Gravitation and Relativity: At the Turn of the Millenium. J. V. Narlikar and N.K. Dadhich (eds). IUCAA. P.B. No. 4, Ganeshkhind, Pune 411 007. 1998. 510 pp. Price: $ 45.

Gravitation and Relativity: At the Turn of the Millenium, as the editors put it is an interesting collection of articles based on the lectures presented by several authors at the 15th Meeting of the International G.R.G. Society at Pune in December 1997. These meetings are generally held once in three years with the previous one (GR14) being held in Florence, Italy, in July 1995. In order to avoid the Indian summer monsoon, GR15 was advanced by six months to accommodate our friends from cooler places so that the participants could enjoy a pleasant climate for exchanging ideas and opinions. Reviewing the proceedings of a conference is altogether a different ball game as compared to reviewing a book. A book generally has a basic theme on which the author builds up a body, bringing in the concepts as they developed with appropriate link from chapter to chapter. On the other hand, the proceedings of a conference basically reflects the main interests of the organizers and the presentations by different authors obviously may not fully link the subject matter. These proceedings are no exception – though the title is very general, the topics addressed are basically few like cosmology, black holes, gravitational waves and a touch of quantum gravity, for the plenary talks and a few assorted topics of workshop sessions.

Gravitation binds the Universe together and as the theory of gravity, Einstein's general relativity provides the best framework to describe the cosmos. The observational basis for describing the cosmos increased ten-fold with the induction of the Hubble space telescope (HST) and as Malcolm Longair presents the picture, the HST has provided enormous service in determining the cosmological parameters to very good accuracies; the Hubble's constant H_0, through the observation of cepheids in the Virgo cluster, which provides accurate distances of galaxies, the deceleration parameter Q_0 through the study of type 1A supernovae and the density parameters Ω_0, Ω_B and the cosmological constant Ω_λ. As is well known, Longair's article is succinct, precise to the point though with a personal bias, it rightly emphasizes the central problems of astrophysical cosmology, and the enormous progress in the observational arena over the last two decades and points at the new theoretical perspectives in understanding the structure of the Universe. One could ask, are all the observations of the distant Universe for real or some of it mere illusions? We know that the first prediction of Einstein's theory is the bending of light ray near a gravitating source and as Chitre puts it, the cosmic illusions are a manifestation of the gravitational lensing which creates shadows of objects in the form of multiple images, arcs or ring-like structures. Michel Berry mentions in his short abstract on the propagation of electromagnetic waves, the twinkling and its opposite, the phenomena of lensing encompass the singularities of bright and dull light that cause caustics and zeros of wave fields. (It is a pity that Berry's full-length article is missing from the proceedings). Chitre has tried to summarize the developments in the field of gravitational lensing, both theoretical and observational, which is more in the form of a review of a large number of papers and is more useful for practitioners in the field with sufficient technical knowledge.

Black hole physics and astrophysics have been at the centre stage for more than two decades and technological developments have yielded rich observations over the years which have made black holes a reality. Ramesh Narayan has presented a very insightful review of the evidence for black holes through models dealing with advection dominated accretion flows around compact objects, while Choptuik has discussed the numerical simulations for identifying the threshold of black hole formation in a spherically symmetric collapse scenario. It is really amazing that the ADAF model of Narayan *et al.* can explain the observed spectra at three different wavelengths, with only one free parameter, namely, the accretion rate. Pullin, discussing the scenario of black hole collisions has summarized present understanding of the analytical 'close approximation' scheme, while Ed Sidel has reviewed the attempts in the numerical procedures for similar studies. These two articles together present a fairly up-to-date scenario of the intense effort that is being put in by several research groups in the understanding of black hole collision process which is supposed to generate copious amount of gravitational radiation in the 'closing in' regime.

Gravitational waves being one of the hottest topics of current research, three of the plenary talks deal with the sources of gravitational radiation and the present status of detectors. Eanna Flanagan's article on the astrophysical sources of gravitational radiation is a good introduction to the topic under discussion. Without going into technical details she has given probable estimates for stellar collapse and coalescence of compact binaries. The article also deals with achieved and projected detector sensitivities presently under construction and of the proposed ones. Gravitational wave detectors seem to have had a lot of coverage in the meeting as Norna Robertson and Cerdonio *et al.* have also covered extensively the same topic, and the presentation by both are up-to-date and very informative. The three articles together are of immense help to graduate students and researchers alike for an introduction to the topic and to learn about the status of research and the world-wide efforts that are going on to open up a new window for the next millenium – the gravitational wave astronomy.

Is gravity quantizable? This question has bothered researchers for over fifty years and it appears that no significant answer has been found as yet. Though the interest in the subject has not dwindled, the coverage is not as extensive as it used to be in earlier meetings. Carlo Rovelli in his brief review of a vast topic has tried to give a critical survey of the present approaches to quantum gravity illustrating the main achievements and difficulties in string theory, loop quantum gravity, discrete quantum gravity, perturbative quantum gravity, quantum field theory on curved space–time, non-commutative geometry, and spin foam models. As Carlo points out both string theory and loop quantum gravity claim certain results, but both are quite far from obtaining any tangible experimental evidence. The article is indeed very informative and useful to get a glimpse of the various attempts and gives a flair of the type of mathematics one ought to know for pursuing any serious research in quantum gravity. In fact, the article by Gary Gibbons on M theory, which is supposed to be a unification of the five

different string theories and the 11-dimensional supergravity theory is certainly meant for the 'connoisseurs' who have a substantial background of differential geometry and topology.

