MATTERS OF GRAVITY

The newsletter of the Topical Group on Gravitation of the American Physical Society

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Editor

Jorge Pullin

Department of Physics and Astronomy
Louisiana State University
Baton Rouge, LA 70803-4001
Phone/Fax: (225)578-0464
Internet: `pullin@phys.lsu.edu`
WWW: `http://www.phys.lsu.edu/faculty/pullin`

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Editorial

Just wanted to mention that the Topical Group continues to grow. We now have 660 members, 10% more than last year (!) and we are now the third largest topical group. We are about half the size of the smallest divisions of APS.

I want to encourage the readership to suggest topics for articles in MOG. In the last few issues articles were solicited by myself. This is not good for keeping the newsletter balanced. Either contact the relevant correspondent or me directly.

The next newsletter is due February 1st. All issues are available in the WWW:
`http://www.phys.lsu.edu/mog`

The newsletter is available for Palm Pilots, Palm PC's and web-enabled cell phones as an Avantgo channel. Check out `http://www.avantgo.com` under technology→science.

A hardcopy of the newsletter is distributed free of charge to the members of the APS Topical Group on Gravitation upon request (the default distribution form is via the web) to the secretary of the Topical Group. It is considered a lack of etiquette to ask me to mail you hard copies of the newsletter unless you have exhausted all your resources to get your copy otherwise.

If you have comments/questions/complaints about the newsletter email me. Have fun.

Jorge Pullin

Correspondents of Matters of Gravity

- John Friedman and Kip Thorne: Relativistic Astrophysics,
- Raymond Laflamme: Quantum Cosmology and Related Topics
- Gary Horowitz: Interface with Mathematical High Energy Physics and String Theory
- Beverly Berger: News from NSF
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- Abhay Ashtekar and Ted Newman: Mathematical Relativity
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- Peter Bender: Space Experiments
- Riley Newman: Laboratory Experiments
- Warren Johnson: Resonant Mass Gravitational Wave Detectors
- Stan Whitcomb: LIGO Project
- Peter Saulson: former editor, correspondent at large.

Topical Group in Gravitation (GGR) Authorities

Chair: John Friedman; Chair-Elect: Jim Isenberg; Vice-Chair: Jorge Pullin; Secretary-Treasurer: Patrick Brady; Past Chair: Richard Price; Members at Large: Bernd Bruegmann, Don Marolf, Gary Horowitz, Eric Adelberger, Ted Jacobson, Jennie Traschen.

We hear that...

Jorge Pullin, Louisiana State University pullin@phys.lsu.edu

Matt Choptuik, Peter Saulson and Jeff Winicour were elected fellows of APS.

Eanna Flanagan was elected vice-chair of the Topical Group.

Sean Carroll and Bei-Lok Hu were elected to the executive committee of the Topical group.

Warren Johnson and Bill Hamilton were honored with the Francis Slack award of the Southeastern Section of APS.

Rodolfo Gambini was awarded the physics prize of the Third World Academy of Sciences (TWAS) in Trieste.

Jim Hough was honored with the Duddell Medal of the Institute of Physics (UK).

Hearty congratulations!

Too many coincidences?

Laura Mersini, Perimeter Institute lmersini@perimeterinstitute.ca

Recent developments in precision cosmology have presented theoretical physicists with a tantalizing picture of the universe. By a combination of all data, there is undisputable evidence that our universe is accelerating [1]. This means that about 70% of the energy density in the universe is made up by a mysterious component, coined dark energy, with an equation of state $-1.2 \leq w_X \leq -0.8$ at 68% confidence level [2].

Two fundamental questions arise in addressing the dark energy (DE) puzzle which make this problem notoriously difficult to answer: its magnitude $\rho_X \simeq 10^{-122} M_P^4$ is 122 orders less than the expected value M_P^4. This is known as the fine-tuning problem; DE domination time over matter energy density in driving the expansion of the universe occurs around redshifts $z \simeq 0$ when the present value of the Hubble radius is $H_0 \simeq 10^{-33} eV$. The latter is known as the coincidence problem of DE [3]

Cosmic microwave background (CMB) measurements have proven a powerful tool in confirming a concordance ΛCDM picture in cosmology, although we still lack an understanding of the origin and nature of DE and dark matter. Together these components make for about 95% of the energy density in the universe's budget.

The $WMAP$ balloon born experiment confirmed the CMB picture of concordance cosmology as previously measured by $COBE$. One of the more surprising findings of $WMAP$ was the suppression of power at large angles, (low multipoles l), of temperature correlations C_l^{TT} in the CMB anisotropy spectrum [4]. These findings can not be considered as conclusive evidence because of the limitations set by cosmic variance. However they are intriguing enough to motivate further effort in circumventing cosmic variance. This can be achieved by means of complimentary data like cosmic shear from weak lensing [5] and cross-correlations with the polarization spectra [6]. Analysis along these lines is lending support to $WMAP$ findings that indeed power is suppressed at low multipoles l. The suppressed modes correspond to perturbation wavelengths of the order of our present Hubble horizon $\lambda \simeq H_0^{-1} \simeq 10^4 Mpc, k \simeq H_0 \simeq 10^{-33} eV$. Contrary to theoretical expectations based on the inflationary paradigm, not only do we have to explain the reason why these modes are suppressed but we also have to address why the suppression occurs at the DE scale, $H_0 \simeq 10^{-33} eV$. Power suppression at horizon sized wavelengths thus introduces a *second cosmic coincidence* to theoretical cosmology. Recall that in an inflationary universe perturbations produced near the end of inflation leave the horizon whenever their wavelength becomes larger than the inflationary horizon H_i due to 'super-luminal' propagation. These modes re-enter the horizon at later times when the Hubble parameter once again becomes equal to their wavelength. This is known as the horizon crossing condition $k = a(t)H(t)$. Thus the largest wavelengths are the first ones to leave the horizon and the last ones to re-enter. Modes currently re-entering $k_0 = a_0 H_0$ have wavelengths horizon size,which means they have been outside of the Hubble horizon for most of the history of the universe. Thus they have not been contaminated by the internal evolution and nonlinearities of the cosmic fluid inside the Hubble radius. These modes carry the pristine information of the unknown physics which sets the Initial Conditions of the universe [7].

Although these cosmic coincidences associated with the two currently observed phenomena namely, DE domination and CMB power suppression at horizon sized wavelengths, are dominantly displayed at low energies, for the reasons mentioned above it is reasonable to expect that they may originate from processes occurring in the very early universe.

This is a strange world. A vacuum energy component should enhance power of long wavelengths due to the integrated Sachs Wolf effect (ISW). Hence we can not dismiss that the observational data seems to point us to the existence of two cosmic coincidences at the present Hubble radius. The bizarre picture of the universe emerging from observational findings for these 'seemingly unrelated' cosmic coincidences occurring at the same energy scale, may likely provide clues of new physics.

String theory and quantum gravity are possible candidates of the unknown physics of the early universe. There are current models in literature that offer an explanation for the CMB power suppression, by having the Initial Conditions set within the framework of string theory [7,8] loop quantum gravity [9] or an unknown hard cutoff [10]. There is also an ongoing search for a possible UV/IR mixing of gravitational scales [11]. However a theoretical model that would successfully accommodate all observed cosmic coincidences around the scale $H_0 \simeq 10^{-33}eV$ is yet to be found.

Perhaps, as the data is suggesting, there is something special about our present Hubble scale. It might be a fundamental scale of very low energy physics. Or perhaps a new scale of low energies derived from a fundamental scale of high energy physics through a possible UV/IR. This radical possibility is not yet realized in a concrete model.

At the moment, our theoretical knowledge of the relation between beauty and a strange world still lies in the realm of speculations while pushing forward the discovery of new physics.

