr-qc/0701120**

In this paper, which is the continuation of my student Maria Borba's master thesis, we show how a static and spherically symmetric geometry can be obtained as a solution to my equations in the Spinorial Theory of Gravitation. We show that as far as the linear order in (m/r) (where m is the mass in units of the constant of gravitation) this theory is no different from the general relativity, because this new solution coincides with Schwarzschild's solution of general relativity. However, in the following non linear order, both theories (STG and GR) differ. So, this theory includes predictions which may be tested in the future and decide which is the most adaptable to reality.

The recent proposal that the expansion of the universe may be accelerated has brought me to a profound analysis of the General Relativity and its role as the theory of gravitation. I have come to reconsider some of its fundamentals, the role of the Principle of Equivalence and some issues related with the physics of fields. I have come to scrutinize an old Heisenberg proposal about non-linear Spinorial fields and noticed the possibility of using it as a fundamental field equation that is capable of producing a new mode of describing gravitation as it describes the interaction of these Spinorial fields with all types of existing matter and energy. This has naturally led me to develop a new Theory of Gravitation, which I called (perhaps tentatively) Spinorial Theory of Gravitation. I started its formulation and consequences, intent on making it a competitive alternative theory to the General Relativity, enabling the treatment of gravitation as an effective field resulting from the interaction of those spinors with matter/energy of any sort. I was invited to present these papers in two conferences, in Rome and Paris, and to present seminars at the Institute of Theoretical Physics of French CNRS (CTP), in Marseille.

The realization of this idea starts by identifying two fundamental Spinorial fields Ψ_{E} and Ψ_{N}. Their origins are related with a complementary view of EEP, according to which the gravitational field—identified, as in the GR, with the metric tensor—constitutes an induced quantity that depends on a microscopic substructure. This substructure does not have a geometric origin, but it is a field of matter. One may say that the General Relativity is based on a view whereby space-time must be understood as the physical arena (in Wheeler's own words) and gravity is nothing but a consequence of the direct modification of the geometry of this arena. The Spinorial Theory of Gravitation (STG), on the other hand, considers that the arena contains matter and energy, and that the geometry is nothing more than a specific mode of relation between these real quantities (substances) interacting among themselves. Thus, there is no practical sense in STG to attribute a dynamics to the geometry.

Its evolution is but a natural consequence of the dynamics of matter interacting gravitationally, as described in those papers.

Accepting the idea that the metric tensor is a derived quantity, that it is not an independent dynamic variable, we find the question: which would these independent dynamic variables be, then, that could represent the gravitational phenomenon?

In his analysis of a similar question, back in the 1950's, Feynman argued against the possibility of identifying such a dynamic entity with different types of fields, such as the scalar, spinorial and vector fields. Let us review this analysis. The argument against the scalar field lies on the impossibility to describe the influence of gravitation on the propagation of the photon. Accepting that the effect of a scalar field would be the production of a conformally flat geometry, it follows that the conformal invariance of Maxwell's Electrodynamics would imply the absence of any direct influence of gravitation on the propagation of the photon. This was eliminated by the observation made in Sobral in 1919. The impossibility to identify gravitation with a vector field is related to the purely attractive effect of gravitation. Concerning the case of a neutrino type field, Feynman's argument lies on the impossibility to obtain a static potential of the $1/r$ type. He then concluded at the time that only a tensor field $\varphi_{\mu\nu}$ would be able to fulfill his criterion, which led him to follow Einstein's steps and produce a gravitation field theory that would contain a second order symmetric tensor, later identified as metric tensor. The Spinorial Theory of Gravitation proposes a different answer to solve this difficulty. In fact, in the papers mentioned here, we show how to obtain a theory, based on a non-linear dynamics for both Spinorial fields, and from that theory we would learn the evolution of the geometry that is identified with the gravitational field. In the case of a star, or generically, of a static spherically symmetric field, the solution to STG equations are rather similar to Schwarzschild's solution to the GR—the difference between both can be observed at the post-post-Newtonian level, as per the above-mentioned papers. This STG theory is thus compatible with classic gravitation tests, and produces a series of novelties that need to be examined if it is to be considered competitive. That is what I have examined and will continue to examine in this project.

