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Workshop III – Cosmology: Observations versus theories

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Abstract. The topics on which there were presentations in this workshop can broadly be divided into the following categories: Observational aspects of large-scale structures in the universities; phase transitions in the early universe; cosmic microwave background radiation; observational cosmology.

1. Observational aspects of large-scale structures in the universities

An investigation on the possibility of detecting high redshift HI in emission using GMRT was reported. The background temperature of the redshifted HI emission and the fluctuations caused in the background by the clustering of damped Lyman-α clouds and the Poisson fluctuations were calculated. It was shown that at 327 MHz, the background temperature is $\sim 10^{-3}$ K, and, for a sCDM model the angular power spectrum of the fluctuations, $l^2 C_l$ varies from 10^{-6} to 10^{-5} K^2 as l changes from 400 to 4000. These values of l correspond to the angular coverage of the GMRT. It was shown that the clustering dominates the Poisson fluctuations over the entire range, implying that these detections can shed light on the evolution of clusters at $z \sim 3$. It was also pointed out that the fluctuations can be detected with about 10 hours of integration time (S Bharadwaj, B Nath and S K Sethi).

The gravitational lens image separation distribution function in the presence of evolving models of galaxies was discussed. Models in which the mergers are fast were ruled out by comparing with the data for lensed quasar with the HST Snapshot. This is because the fast merging models produce large number of small-separation lenses as compared to the no evolution case. It is possible that the mass accretion model and no evolution model for galaxies may be able to explain the small angle separations. These results are, however, sensitive to the Schechter parameters (α, ϕ_*), lens parameters (F) and Faber-Jackson relation $(L \propto v^2)$. However, presently available sample of high redshift QSOs is too small to place stronger constraints on a wide variety of evolutionary models (Deepak Jain, N Panchapakesan, S Mahajan and V B Bhatia).

2. Phase transitions in the early Universe

Using the dynamics of quark-hadron transition in the early universe it was shown that the evolution of the universe does not necessarily follow the small super cooling scenario and that certain choices of the bag pressure parameter and surface tension can have a bearing on the present state of the Universe. They have studied the dynamical behaviour of the quark-gluon phase transition estimating the evolution of the hadron fraction, temperature and the nucleation rate during the process. The details of the possibility of nugget formation have been discussed. An estimate of the parameters like the average separation, time of formation, quark content and survivability have been discussed (Deepak Chandra and Ashok Goyal).

Temperature effects in a theory of induced gravity coupled to matter fields and described by the Lagrangian,

$$\mathcal{L} = \frac{1}{2}\left[g^{\mu\nu}\partial_\mu\partial_\nu - (m^2 + \xi R)\phi^2\right] - \frac{\lambda}{4!}\phi^4 \tag{1}$$

were discussed. Based on one loop renormalized effective potential it is concluded that the scalar gravitational coupling ξ and the magnitude of the scalar curvature R crucially determine the symmetry. The conclusion was that only for some suitable values of scalar-gravitational coupling could the symmetry be radiatively broken or restored (Minu Joy and V C Kuriakose).

The generation of baryon asymmetry of the Universe at energy scales much below the electroweak scale was discussed. Restoration of local electroweak symmetry is achieved by the evaporation of primordial black holes or by re-heating the surrounding plasma by the decay of massive particles. Baryon asymmetry is generated again by the subsequent cooling of the plasma. The standard scenario, requires a first order phase transition and a low Higgs mass to prevent wash-out of the asymmetry after phase transition. The model that was presented was free from such problems (Raghavan Rangarajan, Supratim Sengupta and Ajit Srivastava).

A large number of vortices can be produced due to resonant oscillations of a scalar field that evolves in an effective potential arising from a spontaneously broken U(1) symmetry. Using a model in which the temperature varies periodically with time, it is shown that there can be localized flipping of the field. This results in a vortex–anti-vortex pair in $2 + 1$ dimension. It is found that the late-time defect density is peaked at an average temperature of 0.5 (in scaled units). The average defect density vs average temperature is fitted by a Gaussian. The importance of the this phenomenon in the context of topological defects is discussed (Supratim Sengupta).

Collision of spherical true vacuum bubbles leading to trapped false vacuum pockets (FVPs) were discussed. Analytical solutions for the case of collision of 5 spherical bubbles, three of them of size r, while the rest of size R_1 and R_2, respectively, were presented. The peculiar velocity of the primordial black holes (PBHs) is estimated. The change in the entropy for the above process is also determined. The gravitational wave background produced by a stochastic collection of such PBHs is discussed (Sushil K Singh and Patrick Das Gupta).

3. Cosmic microwave background radiation

Results of the simulation of brightness temperature of the microwave background sky at arc-minute scales due to Sunyaev–Zeldovich effect were presented. In this the non-Gaussian nature of perturbation through a modified Press–Schecter distribution of clusters was taken into account. The results of the simulations were compared with the observational upper limits on the sky variance at arc minute scales with the aim of constraining plausible models of structure formation seeded by strings (Subhabrata Majumdar).

The capabilities of the Sunyaev–Zeldovich meter (MITO) which is dedicated to the study of the S-Z effect towards nearby and extended clusters of galaxies were discussed. For the case of Coma cluster, the S-Z signal has been obtained at 143, 217, 269 and 355 GHz. These results were presented. Further, an analysis of the X-ray emission from Coma was discussed. This was obtained using the Beppo-SAX satellite. These two results were used to derive a value for the Hubble constant (Sergio Colafrancesco).

4. Observational cosmology

For a Universe that satisfies a perturbed Friedman–Limaitre model, the observational determination of its geometry requires not only measurement of local parameters such as curvature, but also the measurement of global parameters such as topology. Observational tests of the topology of the comoving spatial section of the Universe are now actively being made. Just as for the measurements of local parameters, a variety of complementary techniques have now been published and applied to varying degrees on the observational catalogs and sky maps presently available. Some basic principles and some selection of observational analysis were discussed (Boudewijn Roukema).

The observational consistency of cosmological models has been tested on the basis of data on magnitudes and redshifts of distant supernovae and on the angular sizes and redshifts of ultra compact radio sources. There has been an attempt to solve the cosmological constant problem using observational data sets for variable Λ. The data set has also been used to discriminate between the different models for decaying Λ (R G Vishvakarma).