References:

[1] Knop, R.A.et al.(2003), astro-ph/0309368; Spergel, D.N. et al.(2003), ApJS148, 175; Verde, L. et al., MNRAS335, 432.
[2] Melchiorri, A., Mersini, L., Odman, C., Trodden, M. (2003), Phys.Rev.D68,43509, astro-ph/0211522.
[3] Carroll, M.S., astro-ph/0310342, (2003), and references therein.
[4] Bennett,et al., astro-ph/0302207 Astrophys.J.Suppl. 148 (2003); Hinshaw, et al., astro-ph/0302217, Astrophys.J.Suppl. 148 (2003); Tegmark et al, astro-ph/0302496; Melchiorri, A., hep-ph/0311319, (2003).
[5] Kesden, M., Kamionkowski, M., Cooray, A., astro-ph/0306597, (2003).
[6] Dore, O., Holder, G.P., Loeb, A., astro-ph/0309281, (2003).
[7] Bastero-Gil,M., Freese, K., Mersini-Houghton,L., hep-ph/0306289, (2003), and references therein.
[8] Dvali, G., Kachru, S., hep-th/0309095, (2003).
[9] Tsujikawa,S., Singh, P., Maartens, R., astro-ph/0311015, (2003).
[10] Contaldi, C.R., Peloso, M., Kofman, L., Linde, A., JCAP 0307:002,(2003), astro-ph/0303636.
[11] Banks, T., Fischler, W., astro-ph/0307459 and references therein; also see Banks, T., hep-th/0310288, (2003).

The Quest for a Realistic Cosmology in the Landscape of String Theory

Andrew Chamblin, University of Louisville chamblin@prancer.physics.louisville.edu

Recent astronomical observations [1,2,3,4] would appear to indicate that the universe is accelerating. Assuming that these observations have been correctly interpreted, then it is clear that physicists today are faced with a number of mysteries which to date have defied any elegant and straightforward explanation. First of all, there is the obvious question: What is the nature of this mysterious 'dark energy' which is driving the expansion? Evidently this vacuum energy is exactly isotropic and homogeneous at the present time - but what is it? In addition to this question, there is the legendary 'cosmological constant problem': Whatever this dark energy is, why is it so incredibly small? Observationally, the dark energy density is 120 orders of magnitude smaller than the energy density associated with the Planck scale - the obvious cut off. Furthermore, the standard model of cosmology posits that very early on the universe experienced a period of inflation: A brief period of very rapid acceleration, during which the Hubble constant was about 52 orders of magnitude larger than the value observed today. How could the cosmological constant have been so large then, and so small now? Finally, there is the 'coincidence problem': Why is the energy density of matter nearly equal to the dark energy density today? Considering all of these problems at once can be a humbling experience: It is clear that we are presently unable to explain several of the most basic experimental facts about this universe.

String theory is much vaunted as a fully consistent quantum theory of gravity. If this is the case, then we would expect string theory to tell us *something* about the acceleration of the universe. Ideally, string theory would provide clear mechanisms which resolve all of the above mentioned problems.

Remarkably, it is very difficult to get accelerating solutions directly through standard compactification techniques of the low-energy limit of string theory. More precisely, the different string theories are related to each other through dualities, special symmetries which ultimately involve the mysterious quantum M-theory in eleven dimensions. All of these theories have as a low- energy limit some supergravity theory: A *classical* theory consisting of gravity coupled to other fields. These theories should be thought of as special limits of some underlying, quantum M-theory. We do not know what the entire moduli space of this theory looks like, but we know what it looks like at these special limit points. A major triumph for string theory would be to show precisely 'where' in the M-theory moduli space there exist solutions which actually look like our universe. For example, it would be nice if we could recover a realistic M-theory cosmology beginning with one of the supergravity theories. However, there is a 'no-go theorem', due to Gibbons [5], Maldacena and Nuñez [6], and also de Wit, Dass and Smit [7], which basically asserts that if you compactify any string-derived supergravity on a smooth compact internal space, then you will never get de Sitter space. Since the universe is evidently both past and future de Sitter (albeit with vastly differing vacuum energies), this would seem to be a problem.

However, there are various ways around this particular no-go result. The theorem assumes time independence of the internal space, and so one may search for time-dependent solutions.

Following this intuition, Townsend, Wohlfarth and others [8,9,10] have constructed a variety of time-dependent compactifications which describe a period of acceleration. The basic idea is simple: The internal space is described by certain scalar fields known as 'moduli'. These moduli describe the size, shape and other basic properties of the internal space. These moduli typically have exponential potentials, with the property that as you flow to the minimum of the potential the universe decompactifies (i.e., for a given scalar field ϕ, $V(\phi) \sim e^{-\phi}$). One can now imagine 'bouncing' the universe off of this potential: The universe comes in from a period of being decompactified, and rolls up the exponential potential during the process of compactification. At some point there will have to be a 'turnaround' point, where the universe stops compactifying and reenters a decompactification stage. At the turnaround, there is little kinetic energy for the moduli, and so all of the energy is dominated by the potential term, which can then act as a cosmological constant. Problems with this approach include the fact that it is difficult to get a very long period of inflation, unless one uses many moduli [11]. Furthermore, if the size of the extra dimensions vary, then there will be variations in Newton's constant and the fine structure constant. Strong experimental bounds on such variation place tight constraints on these models.

Another way to get around the no-go result involves beginning with rather exotic supergravities which may not necessarily have anything to do with string or M-theory. For example, Hull has championed the viewpoint that we may wish to consider supergravity theories with extra dimensions of time [12]. These supergravity actions come from perfectly well-defined superalgebras, and compactification of these theories can give de Sitter spacetime in any dimension. One drawback is that these theories typically contain *ghosts*: Gauge fields which have the wrong sign for the kinetic term. Furthermore there are the usual problems with causality: If you have two or more dimensions of time, then there exist closed timelike curves through every point. While the extra dimensions of time can be eliminated by applying certain duality transformations which yield another theory, one is often still left with ghosts.

One may also choose to 'compactify' a string-derived supergravity on a *non-compact* space [13]. This gets around the no-go result because the internal space is non-compact. This may sound counterintuitive, but actually it is a well-defined procedure known as 'consistent truncation'. To perform a consistent truncation, one writes the full higher-dimensional space as a product (or in general warped product) of the non-compact directions and some space X. One then constructs a theory on X, with the property that any solution of that theory corresponds to a solution of the theory in the higher dimensions, and vice-versa. In this way one can obtain solutions where X is isometric to de Sitter. One obvious problem with this approach is that it is not clear how one should interpret the large extra dimension.

A related but differing approach involves using the scale invariance of eleven-dimensional supergravity, which is the low-energy limit of M-theory. The equations of motion of eleven-dimensional supergravity admit a scale invariance, whereby rescaling the field content in a certain way simply rescales the action by an overall power of the scale parameter. Instead of compactifying the theory on a circle using 'conventional' Kaluza-Klein boundary conditions (where the fields are periodic), one can use the scale symmetry to allow fields to be rescaled around the circle. Upon reduction to ten dimensions one obtains a new massive supergravity theory, which has the property that de Sitter space is the ground state. Intuitively, the apparent expansion of the universe is really an effect generated by the rescaling of the metric. This theory was first introduced by Howe, Lambert and West [14] and was obtained through consistent truncation by others [15]. It was further studied by this author and Lambert [16,17] where we dubbed the theory 'MM-theory', for modified or massive M-theory. The main problem with MM-theory is that the scale invariance is an anomalous symmetry: Higher derivative corrections to the supergravity Lagrangian manifestly break the symmetry. Since the theory is anomalous in the ultraviolet, the only way it can make sense is if scale invariance is realized deep in the infrared. In this picture were correct, then the cosmological constant itself would be an infrared effect.

Ultimately, all of these classical approaches to cosmology seem a bit contrived: In order to get around the no-go theorem, one is forced to make rather unusual or unnatural assumptions. But of course, all of these expeditions are only probing the *classical* borders of the full landscape of string theory. The world is not classical: There is an underlying quantum reality, and we need to better understand the classical to quantum phase transition within the context of cosmology. Could it be that if we simply venture into the quantum wilderness of the string theory landscape, we will find a realistic cosmology?