5. NOVELLO, M. ; F.T.Falciano ; SALIM, J. M. . On a Geometrical Description of Quantum Mechanics.. International Journal of Geometric Methods in Modern Physics, v. 8, p. 87-98, 2011.

6. NOVELLO, M. ; F.T.Falciano ; SALIM, J. M. . Geometrizing relativistic quantum mechanics.. Foundations of Physics, v. 40, p. 1885-1901, 2010.

In these two papers I have developed with my collaborators an old Gordon idea, according to which there would be a close relation between gravitational processes and the metric structure of space-time. However, in the traditional formulation of Quantum Mechanics and its support on the Copenhagen interpretation, this Gordon idea did not find any possibility to be implemented. So, using deBroglie and Bohm's formulation, we could associate quantum processes to changes in rulers and clocks of classical objects and understand these effects in a structure we call QWIST (Quantum Weyl Integrable Spacetime), meaning quantum effects would be but the outcome of change to a Riemannian structure, where scales of space and time length do not vary in their space-time configuration for a particular geometry of Weyl: that which enables a definition of variable space-time lengths.

This result was restrained to the treatment of a particle that satisfies the Schrodinger equation (non-relativistic case) or the Klein-Gordon equation (relativistic case). We shall address situations involving more than one particle in the near future.

7. Electromagnetic Geometry (ArXiv 1111.2631 November 2011)

M. Novello∨, F. T. Falciano, E. Goulart

We show that Maxwell's electromagnetism can be mapped into the Born-Infeld theory in a curved space-time, which depends only on the electromagnetic _eld in a speci_c way. This map is valid for any value of the two lorentz invariants F and G con_rming that we have included all possible solutions of Maxwell's equations. Our result seems to show that specifying the dynamics and the space-time structure of a given theory can be viewed merely as a choice of representation to describe the physical system.

8. **A proposal for the origin of the neutrino magnetic moment**
M. Novello and E. Bittencourt

We propose a new form of contribution for the anomalous magnetic moment of all particles. This common origin is displayed in the framework of the recent treatment of electrodynamics, called Dynamical Bridge Method, and its corresponding introduction of an electromagnetic metric which has no gravitational character. This electromagnetic metric constitutes a universal process perceived by all bodies, charged or not charged. As such it yields automatically a conclusive explanation for the existence of a magnetic moment for the neutrino.

9. **Marcela Campista ; SALIM, J. M. ; NOVELLO, M. . The spectrum of scalar fluctuations of a bouncing universe. International Journal of Modern Physics A, v. 25, p. 3095-3105, 2010.**

In this paper we proceed with our analysis referring to observable properties and characteristics of cosmological models with bouncing, that is, geometries that represent universes with a collapsing phase prior to the current expanding phase. The idea is to confront results from the evolution of the fluctuations in models with initial singularity and models without singularity, and particularly those with bouncing.

This paper will continue, involving other types of perturbations (vector, with vortices and gravitational waves, besides neutrinos).

10. ANTUNES, V. ; GOULART, E. ; NOVELLO, M. . Gravitational waves in singular and bouncing FLRW universes. Gravitation & Cosmology, v. 15, p. 191-198, 2009.

With a methodology that is totally different from number 9 above, we now look at observable distinctions that would be associated with the propagation of gravitational waves in cosmological models with initial singularity and models without singularity, and particularly those with bouncing. In this paper we examine the phase space of possible configurations as well as their associated topologies. We show that this topological exam can perfectly distinguish both scenarios through the evolution of gravitational waves.

11. NOVELLO, M. ; Aline N. Araujo ; SALIM, J. M. . Cyclic Magnetic Universe. International Journal of Modern Physics A, v. 24, p. 5639-5658, 2009.

Proceeding with our investigation of the consequences to Cosmology of non-linear processes of the electromagnetic field, we show how it is possible to generate cyclical models of the universe from averages over the fields (of the conventional type, as is done in the very application of Maxwell's linear theory on the basis of Tolman's proposal). We particularly exam cases where only the averages of magnetic field survive—cases where the primordial fluid is described as a plasma.