Talking of mathematics, there are two articles dealing with classical general relativity; on dynamics of null surfaces by Kozameh and on Einstein's equation and geometric asymptotics by Helmut Friedrich. As Kozameh points out quite clearly, the null surface formalism gives a fresh viewpoint towards the quantization issue and preserving the geometric character of Einsteinian theory of gravity it provides a new, fully gauge-fixed scheme for generating new perturbation solution. The conformal structure, which was first introduced in general relativity by Roger Penrose, has yielded a rich haul of insight into understanding of the large-scale structure of space–time and later work by Friedrich demonstrated the possibility of analysing the asymptotic behaviour of solutions (asymptotically flat) to arbitrary precision. More recently, the approach has led to the understanding of numerical methods for analysing space–times without cut-off. Friedrich, in his article, has given a review of the development of these ideas, emphasizing the necessity of understanding the interaction between conformal geometry and Einstein propagation in all its detail. The concept of an isolated system which has played an important role in the classical general relativity, was criticized by Ellis in the context of cosmological solutions, and as Friedrich points out it would be useful to reconsider the technical aspects of Ellis' critique in conjunction with the new developments of using conformal field equations, which offer the possibility to calculate numerically entire asymptotically flat space–times together with their conformal boundary on finite grids.

Deviating from these main themes, there are two excellent articles by Ashby on relativistic effects on the GPS and by Zeilinger on quantum coherence experiments. As Ashby reports, the global positioning systems which use accurate stable atomic clocks in satellites and on earth, need accurate determination of various special and general relativistic effects, viz. Sagnac effect, time dilation and frequency shift. The synchronization so provided after including all these effects has varied applications. The article discusses the conceptual basis for navigation using GPS and lists some applications like military navigation, communication, pulsar timing measurements, search and rescue, etc. The article is well-presented without too much technicality and reads easily. While mentioning Zeilinger's article I cannot help recalling the excellent response he received during the lecture and for the large community of theorists present, the amazing achievement of 'teleportation' was very revealing. That one can identify few photons and follow them in practice as entangled states is indeed a crown in the technological achievements of the present millenium. As Zeilinger says, if this can lead to tests of a possible decoherence mechanism caused by gravitational interaction, one may really get a better understanding of the conceptual issues raised by quantum mechanics. It is again a pity that the full version of Penrose's lecture on 'Science and the Mind' is not available in the proceedings. Vishveshwara's article 'After the Fall', which was the toast of the conference reflects the inimitable style of presentation that can make a good reading for experts and non-experts alike. Had it been possible to intervene the text of a speech with the laughter it evokes, this article would have covered the whole book. Vishu covers the historical developments of Newton's gravity to super and quantum gravity, punning upon almost every technical word, and enlivening with cartoons which have been popular among the GR community for over ten years. The article is indeed extremely refreshing and several facts which Vishu brings out could have been new to many in the field.

After all these plenary talks, the proceedings picks up some repertoires of workshops which need no special mention. It is a little surprising why there is no report concerning the session B1 on 'Relativitistic Astrophysics' and C2 on 'Tests of Special and General Relativity'. While many of the workshop chairs have taken trouble to read the various presentations and summarize, the one on B2 – Observationally Oriented Cosmology has simply put together the abstract sheets supplied by the contributors. Though the abstract says that it gives truncated summary, it is strange to see a lot of 'print space' being wasted in giving the long affiliations of the contributors.

All in all, it could be mentioned that the proceedings does contain some very good 'state of the art' presentation of the topics in gravitation and would be useful as an overview for serious researchers. However, now-a-days apart from a triennial conference like GR, there are many topical meetings at the rate of two or three per year, many an article gets repeated in different volumes with new headings. In spite of this foreseeable danger, the book could be of use for selective topics and thus should be on the shelves of every scientific library.

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Eco-restructuring: Implications for Sustainable Development. Robert U. Ayres (ed.). United Nations University Press, The UN University. 1998.

'Sustainable development' is amenable to many interpretations and there is still no acceptable definition of what sustainable development is and is not. Viewed against this backdrop, this book, under review, reflects a 'growing concern for environmental degradation associated with industrial development, economic growth and energy use ranging from local air and water pollution, soil contamination, and reduced bio-diversity to stratospheric ozone depletion and the damage potentially caused by global climate change' (p. 149) without prejudice to two fundamental premises, viz. (i) that economic growth must continue at least for the foreseeable future, and (ii) the nature of that growth must change radically in order to satisfy the basic requirement of long-term eco-sustainability. It is equally true that lack of economic growth and development translate into increased poverty and population growth which, in turn, lead to accelerated environmental deterioration (p. 173). In order to arrest this trend and save the mankind from possible total extinction, the contributors stress on the imperative need for global