In fact, it is the case that quantum effects seem to lead in the right direction. In a recent paper, by Kachru, Kallosh, Linde and Trivedi (KKLT) [18] it was shown that if you carefully consider certain instanton corrections, you can construct solutions of string theory which exhibit a small, positive cosmological constant. Their example is an example of a 'flux compactification' - crudely, a compactification in which certain fluxes are turned on. Typically, certain branes are the 'sources' for a given flux. For example, just as the electron is the source for F_{ab} (a two-form), so a membrane can act as the 'electric' source for a four-form flux. In four dimensions, the equations of motion for a four-form will tell you that the form is locally just covariantly constant: The term $(F_4)^2$ in the action will thus 'look' like a cosmological constant. Membranes in such scenarios are thus surfaces across which the effective cosmological constant can jump. Neutralization of the cosmological constant through membrane nucleation was first studied by Brown and Teitelboim [19], and has been further explored in the context of string theory by others [20,21].

In the KKLT construction, the authors begin by compactifying six dimensions of space on a Calabi-Yau manifold - a complex manifold which has a special holonomy that leaves minimal supersymmetry ($N = 1$) in the effective four-dimensional theory obtained through the compactification. Certain background fluxes are turned on throughout the construction, and in the effective four-dimensional theory the spacetime is initially anti-de Sitter (adS). A Calabi-Yau manifold has certain moduli associated with the fact that it admits a complex structure, and these moduli need to be fixed. KKLT show that this is possible by arguing that quantum effects modify the superpotential [22] in such a way that they are able to explicitly demonstrate the existence of supersymmetric adS vacua with fixed complex and Kahler moduli.

Finally, and crucially, KKLT add in certain branes, known as ('anti') D3-branes. These branes have the effect of 'lifting' the stable (and supersymmetric) adS vacuum to a *de Sitter* (dS) vacuum. By fine tuning various things, the authors are able to argue that the resulting dS vacuum can even have a very small cosmological constant [1]. Furthermore, the inclusion of the three-branes breaks supersymmetry, and so it would seem that supersymmetry breaking and

[1]It is worth pointing out that there has been some non-trivial criticism of this construction. Put crudely, the construction is entirely at the level of effective field theory, and it is unclear that it really can be embedded into a full 'stringy' setup. Since this is a technical point beyond the scope of this review, I will have nothing more to say about it here.

a positive cosmological constant always go ‘hand-in-hand’ in these constructions. Finally, the de Sitter vacua are always metastable in these models, i.e., they are false vacua and therefore have some lifetime. In particular, KKLT argue that these vacua are resonances which can decay faster than the timescale for the Poincare recurrences which have bothered some people [23].

Now, the KKLT model is but a very special case of a huge class of more general compactifications. One can imagine solutions where only four dimensions are compactified, or indeed where none of the dimensions are compactified and the universe exhibits the full eleven dimensions of M-theory. One could imagine that other fluxes are turned on, or that no fluxes are turned on. If we think of the string theory landscape as a huge potential or functional which varies depending on all of the different possible moduli, then it is clear that the quantum wilderness of string theory is a vast, higher dimensional cornucopia of moutaintops, valleys and precipices. The moduli space of supersymmetric vacua is rather like a vast plain extending up to the mountains - one may move continuously between different vacua by varying certain moduli. Accelerating cosmologies correspond to isolated valleys which sit up between the mountain peaks and passes (i.e., one might imagine equating the magnitude of the dark energy with the altitude of the valley). For whatever reason, we live in a universe where four spacetime dimensions are compactified, and our ‘altitude’ is just *barely* above sea level.

Of course, when one starts to think of the universe in these terms, it can have a profound impact on one’s expectations and outlook. It starts to look like many things - the masses of the elementary particles, the values of the couplings, the value of the cosmological constant - are probably just accidents, random numbers that will never be calculated from first principles using string theory. But it is a short journey from this philosophy to that house of ill-repute known as the Anthropic Principle [2]. For this reason, various people have begun to ‘count’ [24] all of the different discrete valleys in the string theory landscape. After all, it may be that many of the vacua look somewhat like our universe - and even if only about 1% look like home, we will have still learned something about our world.

In summary, cosmology is now a science based on high precision measurements which are yielding very detailed information about the large-scale structure of the universe. For some time it was unclear that string theory could consistently explain the observed acceleration of the universe. This situation has now been rectified, and there is now a realization that there are likely many metastable, de Sitter like vacua in string theory. These are just the first tentative steps towards a fully realistic string cosmology, and the years ahead will no doubt bring even more twists, turns and surprises.

I thank N. Lambert and H. Reall for discussions, and the Kavli Institute for Theoretical Physics for hospitality while this work was completed.

[1] A.G. Riess *et al*, Astron. J. 116 (1998) 1009-1038; astro-ph/9805201.

[2] S. Perlmutter *et al*, Astrophys. J. 517 (1999) 565-586; astro-ph/9812133.

[3] D. Spergel *et al*, Astrophys. J.Suppl. 148 (2003) 175; astro-ph/0302209.

[4] L. Verde *et al*, Mon. Not. Roy. Astron. Soc. 335 (2002) 432; astro-ph/0112161.

[2] To quote Lenny Susskind: ‘We live where we can live.’, (New York Times, Sept. 2, 2003)

[5] G. Gibbons, in GIFT Seminar on supersymmetry, supergravity and related topics, edited by F. del Aguila, J. de Ascarraga and L. Ibanez, World Scientific (1984).

[6] Juan Maldacena and Carlos Nuñez, Int. J. Mod. Phys. A16 (2001) 822-855; hep-th/0007018.

[7] B. de Wit, D. J. Smit and N. D. Hari Dass, Nucl. Phys. B **283**, 165 (1987).

[8] P. Townsend and M. Wohlfarth, Phys. Rev. Lett. 91 (2003) 061302;

hep-th/0303097. M. Wohlfarth, hep-th/0307179.

[9] F. Darabi, Class. Quant. Grav. 20 (2003) 3385-3402; gr-qc/0301075.

[10] R. Emparan and J. Garriga, JHEP 0305 (2003) 028; hep-th/0304124.

[11] Chiang-Mei Chen, Pei-Ming Ho, Ishwaree P. Neupane, John E. Wang, JHEP 0307 (2003) 017; hep-th/0304177.

[12] C.M. Hull, JHEP 9807 (1998) 021; hep-th/9806146.

[13] G.W. Gibbons and C.M. Hull, hep-th/0111072.

[14] P.S. Howe, N.D. Lambert and P.C. West, Phys. Lett. B416 (1998) 303-308; hep-th/9707139.

[15] I.V. Lavrinenko, H. Lu and C.N. Pope, Class. Quant. Grav. 15 (1998) 2239-2256; hep-th/9710243.

[16] A. Chamblin and N. Lambert, Phys. Lett. B508 (2001) 369-374; hep-th/0102159.

[17] A. Chamblin and N. Lambert, Phys. Rev. D65 (2002) 066002; hep-th/0107031.

[18] Shamit Kachru, Renata Kallosh, Andrei Linde and Sandip P. Trivedi, Phys. Rev. D68 (2003) 046005; hep-th/0301240.

[19] J.C. Brown and C. Teitelboim, Nucl. Phys. B297: 787-836, 1988.

[20] Raphael Bousso and Joseph Polchinski, JHEP 0006 (2000) 006; hep-th/0004134.

[21] Jonathan L. Feng, John March-Russell, Savdeep Sethi and Frank Wilczek, Nucl. Phys. B602 (2001) 307-328; hep-th/0005276.

[22] S. Gukov, C. Vafa and E. Witten, Nucl. Phys. B584 (2000) 69-108; Erratum-ibid. B608 (2001) 477-478; hep-th/9906070.

[23] L. Susskind, hep-th/0302219.

[24] M.R. Douglas, JHEP 0305 (2003) 046; hep-th/0303194.