12. NOVELLO, M. ; BERGLIAFFA, S. E. P. . Bouncing Cosmologies. Physics Reports, v. 463, p. 127-213, 2008.

In this paper we make a thorough review of all proposed cosmological models without singularity and containing a bouncing. We examine both the classical processes of avoiding singularity and the modes that use effects of a quantum nature, be it of the matter or of the very gravitational field.
As we examine more than 500 papers, we casually discovered an interesting curiosity worthy of a note: the first complete analytical solution of a cosmological model with bouncing was made by two Brazilians, Mário Novello and José Martins Salim, in 1969.

13. NOVELLO, M e J. P. Gazeau. The question of mass in (anti-) de Sitter spacetimes. Journal of Physics. A v. 41, p. 304008, 2008.

14. Cosmological stability of Weyl conformal tensor.
E. Goulart, M. Novello, (Rio de Janeiro, CBPF) . 2008. 6pp.
Published in Grav.Cosmol.14:321-326,2008.

Related papers:

Cosmological effects of nonlinear electrodynamics.
M. Novello . 2005. 10pp.
Int.J.Mod.Phys.A20:2421-2430,2005.

Nonlinear electrodynamics and the Pioneer 10/11 spacecraft anomaly.
Jean Paul Mbelek (Saclay), Herman J. Mosquera Cuesta (Rio de Janeiro, CBPF & ICTP, Trieste), M. Novello, Jose M. Salim. Europhysics Letters v. 77 n. 1, 19001, 5 pp (January 2007)

A toy model of a fake inflation.
Mario Novello (Rio de Janeiro, CBPF) , E. Huguet, J. Queva (APC, Paris & Paris U., VI-VII) .
Apr 2006.
Published in **Phys.Rev.D73:123531,2006**.

Extended born-infeld dynamics and cosmology.
M. Novello (Rio de Janeiro, CBPF) , Martin Makler (Rio de Janeiro, CBPF & Rio de Janeiro Observ. & Rio de Janeiro Federal U.) , L.S. Werneck (Valongo Observ.) , C.A. Romero (Paraiba U.) . Jan 2005. 13pp. Publicado em **Phys.Rev.D71:043515,2005**.

Constructing Dirac linear fermions in terms of non-linear Heisenberg spinors.
M. Novello
Published in Europhysics Letters EPL, 80 (2007) 41001
(e-Print: arXiv:0705.2692 astro-ph)

A Spinor theory of gravity and the cosmological framework.
M. Novello
Published in JCAP 0706:018,2007.
(e-Print: gr-qc/0701120).

Cosmological Effects of Nonlinear Electrodynamics.
M. Novello, E. Goulart, J.M. Salim, S.E. Perez
Bergliaffa.
Published in Class.Quant.Grav.24:3021-3036,2007.
(e-Print: gr-qc/0610043)

The Nature of Lambda and the mass of the graviton: A Critical view.
JP Gazeau (Paris U. VII, APC) and M. Novello (Rio de Janeiro, CBPF).
(e-Print: gr-qc/0610054)

Ongoing Doctorate Advisor to:

- **Vicente Antunes**
- **Aline Nogueira Araújo**
- **Josephine Nogueira Rua**

- **Eduardo Bittencourt**

Organization of schools and international scientific events:

a) XIV Brazilian School of Cosmology and Gravitation (August 29 to September 11) held in Mangaratiba, RJ.

b) II Conferência de SOBRAL (The Sun, the stars, the universe and general relativity)

Books published (besides Conference Procceedings and the Brazilian School of Cosmology and Gravitation):

i) Eletrodinâmica não linear (causalidade e efeitos cosmológicos) in collaboration with Érico Goulart. Published in the CBPF collection by Editora Livraria da Física.

ii) **Cosmologia**. Published in the CBPF collection by Editora Livraria da Fisica.

iii**) Do big bang ao universo eterno**, a promotion book published by Editora Jorge Zahar.

iv) **Qualcosa anziché Il nulla (La rivoluzione del pensiero cosmológico)**. Translation into Italian of my epistemology book “O que é Cosmologia?” (Ed. Jorge Zahar)
published in 2011 by Editora Einaudi (Torino and Milan).

