Workshop summary for cosmology

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Abstract. We summarize the talks presented at the ICGC 2007. Our summary follows a non-chronological order, reflecting the themes. We include a brief background of the topic and highlight talks that we found interesting or thought deserved specific attention.

1. Introduction
In all five sessions were held from 17th to 21st of December, each lasting about 1 hour and 45 minutes. About thirty five presentations on various aspects of cosmology were selected. In the sessions that were predominantly devoted to specific areas, the first talk was chosen as a highlight talk and given the maximum time, the rest of the slots were 10-15 minutes long. For coherence we shall present our summary according to focus of different sessions. We give only highlights of sessions and do not give a detailed account of all the talks. What is presented is a gist of the overall sense of specific sessions.

2. Workshop Summaries
2.1. CMB and the Epoch of Reionization
Observations of the Cosmic Microwave Background (CMB) radiation have brought the broad field of cosmology into a precision era. The background model has now been determined to an unprecedented precision. Post recombination epoch our Universe became neutral. However, around a red-shift of 6-10, the first structures in the Universe started to form, giving radiation that reionized the Universe. The Epoch of Reionization (EoR) is an emerging and active field of current research in cosmology. Not only is it of interest in itself, being an important epoch in the history of the Universe when the first structures started to form, it is also of interest to better constrain the parameters of the background Universe, in particular the matter and dark energy content of the Universe.

Bagla began the session by discussing a complimentary probe to the observations of the 21 cm, hyperfine transition in the neutral hydrogen by introducing the observations of the Inter-Galactic Medium (IGM) using the hyperfine transition of 3He+. Dutta focused on the 21cm signal to probe the EoR using the multi-frequency angular power spectrum that can extend the cosmological parameter estimation to significantly higher red-shifts. Foreground subtraction using GMRT was discussed by Ali, addressing the problem of foregrounds masquerading as the cosmological signal. A consistent, semi-analytic model of star formation history and the reionization history of the universe was presented by Samui. There were several talk on different aspects of CMB observations. Saha discussed estimating the CMB angular power spectrum using...
a linear combination of multi-frequency maps. As opposed to the usual parameterization in terms of power law, a direct reconstruction of the primordial density spectrum using post WMAP 3 was presented by Shafieloo. Testing for the isotropy of the cosmic microwave background using a new symmetry based method was presented by Samal. Ghosh discussed a model independent approach, using multichannel foreground removal method, to the angular power spectrum estimation from multi-frequency CMB data.

2.2. Large Scale Structure and N-body Simulations
N-body simulations are an indispensable tool for studying the formation of non-linear structures in the Universe. The talks in this session focused on quantifying the limitations in this technique and ways to improve them. Observations of clusters of galaxies were also discussed. Specifically, Prasad discussed the role of truncation of the power spectrum on large scales due to the limitation of finite box size in the N-body simulations, arguing that it suppresses clustering and leads to overestimation of haloes at small scales and underestimation on the large scales. Critical point analysis that uses the zeroes of the gradient of the density field, to study the topology of large scales structures was then discussed by Pandey. Prasad discussed the effect of small scale features in the power spectrum on the formation of large scale structures. Khandai discussed steps towards improving the N-body codes through Adaptive TreePM codes, along with the preliminary results of their investigations. The question of fractal dimension of the Universe and approach towards homogeneity at large scales was presented by Yadav. Raut presented the exciting topic of doing cosmology with clusters using the Sunyaev-Zel’dovich effect. These observations would hopefully provide complimentary probes of the background Universe.

2.3. Dark Energy, Brane World and Inflation
What constitutes dark energy is one of the most profound mysteries of our times. The simplest model, called the cosmological constant model, does explain most of the observations. However, it does not lead to a natural explanation since it runs into a fine tuning problem. Although the energy density in the cosmological model remains a strict constant and does not lead to any clustering, other possibilities for dark energy do lead to the possibility that it might cluster. If this is true then observations can further elucidate the nature of dark energy by observing its effects on small scales.

Jassal, Unnikrishnan and Melchiori presented scenarios in which clustering of dark energy takes place, albeit mostly on the large scales. However, since there is no definitive model for dark energy, these presentations focused on phenomenologically motivated scenarios, thus leading to only a partial solution to the problem. Brane world scenarios, emerging out of higher dimensional theories, also offer hope for resolving the dark energy puzzle and were discussed during the session by Chakraborty. Exploring the rich possibilities, Das discussed interacting scalar fields as a possible source for dark energy. Barera discussed dissipation and particle production during inflation. Models with a mixture of dark energy and dark matter were discussed by Sen. Subject only to the condition that the dark energy satisfies the weak energy condition, constraints on cosmological parameters were placed. It was shown that the weak energy condition constrains the coordinate distance \( r(z) \).

2.4. Other Aspects of Gravity
The issue of spatial averaging in the context of Einstein’s equations was discussed by Paranjape. It was shown that by using the formalism of Zalaletdinov’s Macroscopic Gravity, it is possible to construct spacetime scalar corrections to the standard FLRW equations. The problem of the dependence of the result on the time slicing still persists. Hossein presented an analysis of the Magellanic Stream in the context of modified gravity. Li discussed the cosmological back-reaction problem and P. Gupta discussed the issue of rotating black holes from first order
phase transition in the early Universe. Srivastav presented a unified picture of dark energy from modified gravity. Cylindrically symmetric inhomogeneous magnetized string cosmological models with cosmological term $\Lambda$ varying with time were discussed by Pradhan. It has been assumed that the expansion($\theta$) in the model is proportional to the eigenvalue of the shear tensor $\sigma_{ij}$ in a specific direction. The properties of such a model were discussed and it was shown that model admits a small value of the cosmological constant.