SFB/TR 7: Gravitational Wave Astronomy

A. Gopakumar & D. Petroff, SFB/TR 7, gopu,petroff@tpi.uni-jena.de

The first meeting of researchers participating in a new German initiative on gravitational wave astronomy took place in Tübingen from October 9–10, 2003. The ambitious project entitled 'Gravitational Wave Astronomy' and referred to as SFB/TR 7 (Sonderforschungsbereich/Transregio 7) is being funded by the DFG (Deutsche Forschungsgemeinschaft), for an initial period of four years (2003–2006) and with the possibility of extensions for up to twelve years. SFB/TR 7 brings together more than 50 scientists as well as numerous Diploma and Ph.D. students from five German academic institutions, to tackle various issues related to the realization of gravitational wave astronomy in the near future. Opening a new window to the universe by observing gravitational waves requires close interaction between experimentalists and theoreticians working on various aspects of gravitational radiation. It is highly desirable that experimentalists involved in the design and construction of gravitational wave detectors associate closely with theoreticians providing detailed information about the nature and abundancy of expected sources and their signals, as well as with those who analyse the raw detector data and develop new analysis strategies. It is to achieve the above objectives that the DFG is supporting experimental and theoretical physicists, astrophysicists and mathematicians from Universities in Hanover, Jena and Tübingen as well as Max-Planck Institutes for Astrophysics in Garching and Gravitational Physics in Golm.

Prof. G. Neugebauer (Jena) is the speaker of SFB/TR 7 and the executive board is also comprised of Profs. K. Danzmann (Hanover), W. Kley (Tübingen), E. Müller (Garching), G. Schäfer (Jena) and B. Schutz (Golm). The project is subdivided into three sections dealing with the analysis of the gravitational field equations, the structure and dynamics of compact objects and the detection of gravitational waves. Each of these sections consists of several working groups, which tackle specific issues relevant to the parent section as well as to gravitational wave astronomy in a broader sense.

During the meeting, each working group presented a brief status report of its work. Junior scientists were encouraged to assume the responsibility of preparing and delivering the talks, which helped to lend the conference a relaxed and open atmosphere. The three working groups analysing the structure of the field equations relevant to numerical simulations were the first to present their projects. This portion of the meeting was made up of the six talks listed below: • Vacuum Initial Data with Trapped Surfaces • A Program for the Numerical Treatment of Radiating Systems • Gravitational Radiation from Distorted Black Holes • Initial Data for the Conformal Einstein Equations • A Skeleton Solution of the Einstein Field Equations and • A Minimal No-Radiation Approximation to the Einstein Field Equations.

The second, and largest section in SFB/TR 7, is made up of six working groups, which presented ten talks related to their respective research interests. These can be broadly classified, according to the underlying astrophysical scenarios, into four categories. The first deals with the structure of solitary compact objects, the second with their dynamics and the third with the collapse of relativistic objects. The fourth category focuses on binary dynamics within the post-Newtonian and numerical relativity frameworks. The titles of these talks (in the order presented at the workshop) are • An Updated Version of a Computer Program for the Calculation of Rotating Neutron Stars and Specific Applications • Oscillation Modes of Rotating Neutron Stars • New Methods for Gravitational Collapse to Neutron Stars and Black Holes • Gravitational Collapse of Rotating Neutron Stars • Cylindrical Collapse • Binary Dynamics of Spinning Compact Objects • Gravitational Waves from Binary Systems with Oscillating Dust Discs as Components • Evolutions in 3D Numerical Relativity using Fixed Mesh Refinement • Binary Black Hole Evolutions from Innermost Quasi-Circular Orbits and • Merging Neutron Star Binaries – Results and Future Plans.

On the second day, the experimentalists and data analysts making up the third section of our SFB, briefed the participants on their research progress. The experimentalists gave talks on both currently implemented technologies, e.g. in GEO600, and on possible future methodologies with the titles • High Resolution Interferometer Concepts Based on Reflective Optical Components, • Low Loss Gratings for Gravitational Interferometry, Design Considerations and Fabrication and • Cryogenic Q-factor Measurement of Optical Substrates. The session on data analysis consisted of a detailed review and a discussion session on the iterative design of the sensitivity curve for future gravitational wave detectors.

Those interested in learning more about SFB/TR 7 are referred to the website

http://www.tpi.uni-jena.de/˜sfb/index.html.

The mock LISA data archive

John Baker, Goddard jbaker@milkyway.gsfc.nasa.gov

The LISA gravitational wave observatory is expected to observe a broad variety of astrophysical phenomena, and may discern detailed characteristics of thousands of individual astronomical systems. But realizing these goals will require careful resolution of a variety of data analysis challenges. The Mock LISA Data Archive (MLDA), hosted at the AstroGravS website (http://astrogravs.nasa.gov) is a resource for researchers interested in developing algorithms for analyzing LISA data. Our goal is to facilitate collaboration and to encourage additional researchers to become involved in the LISA data analysis community.

The archive contains simulated LISA output data representing the instrument's response to several classes of gravitational wave sources. State-of-the-art model waveforms from these sources have been run through a simulation of LISA's response. The MLDA currently contains four source classes: Supermassive Black Hole Binaries; Extreme Mass Ratio Captures; Galactic Binaries; and realizations of the Galactic Background. The present simulations of LISA's response have been produced with the publicly available LISA Simulator (http://www.physics.montana.edu/lisa/). New source data and more advanced response simulations will be added as they become available. Contributions to the MLDA are most welcome.

The MLDA provides for the development of techniques to tackle each source class individually, or the signals can be combined to produce a more realistic test of a data analysis procedure. A fixed signal stream can be combined with multiple noise realizations, which is useful for Monte-Carlo studies of algorithm performance.

One of the goals of the MLDA is to provide a common ground for comparing different approaches to LISA data analysis. Each simulated data stream comes with reference files containing a description of the sources that have been modeled. Thus, the MLDA can serve as a training ground for the LISA data analysis community.

At some time in the future, prior to the launch of the LISA observatory, the MLDA hopes to host a Mock LISA Data Challenge to see which algorithms perform best in a blind test using realistic multi-source Mock Data sets.

The MLDA is designed to be a community resource, with input from the entire LISA community. We invite interested researchers to become involved in LISA data analysis, to utilize the archive, and to participate in its further development. Please let us know what you think, and how you would like to be involved.

MLDA Steering Committee:

Neil Cornish, Convener, Montana State University, John Baker, GSFC, Matt Benacquista, Montana State University–Billings, Joan Centrella, GSFC, Scott Hughes, MIT, Shane Larson, Caltech.

Second Gravitational Wave Phenomenology Workshop

Neil Cornish, Montana State University cornish@physics.montana.edu

It is likely that Sam Finn had to twist some arms to get a good turnout of astrophysicists at the First Gravitational Wave Phenomenology Workshop in November 2001, but two years later, with the scent of data in the air, he would have had a hard time keeping them out of the second workshop, which took place at Penn State on November 6-8, 2003.

The goal of the workshop was to foster dialog between observers, astrophysical source modelers, and data analysts, on the question of how gravitational wave observations could be used to "inform our understanding of the cosmos" (to quote the workshop website, http://cgwp.gravity.psu.edu/events/GWPW03/). The workshop was designed to be discussion heavy, with short talks providing the starting point for longer discussions.