Publication of Conference Proceedings

1**) Cosmology and gravitation. Proceedings, 12th Brazilian School, BSCG 2006, Mangaratiba, Brazil, September 10-23, 2006.**
Mario Novello, (ed.), Santiago E. Perez Bergliaffa, (ed.)**, . 2007. 431pp.**
Prepared for 12th Brazilian School of Cosmology and Gravitation (XII BSCG), Rio de Janeiro, Brazil, 10-23 Sep 2006.
Published in AIP Conf. Proc. 910 (2007) 431 p

2) Mach or Higgs? The Mechanisms to generate mass.
M. Novello, (Rio de Janeiro, CBPF & ICRA, Pescara) . Aug 2010. 35pp.
Presented at 14th Brazilian School of Cosmology and Gravitation (BSCG 2010), Mangaratiba, Rio de Janeiro, Brazil, 30 Aug - 11 Sep 2010.
e-Print: arXiv:1008.2371 [physics.gen-ph]

3) Cosmology and gravitation. Proceedings, 13th Brazilian School, BSCG-2008, Mangaratiba, Brazil, July 20-August 2, 2008.
Mario Novello, (ed.), (Rio de Janeiro, CBPF) , Santiago E. Perez Bergliaffa, (ed.), (Rio de Janeiro State U.) . 2009. 442pp.
Published in AIP Conf. Proc. 1132 (2009) 442 p

4) Proceedings of the XIV Brazilian School of Cosmology and Gravitation.

5) Proceedings of the II Conferência de SOBRAL – The Sun, the stars, the universe and general relativity – (American Institute of Physics, New York, 2010).

6) A model for mass generation based on gravitation, M. Novello in the XIV LISHEP conference, July 6, 2011.

NOVELLO, M. ; Maria Borba . Reproducing gravity through spinor fields. Gravitation & Cosmology (Print), v. 17, p. 224-229, 2011.

The latter is a part of the “Lectures Notes” on STG that I prepared for a course in November 2010, invited by the organizing committee of the Marseille School of Cosmology, of the Centre de Physique Théorique.

A brief summary of the lines of research:

I. Effective Geometry (kinematic and dynamic aspects);
II. Cosmological Models with Bouncing (exact theory and perturbation);
III. Spinorial Theory of Gravitation (static solution and cosmologic solution);
IV. Gravitational Mechanism for the Generation of Mass;
V. Geometric interpretation of the quantum theory via Bohm-deBroglie formulation.

In the past decades, an overwhelming amount of astronomic information involving the detection of highly energetic particles, gravitational lenses and other astrophysics processes has changed the Astrophysics and Cosmology scenario in great depth. The Theory of General Relativity (TGR) constitutes the Modern Theory of Gravitation. However, many of its consequences have not been strictly observed (such as gravitational waves, for instance), and there are some critical situations where the TGR does not seem to apply and needs modifications or generalizations. These situations are i.) final stage of certain stellar evolutions, and ii.) primordial Cosmology (the issue of singularity and initial conditions of the Universe).

Along the 1970's, the problem of singularity has become the major issue in Cosmology. The hypothesis of such singularity, at a finite time of our epoch, the discomforting consequence that it is not possible for us to know the initial data of the universe! It limits the possibility of obtaining a complete cosmologic description, similar to what happens with black holes. Firstly, the existence of a primordial singularity was considered a definitive datum, thanks to the high status acquired by a series of theorems. The latter, demonstrated in the realm of General Relativity, seemed to show Classical Physics' impossibility to produce non-singular gravitational configurations. This was the main reason for more careful examinations of quantum aspects in Cosmology. However, along the 1980's, different approaches—conceived in areas such as Thermodynamics outside equilibrium or other approaches involving different forms of coupling fields of matter with gravitation—produced effective alternatives to solve this problem, as they generated non-singular cosmologic solutions. These results have originated a new and profound line of investigation on the properties of the Universe in its extremely condensed but non-singular phase.

Thanks to improved observation techniques, current data quality enables much more precise comparisons with theoretical predictions. The interaction between theory and observation has thus become much more intense in the past few years, particularly in Cosmology. For instance, by analyzing the distribution of matter and studying the spectrum of power of Cosmic Microwave Background Radiation, one may test theories that describe the primordial Universe and understand the evolution mechanisms of initial fluctuations. Thus, a model that predicts an eternal Universe rather than an initial singularity, for instance, produces a signature on the large scale structure that may be sought through current data. A central objective of this project is to study this interrelation between the dynamics of the structures of the Universe and the very structure of space-time, that is, of gravitation.

