CMB Power Spectrum: New Approach to Cosmological Fluctuation using the Background Field Method

S. Ichinose

Laboratory of Physics, School of Food and Nutritional Sciences, University of Shizuoka, Shizuoka 422-8526, Japan

e-mail: ichinose@u-shizuoka-ken.ac.jp

A new field theory formulation is presented for the analysis of the CMB power spectrum distribution in the cosmology. The background-field formalism is fully used. The gravitational (metric) field $g_{\mu\nu}$ is not taken as the quantum field, but as the background field. The statistical fluctuation of the metric field is taken into account by the path (hyper-surface)-integral over the space-time. Using a simple scalar model on the curved (dS$_4$) space-time, we make the analysis comparing with the S-matrix calculation of the flat (3+1 dim Minkowski) field theory (QED). The concrete new points are as follows.

1) This is the systematic formulation for the n-point function.
2) Clear separate treatment is done for the classical effect, the statistical effect and the quantum effect.
3) For the classical part, the perturbation around the homogeneous and isotropic limit (Robertson-Walker universe) is systematically treated using the propagator method.
4) We calculate the quantum effects of the matter-field. Casimir energy of the universe is finitely obtained. The absolute value is consistent with the observation.
5) We introduce fluctuation around the homogeneous part as the statistically-distributed fluctuation. We introduce a statistical averaging functional using the path-integral method. We make the functional by use of the area of a 3D hyper surface embedded in 3+1 space-time. We stress that the fluctuation comes not from the quantum gravity but from the unknown ‘statistical’ fluctuation
6) IR parameter ($l$) is introduced for the time axis as the periodicity for the time axis. Time reversal($Z_2$)-symmetry is introduced in order to treat the problem separately with respect to the $Z_2$ parity $P = \pm 1$. This procedure much helps both UV and IR regularization to work well.
7) The IR divergence problem is closely examined. It is compared with the case of QED.
8) The usual CMB power spectrum is obtained.