The meeting began with an update on the three types of gravitational wave detectors currently in operation, and the implications that these observations have on astrophysical models. Stan Whitcomb described the various ground based Laser Interferometers; Giovanni Prodi talked about Acoustic (Bar) Detectors; and Andrea Lommen discussed Pulsar Timing Arrays. A common theme was that even null detections can be used to place bounds on astrophysical processes, and while the current upper limits are not that strong in most cases, we are already doing gravitational wave astronomy. Andrea gave one example where Pulsar Timing had been able to rule out the suggestion that the Radio Galaxy 3C66B harbors a supermassive black hole binary of $5.4 \times 10^{10}\, M_{\odot}$. Another common theme in the detector session was optimism for the future. Stan boldly predicted that LIGO and VIRGO would reach their design sensitivities in 2004, Giovanni saw a bright future for dual resonant bars, and Andrea foresaw Pulsar Timing Arrays being able to detect the gravitational wave background produced by supermassive black hole binaries. The impact of the observations on our understanding of Neutron Star Physics, Stellar Populations and Burst Sources was then addressed by Ben Owen, Vicky Kalogera and Andrew MacFadyen. Ben outlined how targeted searches for periodic signals from know Pulsars could be used to constrain the material properties of a Neutron Star's crust. Vicky emphasized that large uncertainties in the theoretical models mean that any observational input - upper bounds or a few direct detections - would strongly constrain certain stellar population models. As an illustration of this point, Vicky showed how the recent discovery of a third binary pulsar in our galaxy has lead to a six-fold increase in the predicted Neutron Star Inspiral event rate for LIGO. In the same vein, Andrew explained how uncertainties in the modeling of Gamma Ray bursts would be reduced by co-ordinated gravitational and electromagnetic observations, even if no gravitational wave counterparts were found.

The second day of the workshop was devoted to gravitational wave source astrophysics and source modeling. Brad Hansen reviewed the evidence for Intermediate Mass Black Holes (IMBH) and brought up the interesting possibility that an IMBH might be responsible for dragging the observed population of young, massive stars into the lair of the supermassive black hole at the galactic center. Christian Cardall and Adam Burrows described supernova modeling and what the gravitational wave signatures might look like. They had good news for gravitational wave astronomers - supernova simulations fizzle unless there is asymmetry. Adam showed some possible waveforms with very interesting ringing structure. Milos

Milosavljevic took on the “last parsec problem” and concluded that it probably wasn’t much of a problem - a range of physical mechanisms could succeed in getting black hole binaries close enough to evolve under radiation reaction. Leor Barak brought us up to date on the impressive progress that has been made in solving the self-force problem, and how the new calculation schemes were being used to model extreme mass ratio inspiral. Deirdre Shoemaker and Masaru Shibata led the discussion on numerical relativity, and its application in the areas of black hole and neutron star binary evolution. Both conceded that significant problems remained to be solved, especially when black holes enter the picture, but they also showed how partial results were better than no results. Shibata drew an analogy between numerical relativity and the operation of the laser interferometers. The system is up and running, and while the performance is below the design goals, they are collecting data and learning as they go.

The final day had us looking to the future, and the promise of advanced detectors. Sam Finn discussed second generation ground based laser interferometers, and emphasized how astrophysical considerations will play a role in making design choices. Eugenio Coccia described how future acoustic detectors, with their improved sensitivities and wider bandpasses, can provide coverage of the very high frequency portion of the spectrum. The final speaker, Neil Cornish, got a little carried away with the “advanced detector” theme, and after a brief description of the Laser Interferometer Space Antenna (LISA) and its potential impact, he went on to describe two post-LISA missions. These follow-on missions use multiple detectors for improved angular resolution, and in the case of the Big Bang Observatory, co-aligned interferometers for detecting the Cosmic Gravitational Wave Background.

A proper account of the workshop would report on the discussions that followed the talks, as these discussions involved all the workshop participants, and took us well beyond the formal presentations. But lacking extensive notes, I’ll have to skip the best part and simply encourage people to attend the third meeting in the series.

“Apples with Apples II”: Second Workshop on Formulations of Einstein’s Equations for Numerical Relativity

Miguel Alcubierre, UNAM, Mexico malcubi@nuclecu.unam.mx

Last December 1-11 saw the second “Apples with Apples” workshop on formulations of the Einstein equations for numerical relativity. As in the case of the first workshop, the venue was the Institute of Nuclear Sciences (ICN) of the National University of Mexico (UNAM), in Mexico city. This second workshop was attended by some 40 people from Mexico, the U.S., Europe and Japan, that is, considerably more than the 25 who attended the first workshop. The workshops are getting more popular!

As before, the purpose of the workshop was to gather a group of experts in the recent developments of the different formulations of the Einstein equations and their applications to numerical relativity. In particular, these workshops have as their main focus both the sharing of ideas as well as the direct comparison of the results of actual numerical simulations, in the hope of learning what makes one formulation better suited for numerical work than others. The workshops have a very open and relaxed format, extended over a two week period, to allow time for informal discussions and work sessions (and I mean really work sitting in front of the laptop). Of course, eating mexican food and drinking tequila are also a part of it, as our boat trip in the canals of Xochimilco can show.

There where over 25 talks this time, and it would take too much space to mention them all here (but have a look at the web page http://www.appleswithapples.org, where most of the talks can be found as PS or PDF files). In my own personal opinion, the highlights included Jeff Winicour’s introductory talk describing the aims of the Apples with Apples meetings, Denis Pollney’s talk on test-suites for numerical relativity, Carsten Gundlach’s talk on well posed BSSN, Scott Hawleys’ talk on constrained evolution, Hisaaki Shinkai and Gen Yoneda’s talk on constraint propagation analysis, and Manuel Tiglio’s talk on dynamical control of constraint violation. Of special interest where a series of talks on well posed boundary condition, from Jeff Winicour and Bela Szilagyi’s work with the Abigel code, to Mihaela Chirvasa’s talk on absorbing boundary conditions, and of course Olivier Sarbach’s talk on constraint preserving boundary conditions. Results from the conformal field equation approach were also presented by Sascha Husa and Christiane Lechner. A particular highlight was the participation of Nina Jansen and her passionate discussion of tests performed on different systems following the paper coming out of the first Apples with Apples meeting (gr-qc/0305023). Nina’s participation helped us focus on which of those tests are really useful, and what direction should be taken to suggest new tests. At the end of the meeting, an agreement was reached for the several groups represented to test their codes following the test-suite suggested in gr-qc/0305023.

If anything, the meeting helped us realize that the numerical community is finally addressing the issues of well posedness of evolution systems, gauge conditions, and boundary conditions head on. Mysteries remain as to why some well posed formulations perform well numerically and other do not, but significant progress has certainly been made.

And now, to the future. Oscar Reula has graciously offered to host “Apples with Apples III” in Cordoba, Argentina. Final dates are still not clear, but the meeting will probably take place in late 2004 or early 2005. Winter in the U.S. and Europe, but summer down below the equator. See you in Argentina!

3 Conferences for 30 years of Gravity at UNAM

Alejandro Corichi, National University of Mexico (UNAM) corichi@nuclecu.unam.mx

The Department of Gravitation and Field Theory of the Institute for Nuclear Sciences at the National University in México (ICN-UNAM), as part of the celebrations commemorating its 30 years of existence, was host to three conferences the first week of February. The first one was a 3-day discussion workshop on Loop Quantum Gravity (LQG) with participants coming from Canada, the USA and México. The second event was a one-day celebration for Mike Ryan's 60th birthday, and finally a two-day celebration for Professor Marcos Rosenbaum, for his contributions to the Institute and the University. All three events shared a friendly atmosphere and productive discussions between the participants.

The LQG workshop entitled "Frontiers of Loop Quantum Gravity" had 25 participants and the discussions centered among five topics of current interest: Phenomenology, Semiclassical Issues, Hamiltonian Constraint, Spin Foams and Future Directions. Each session was three hour long, with 2 short presentations and lots of discussion. On Friday Jan 30th, the workshop started with a presentation by Daniel Sudarsky on recent results that show that a low energy effective description in terms of a Lorentz violating theory (with a preferred frame) is already ruled out by existing experimental and theoretical bounds. This leads to a subtler possibility for manifestations of the discreetness coming from the Planck scale in the form of a Double Special Relativity (DSR) framework. L. Freidel gave a review talk on the two kinds of DSR theories which he called DSR-1 and DSR-2, and their prospects for becoming physically viable.

The Session on Semiclassical issues had two short presentations. Hanno Sahlmann gave a nice summary of the current approaches to construct semi-classical states of the theory, from the now classical *weave* states, gauge coherent states and shadow states to statistically generated states. Abhay Ashtekar gave a presentation on possible physical applications that the semiclassical states might try to attack; in particular the construction of states that approximate the Minkowski vacuum and the definition of effective potentials for scattering scenarios.