The theory of perturbation, which describes the fluctuations that originate the large scale structure and anisotropy in the cosmic background radiation, has been the object of intense investigation by our group. The non-linear evolution of the structures, a more advanced evolutionary stage of the fluctuations, is also being studied. Observable effects of the quantum nature of space-time are equally being derived, just as the relation between gravitational waves and neutrinos in the context of neutrino oscillations in the explosion of supernovas. I shall develop these lines in an integrated manner, focused on obtaining amounts that can be measured in space or in the laboratory.

Analog models of the general relativity

In 1998, CBPF's Gravitation and Cosmology Group (currently ICRA) started a systematic analysis of the propagation of photons in theories of non-linear electromagnetism (NLEM) and in the presence of media with dielectric properties dependent upon an external field. Most of this work was done in the area of analog models of gravitation. These models seek to replicate in laboratory gravitational configurations using non gravitational systems, such as Bose-Einstein's condensates, ordinary fluids without viscosity and with dielectric properties, and non-linear electromagnetism in vacuum (see, for instance, the proceedings from the *Workshop on Aritificial Black Holes*). Various important results have been obtained by our group in this area: closed timelike curves for the photons, electromagnetic wormholes, and analog black holes. The latter could be built in the laboratory to test some theoretical predictions. In particular, the electromagnetic black hole proposed by our group would emit laboratory detectable Hawking's radiation, which would allow us to confirm a crucially important result in Quantum Theory of Fields in curved space-time.
The effective metric appears in systems of varied nature, when the subjacent dynamics changes the structure of the geometry in such way that the geometry where the highest energy excitations of the field (whether photons, phonons,

etc) move is no longer that of the background. One such system is a non-linear electromagnetic field, originated by the effects of QED vacuum polarization.

Analog Black Holes – Photon propagation in material media

The propagation of electromagnetic waves through vacuum is a well determined phenomenon by Maxwell's set of equations, which are second order partial differential equations. However, special care is needed to characterize the propagation of those waves in non-trivial media, as when the electromagnetic field reaches its critical value or in material media. A complicated set of differential equations will have to be involved, in general and for every case to be studied. For the case of non-linear electrodynamics, Dittrich and Gies obtained the conditions over the cones of light for a class of theories with a non-trivial vacuum structure. Using a rule known as polarization sum, these authors obtained but the average speed of waves. Important aspects about wave propagation are not described, such as the effect of the optical birefringence, where a different wave speed will be associated to each polarization mode. Using a different procedure, members of our group obtained the conditions over the cones of light associated with the propagation of electromagnetic waves to non-linear theories without imposing any restriction upon the polarization modes. The same authors developed a geometric interpretation for the propagation of waves, showing that these waves travel over null geodesic in an effective geometric structure, determined on the basis of the conditions over the cones of light. The importance of this geometric formulation consists of the possibility to compare effects that occur with the propagation of light in non-trivial situations with kinematic aspects coming from the theory of general relativity. A most burning question about this issue is whether there are ways in which to obtain material structures that may exhibit a horizon of events, similar to what has been described by the Schwarzschild solution in Einstein's theory of gravitation.

In order to answer the questions above, the first investigation to take place involves determining the equations governing the propagation of electromagnetic waves in material media and the geometric description associated with this propagation. In this situation, Maxwell's traditional equations must be re-written, with the introduction of constitutive relations that relate the electromagnetic field (E, H) with the fields induced in the material medium (D, B). In general, constitutive relations may be presented in the tensor form, ensuring the possibility of studying even propagation in anisotropic media.

It is important to notice that, up until recently, only kinematic aspects of the General Relativity could be mimicked as such, without describing its dynamic properties.
The most relevant of the results obtained previously includes the possibility of producing a non-gravitational Black Hole (NGBH) in laboratory through non-linear electromagnetic processes.

Recently, my collaborator Erico Goulart and I managed to show, in **Beyond Analog Gravity: The Case of Exceptional Dynamics.** M. Novello, E. Goulart, (Rio de Janeiro, CBPF) . Feb 2011. 3pp. (Published in **Class.Quant.Grav.28:145022,2011**. e-Print: **arXiv:1102.1913** [gr-qc]), that it is possible to go beyond the mere kinematic characteristics which are typical of the analog models studied this far, including the very dynamics of the process. This was done for the case of a scalar field and our purpose on this line of research is to advance as much for the electromagnetic field, be it in non-linear field theories or in non-linear dielectric media.

Recent studies I have been developing with collaborators in my research group have shown the important role non-linear Electrodynamics may play in crucial Cosmology issues, involving moments in the history of the evolution of the Universe, referring to regimes of high and low curvature (very intense and very weak gravitational fields), that is, for an extremely condensed state of the universe and in the acceleration phase.

In a series of paper, we show that a strong magnetic field, in various theory examples of Non-Linear Electrodynamics (NLE), is capable of avoiding the primordial cosmologic singularity, which is present and inevitable in Maxwell's linear theory. It concerns the change of field behavior in extremely strong field regions.
An extensive analysis made with my collaborator SEP Bergliaffa, in a paper published in Physics Reports (**Bouncing Cosmologies.** M. Novello, S.E.Perez Bergliaffa, (**Phys.Rept.463:127-213,2008**. e-Print: **arXiv:0802.1634** [astro-ph]), we examine the different scenarios without singularity proposed in Cosmology. In this project, I will continue to address these as well as other related issues.

Synthesizing these lines of research:

i) **The Eternal Universe:** This is an attempt to answer the challenging question as to whether the universe had a singular start at a point of maximum condensation, as admitted in Cosmology's standard model, or whether it would have collapsed from a large volume down to a minimum value, different from zero, and then moved into an expansion phase.

ii) **Spinorial Theory of Gravitation:** The difficulties to reconcile observations of Supernovas with Friedmann's equations have led to a review of the fundamentals of the very Theory of Gravitation. One such possibility is being studied by our group and has been given strong support when professor M Novello visited the ICRA in Italy, both to the ICRANet headquarters in Pescara and to the La Sapienza University in Rome.

iii) **Dark Energy:** Observations made in 1998 with distant Supernovas suggests that the universe could be in a phase of accelerated expansion. Interpreted in accordance with the theory of relativity, these surprising results suggest that there must be negative pressures dominating the dynamic evolution of the universe. Besides bringing Einstein's cosmological constant to consideration, they create a series of burning questions that challenge Cosmology and Astrophysics. This line of research is intended on studying unconventional forms of high negative pressure energy in order to contribute to enhance knowledge about its nature, mechanisms and role in the evolution and structure of the universe.

iv) **Artificial Black Holes:** Under certain circumstances, it's been observed that non-universal processes such as the propagation of electromagnetic and sound waves as well as some particularities of liquid helium may be described as special consequences of geometry modifications associated with the medium where these phenomena occur. It is thus possible to produce configurations of a non-gravitational nature, such as special cases of gravitational fields. Called "Analog Models", this method allows us to mimic the behavior of gravitational fields in laboratory, including the creation of a Black Hole (electromagnetic?). This type of investigation may enable future testing of some gravitational black hole properties, including the theoretical possibility of radiation emission.

v) **Origin of galaxies and galaxy clusters**: The universe is organized in billions of galaxies; and each one, in hundreds of billions of stars. Galaxies, in their turn, are organized in clusters. These hugely immense structures originated from small deviations from the high homogeneity existing in the early moments and grew due to the attractive nature of gravitation. These minuscule deviations have admittedly resulted from quantum fluctuations of matter and the gravitational field. Recent observations enable a distinction between different competitive mechanism, capable of generating those primordial seeds of inhomogeneities. This line of research is based on the idea of producing a theoretical model capable of building a realistic scenario that is compatible with data from the observation.

I add here some selected articles that appeared this year:

1. http://arxiv.org/PS_cache/arxiv/pdf/1111/1111.2631v1.pdf
2. http://arxiv.org/PS_cache/arxiv/pdf/1111/1111.2347v1.pdf
3. http://arxiv.org/PS_cache/arxiv/pdf/1108/1108.6067v1.pdf
4. http://arxiv.org/PS_cache/arxiv/pdf/1102/1102.1913v2.pdf
5. **doi:10.1088/0264-9381/28/3/035003**