Spin Foams was the topic of the next session on Sat. Jan 31st, where Alejandro Perez gave a status report on the Barret Crane model. In particular, there was discussion on recent progress on the proper definition of the path integral measure for the Plebanski action and its possible relation to the elimination of bubble divergences when the symmetries of the system are properly addressed. The other important issue that was discussed was the dominance of degenerate configurations in the asymptotics of the terms that compose the state sum model. Louis Crane discussed possible new mathematical descriptions for spin foam models via an n-categorical approach.

In the Hamiltonian Constraint session, Abhay Ashtekar discussed the status of the so-called Thiemann-like Hamiltonians. Are they clinically dead? The consensus after the discussion was that they are still alive, and no fatal flaw has been found in the approach, even when there is still no agreement on the right way of finding a projector on physical states. Thomas Thiemann gave an introduction to the Master Constraint program, where the particular proposal for finding such operator seems to be very promising. It was agreed upon that this approach might shed light on defining the projector (via a spin foam model).

In the Morning of Sun Feb 1st Jorge Pullin gave a summary of the results that he and R. Gambini have found in defining consistent discretizations for quantum and classical gravity. In particular, he discussed some of its applications to quantum cosmology and decoherence. Abhay Ashtekar summarized what had been discussed in the workshop in the Concluding Remarks, and a general discussion followed. In particular, there was discussion about different possible discrete frameworks, observables associated to particles and the cosmological constant in $2+1$ gravity and the relation between spin foams and the continuum.

The general agreement between the participants was that the meeting was very productive for clarifying (and reaching consensus) on several conceptual and technical issues, and in defining direction in which we should focus our attention in the future. There was such excitement that this was dubbed the "First NAFTA meeting on LQG" and the participants somewhat committed to followups to this workshop that would take place in Canada, the USA and México on a rotating basis.

On Monday Feb 2nd, the Ryan-fest was held at UNAM, to celebrate both Mike's 60th birthday and 30 years of his arrival to México. The program was divided into technical talks and more informal 'anecdotic' ones: Abhay Ashtekar gave a seminar on Loop Quantum Cosmology followed by a talk on Non-commutative Quantum Cosmology by Octavio Obregon and later on by Richard Matzner on Linearizations and Hyperbolicity in Numerical Relativity. On the less technical side there were talks by Marcos Rosenbaum who described Mike's path during this last 30 years and his influence in starting and consolidating the gravity group at UNAM. Roberto Sussman gave us a student's perspective of Mike as a teacher in the 'old times', and Jorge Pullin took us to a Journey of discovery through the eyes of Mike's papers of all times.

The final event was a two-day celebration for Marcos Rosenbaum who was responsible for the mere existence of the Institute for Nuclear Sciences (and the Gravity Department) as a research center, of which he was the director for 16 years. There were two kinds of talks: those by present and past University Officers (including the present and a former Rector), who highlighted Prof. Rosenbaum's service to the University at large. The second series of talks were of a scientific nature and were divided into the two main areas of research of Prof. Rosenbaum: General Relativity and Mathematical Physics. Among the invited speakers were Stanley Deser, Richard Matzner, Octavio Obregon and Raymundo Bautista. These talks were complemented by talks from 'local' people such as M. Alcubierre, C. Chyssomalakos, M. Ryan, A. Turbiner and the author of this note.

What this series of events made clear for the participants was that the Gravity Department at UNAM http://www.nuclecu.unam.mx/~gravit, after only 30 years of its birth, is now coming of age, fit and running. We wish the department, and both Professors Ryan and Rosenbaum many more years of healthy and productive life.

Building bridges: CGWA inaugural meeting in Brownsville

Mario Diaz, UT Brownsville mdiaz@utb1.utb.edu

Building Bridges, as it was called the inaugural meeting of the Center for Gravitational Wave Astronomy at the University of Texas at Brownsville was held in Brownsville at the school main campus on December 14 and December 15 of last year.

The title was a suggestive metaphor to indicate the main goal of the CGWA, which is to give a common ground to the efforts of data analysts, source modelers and astrophysicists in support of gravitational wave astronomy and in particular of LISA science. The CGWA was created with NASA support under the agency's university research centers program. The program of the conference consisted of several invited talks and a contributed poster session.

The first day Bernard Schutz (AEI) and Tom Prince (Caltech-JPL) talked about the science promise of LISA and the LISA challenges for the scientific community, respectively. Schutz described in detail several aspects of the LISA mission, its challenges and its promises. He pointed out how different other presentations through the meeting were resonating with the major themes for LISA, i.e.: Supper Massive Black Holes (SMBH), how have they accompanied galaxy formation and their merger history, LISA noise confusion problems and the data analysis needs for the mission. He also described the future beyond LISA and other missions that are in the design stages like the Big Bang Observer. Prince framed LISA's mission in the context of NASA's structure and evolution of the universe roadmap. He referred to the significance within this context of the agency's Beyond Einstein program, which concentrates on understanding what powered the big bang, what happens at the edge of a black hole and what is dark energy.

Then Doug Richstone (U. of Michigan) completed the morning session with his talk about "Things invisible to see: Supermassive black holes in ordinary galaxies". Richstone concentrated on discussing what has triggered the interest on them, the current demographic picture and emerging developments in the field. He particularly discussed the possibility of gravitational wave observations of black hole mergers.

In the afternoon David Merritt (Rutgers) and Simon Portegeis Zwart (U. of Amsterdam) discussed the astrophysics of black holes, while Neil Cornish (Montana State) and Lior Barack (CGWA-UTB) referred to different aspects of LISA science. Merritt talked about the Astrophysics of Binary Supermassive Black holes. His presentation highlighted some of the outstanding questions in the field, like the resolution of the final parsec problem, and other different aspects of the dynamical evolution of black holes (are there un-coalesced binary black holes? how are black holes ejected from galaxies? Zwart discussed in detail the technique of n-body simulations in regards to the formation of intermediate mass black holes in young dense star clusters. Cornish discussed with some extension LISA challenges in the area of data analysis. He presented some approaches to the solution of some of these challenges with the utilization of an array of techniques that have been developed by his group. Barack started with a quick overview of capture sources and data analysis problems associated. He then introduced a class of approximate analytic waveforms and showed how can be utilized to estimate LISA's parameter extraction accuracy and to estimate SNR thresholds for detection. He revisited detection rates in light of this model as well.

A banquet followed in the evening with the normal occasion for socialization. Bernard Schutz talked about the significance of the creation of the CGWA and Richard Price referred in a jovial tone to the accomplishments and future endeavors of gravitational wave physicists in Brownsville.

In the morning of the following day Beverly Berger (NSF) started with a presentation about NSF role in support of gravitational wave science in particular and gravitation and general relativity at large. Soumya Mohanty (CGWA-UTB) presented “Beyond the Gaussian, stationary assumption: data analysis techniques for real interferometric data”. The following talks concentrated on issues and challenges in the area of numerical source simulation: Carlos Lousto (CGWA-UTB) spoke on “What can be learned about binary clack hole evolution due to gravitational radiation”. Bernd Bruegmann (PSU) discussed several issues related to black hole simulations in numerical relativity. Richard Price (U. of Utah) spoke on the “Periodic Standing Wave” method, an alternative to full numerical relativity for binary black hole inspiral. This method uses an exact numerical solution for rigidly rotating (“helically symmetric”) sources and fields to give an approximation for the intermediate epoch of inspiral in which the holes have strong gravitational interaction, but are not yet in their final plunge. Luis Lehner (LSU) made an effort at predicting the next steps in the simulations of Einstein’s equations, while John Baker (GSFC) talked about the Lazarus approach. Yasushi Mino (CGWA-UTB) gave the last lecture of the conference on the past, present and future of the self-force problem. The slides for the talks can be viewed at the CGWA web site: http://cgwa.phys.utb.edu/events/program.php.

The contributed poster session was also well attended and consisted in a good number of posters covering a wide range of topics within the meetings theme. A very positive aspect to remark from this meeting is the large number of students that attended from different places in the country and also from abroad.

Strings Meet Loops

Martin Bojowald, Albert-Einstein-Institute, Potsdam, Germany mabo@aei.mpg.de

During October 29–31, 2003 the Albert-Einstein-Institute in Potsdam, Germany hosted the Symposium "Strings Meet Loops" which was organized by Abhay Ashtekar and Hermann Nicolai. The primary purpose was to bring together researchers working on string theory on the one hand, and on canonical and loop quantum gravity on the other, and to enhance the exchange of ideas between the two communities. Correspondingly, the program consisted of talks that were primarily addressed to the other community: four from string theorists (Kasper Peeters, Bernard de Wit, Michael Douglas and Jan Plefka) and four from the loop community (Abhay Ashtekar, Jurek Lewandowski, Martin Bojowald and Laurent Freidel). They provided broad overviews of the current areas of active research in both approaches, focusing on conceptual frameworks and physical issues. In addition, there were two talks of interest to both programs but not explicitly belonging in either (Marc Henneaux and Max Niedermaier) as well as Introductory Remarks by Hermann Nicolai and Closing Remarks by Abhay Ashtekar. Over 50 participants from Europe, US and Canada attended the symposium. In addition, researchers from the Perimeter Institute and Rutgers participated in the afternoon sessions via video camera. (The full program and images of the transparencies used in the talks will remain available for download from the web page http://www.aei-potsdam.mpg.de/events/stringloop.html.)

The main purpose of all the talks was to serve as concrete platforms for subsequent discussions for which plenty of time was allotted by the organizers and used by the participants. In fact, the discussions quickly extended from the material covered in the preceding talk to its general area, resulting in a lively exchange of viewpoints from the different perspectives represented by members in the audience. In this regard, the hopes of the organizers were exceeded by the vibrant atmosphere during the symposium which resulted in frank discussions of the main open problems and of expectations toward the other community concerning issues which should be addressed in the future. Several prevalent misunderstandings have been clarified in these discussions.

The success of the symposium can also be seen in the interest from different sides to organize a a second symposium "Strings Meet Loops: 2," in the future.

International Conference on Gravitation and Cosmology 2004

Ghanashyam Date, Institute of Mathematical Sciences, Chennai, INDIA shyam@imsc.res.in

The *International Conference on Gravitation and Cosmology* is a series of conferences held approximately every four years in India. The series has been conceived as a means to provide younger researchers an exposure to latest research trends and to promote interaction between the International and the Indian research communities. Each of these conferences focuses on two or three 'theme topics' and are typically attended by about a 100 participants from India and abroad. The previous conferences in this series were held at Goa (1987), Ahmedabad (1991), Pune (1995) and Kharagpur (2000) and have been quite successful in the stated objectives.

The fifth conference in the ICGC series, ICGC-2004, was organized by the Cochin University of Science and Technology (CUSAT) at the *Riviera Suites* on the outskirts of Cochin during January 5–10, 2004. It had 17 plenary talks and, as a new feature, it also had 8 short talks which were more specialized than the plenary talks but still accessible to a wider audience. There were three focus themes: Cosmology, Gravitational Waves and Quantum Gravity. About 70 contributed papers were presented in oral presentations and poster sessions in four workshops on: Quantum Aspects of Gravitation, Classical Aspects of Gravitation, Cosmology and Gravitational waves and Relativistic astrophysics.

<u>Cosmology:</u> *Robert Crittenden* summarized the WMAP results and *Manoj Kaplighat* discussed the early re-ionization aspect. *Jerry Ostriker* gave a status summary of the 'standard model' of cosmology and emphasized the need and role of various complementary observations in building up a comprehensive picture of cosmology. Looking some what into the future, *Subhabrata Majumdar* discussed cluster surveys while *Bhuvnesh Jain* discussed weak lensing. Finally, *Robert Crittenden* doubled up for *Edmund Copeland* and surveyed a variety of theoretical ideas being pursued, some quite desperate, regarding an understanding of the Dark Energy.

<u>Gravitational Waves:</u> Talks in this theme covered various aspects from analytical and numerical computations of wave forms to interesting design aspects of interferometric detectors. *Gabriela González* described the LIGO experiment and the science runs. *Vicky Kalogera* discussed the event rate estimations from compact binaries. Detector assembly integration and simulations were discussed by *Biplab Bhawal* while *Sanjeev Dhurandhar* discussed in detail data analysis strategies required to construct efficient and effectual templates for gravitational wave detection. The analytical computations of the chirps within the PN expansion framework was discussed by *Luc Blanchet*. *Masaru Shibata* provided the current status and an optimistic future of numerical simulations using supercomputers. *Frederic Rasio* discussed the possibility of constraining the equation of state for neutron stars from observations of gravitational wave forms.

<u>Quantum Gravity:</u> In this theme there was one talk on string QG, two on loop QG, two on black hole entropy in various approaches, one on brane cosmology and one on phenomenological QG. *Sandip Trivedi* described the recent advances in getting not one but a very large number ($\sim 10^{100}$) of De Sitter vacua in string theory. This is achieved by a controlled SUSY breaking in a compactification with fluxes. *Jorge Pullin* briefly described the main historical

steps in the loop quantum gravity program and then focused on the recent proposal of a priori discretization of space-time. In a discrete time formulation, the evolution is achieved by finite canonical transformations. For a constraint theory, this allows one to obtain a constraint-free formulation. Various implications were discussed. *Martin Bojowald* detailed the loop quantum cosmology framework and presented interesting recent results. *Saurya Das* presented a fairly comprehensive comparison of the calculation of black hole entropy in various approaches such as strings, LQG, horizon CFT, AdS/CFT etc. including the logarithmic corrections. He also discussed the attempts to understand the Hawking effect and the information loss issue. *Parthasarathi Majumdar* discussed the universality of canonical entropy including logarithmic corrections. Brane cosmology, particularly the possibility of inflation being driven by a scalar field propagating in the bulk as well, was discussed by *Misao Sasaki*. *Jorge Pullin* summarized the attempts to look for QG signals via Lorentz invariance-violating modifications of the dispersion relations.

<u>Other talks:</u> Apart from the talks devoted to the main themes, there were five talks dealing with different aspects of gravitation. *Clifford Will* summarized the current limits on the various parameters from the traditional tests of GR and also discussed newer possibilities from gravitational waves. Gravitational collapse and the status of naked singularities was summarized by *Tomohiro Harada*. *Patrick Das Gupta* discussed the so called 'short' duration GRB's and their statistics. *Sayan Kar* discussed the issue of quantification of 'small' violations of the averaged energy condition and its role in traversable worm holes. The classic topic of 'Kerr-Schild geometries' was discussed by *Roy Kerr*. *Ghanashyam Date* gave an over view of the conference.

There was also an 'outreach lecture' by *Clifford Will* on *"Was Einstein Right?"* for the undergraduate students in a city college. The otherwise intense atmosphere of the conference was lightened by a delightful pre-dinner talk by *C. V. Vishveshwara* titled: "Cosmos in Cartoons".

The conference had a half-a-day 'cultural session' consisting of a *backwater cruise*, the traditional classical dance of *Kathakali* (narration of stories through dance) and the, unique to Kerala, twelfth-century martial arts called *Kalaripayat* followed by the conference banquet.

After this memorable experience, one looks forward to future ICGC meetings.

Links to presentation as pdf/ppt/ps files can be soon found at Presentation (pdf/ppt/ps files) will soon be available at http://meghnad.iucaa.ernet.in/~iagrg/talks.html.

The proceedings of the conference will be published as a special issue of *Pramana – Journal of Physics*.

The conference was sponsored by: The Abdus Salam ICTP, Italy; BRNS (DAE), Mumbai; CSIR, New Delhi; DST, New Delhi; HRI, Allahabad; IIA, Bangalore; ISRO, Bangalore; IMSc, Chennai; IOP, UK; IUCAA, Pune; RRI, Bangalore and UGC, New Delhi.

27th Spanish Relativity Meeting (ERE-2003)

Juan A. Miralles (Alicante), José A. Font (Valencia), José A. Pons (Alicante)
ja.miralles@ua.es, ja.miralles@ua.es, jose.pons@ua.es

The 27th Spanish Relativity Meeting (ERE-2003) was held at the University of Alicante (Spain) from September 11 to 13, 2003. The Spanish Relativity Meetings are annual conferences on General Relativity which started back in 1977, each year being organized by one of the different groups doing research on Relativity and Gravitation in Spain. In this occasion the meeting was jointly organized by groups from the University of Alicante and the University of Valencia. A brief history of these meetings can be found online at the conference web site http://www.sri.ua.es/congresos/ere2003/ereeng.htm

The scope of the conference has expanded over time as a follow up of research activity in Relativity and Gravitation in Spain. The program of the 27th edition included a series of six plenary lectures in the mornings, plus several shorter communications, both in the morning and in the afternoon, where participation of young scientists was, as usual, encouraged. The number of delegates attending the meeting was over sixty people, mostly from Spain but also from abroad. A total number of thirty-three contributed talks were presented, covering a broad range of topics including cosmology, numerical relativity, and formal aspects of mathematical relativity. The subjects of the plenary lectures covered topics of current interest in the field of Gravitational Radiation. The abstracts of these talks can be accessed online at the conference web site http://www.sri.ua.es/congresos/ere2003.

Ewald Müller (MPA, Germany) gave a review talk on core collapse supernovae as sources of gravitational radiation. In particular he showed pioneer results on the gravitational wave emission from simulations of highly aspherical models on which the asphericities are caused by convective mass flow both in the proto-neutron star and in the post-shock neutrino heated hot bubble region.

In his talk Nils Andersson discussed the various ways in which neutron stars may give rise to detectable gravitational waves. He described the modeling of these systems which requires an understanding of much of modern physics, ranging from general relativity to superfluidity and nuclear physics at extreme densities. The main aim of his talk was to outline how gravitational-wave data can be used as a probe of exotic physics in neutron stars.

Signal detection was discussed in the corresponding talks of Alberto Lobo (University of Barcelona), Alicia Sintes (University of the Balearic Islands and AEI), Pia Astone (University of Rome), and B. Sathyaprakash (Cardiff University). In particular Pia Astone discussed recent controversial results obtained with two gravitational wave resonant bar detectors, Explorer (located at CERN) and Nautilus (in Frascati, LNF). These detectors are allowing to investigate various classes of signals, such as bursts, continuous waves, stochastic background. They operated in the year 2001 with unprecedented sensitivities, being potentially able to detect the conversion of 10^{-4} solar masses in the Galaxy into gravitational waves.

Alicia Sintes presented a talk focused on the search of continuous gravitational waves from rotating neutron stars, which are among the most promising sources for ground based interferometer detectors. Although young rapidly rotating neutron stars are probably better initial candidates for gravitational wave detection than the known set of radio pulsars, the data analysis problem for these putative sources is more difficult because of their unknown location and frequency evolution. Since the expected gravitational wave amplitude from pulsars is very weak, it is necessary to integrate the data for long periods of time (months to year) with the signal-to-noise ratio increasing roughly as the square root of the observing time. Several data analysis techniques have been used, and others are under development, which are able to handle efficiently these long stretches of data. These techniques were thorough fully discussed in her talk.

The problem of searching for black hole binaries was discussed in the talk by B. Sathyaprakash. Post-Newtonian calculations and numerical relativity simulations have provided with waveform templates that can be effectively used to identify the inspiral and merger signals buried in noisy data. Sathyaprakash presented the state-of-the-art techniques of search algorithms tailored to dig out signals of known shape, which have been developed and implemented to increase the chance of detection. Applying these waveform templates and search algorithms on real data have taught us important lessons about how to deal with problems arising from handling non-stationary and non-Gaussian backgrounds.

Alberto Lobo gave a review talk on LISA, the first space borne gravitational wave detector, a joint ESA-NASA mission scheduled for launch in 2011. He presented the scientific objectives of LISA, as well as its present development status. Lobo also described the situation of the Spanish involvement in the mission.

Finally, part of the meeting was devoted to discussing the establishment of the Spanish Society of Relativity and Gravitation (SEGRE). The 28th edition of the Spanish Relativity Meeting will take place in Madrid from September 22 to 24, 2004.

Mathematical Relativity: New Ideas and Developments

Simonetta Frittelli, Duquesne University, simo@mayu.physics.duq.edu

This meeting took place in Bad Honnef, on the shores of the Rhine, Germany, on March 1-5, 2004. This was the latest in an ongoing series of seminars sponsored by the Heraeus foundation, the most important German private funding institution in physics and one that cooperates frequently with the German Physical Society.

The meeting was principally aimed at a broad audience that included a large representation of junior participants. There were 60-minute plenary talks in the morning, and 30-minute selected contributed talks in the afternoon. The plenary talks covered mostly recent developments in topological, analytical and numerical methods in mathematical relativity. Undoubtedly by thoughtful design on the part of the organizers (Jörg Frauendiener, Domenico Giulini and Volker Perlick), many plenary talks complemented or supplemented each other in a refreshingly cohesive way.

The conference was opened by Bobby Beig (Vienna) with a description of hyperbolic equations for matter fields. This was followed by a presentation on the space of null geodesics by Robert Low (UK), and a discussion about the geometry of pp-wave spacetimes (which generalize classical plane waves) by Miguel Sanchez (Spain).

In what was characterized as "the revenge of the physicists" by some participants, the presentations of the second day all revolved around the interplay between numerical and analytical issues, with talks delivered by Jeff Winicour, myself, Luis Lehner and Beverly Berger (all USA). These talks were meant to illustrate not only how analysis and geometry can guide numerical efforts, but, conversely, how numerical simulations can provide clues for analytic developments.

Bob Wald (USA) opened the third day with a review of conserved quantities associated with hypersurfaces that go to null infinity in asymptotically flat spacetimes, which prompted a curious dialogue between Bob and Roger Penrose (UK) about what "normal" people refer to as the "problem" of angular momentum. This was followed by the revenge of the mathematicians Paul Ehrlich (USA), with an anecdotic perspective on the influence of the book *Global Lorentzian Geometry*, and Antonio Masiello (Italy), who spoke about the Avez-Seifert theorem for the relativistic Lorentz equation. The day ended with an evening talk by Roger Penrose about the three **F**'s in modern physical theories: **F**ashion (strings), **F**aith (quantum mechanics) and **F**antasy (inflation).

Undaunted by the implications of Penrose's address, Alan Rendall (Germany) delivered an impression of good old inflation from a mathematician's point of view the very next day, followed by Helmut Friedrich (Germany) on conformal infinity and its connection to the Newman-Penrose constants, and Sergio Dain (Germany) with a description of the use of trapped surfaces as boundaries for the constraint equations on initial values for black hole spacetimes.

The meeting closed with talks by Greg Galloway (USA) on asymptotically deSitter spacetimes, and Laszlo Szabados (Hungary) on the definition of center of mass associated with Cauchy surfaces in asymptotically flat spacetimes.

The venue for the meeting was highly conducent to interaction between junior and senior participants. This was a large mansion (the Physikzentrum) featuring accomodations, dining and a state-of-the-art conference room. There was a common room where breakfast and lunch were served at tables for six people, and an old-fashioned basement cellar where a buffet dinner was available and where much informal social interaction took place in the evenings (apparently including fortune readings). A conference picture can be accessed at http://mayu.physics.duq.edu/~simo/badhonnef04.html

The substance of the the plenary talks will be published as a Springer volume in the near future. The complete program including the abstracts of the contributed talks and posters is available online at

http://www.tat.physik.uni-tuebingen.de/~heraeus/.