Rajeev Kumar Jain

Research Summary:

My research work is primarily focussed on understanding the origin and evolution of cosmological perturbations in inflationary scenarios and the resulting signatures on the cosmic microwave background. The issues I have been studying during the last year are as follows:

1. Non-gravitating scalar field in the Friedmann universe
2. Amplification of tachyonic perturbations at super-Hubble scales
3. Generation of features in the primordial spectrum
4. Evolution of cosmological perturbations in bouncing universe

I have briefly described below the work I have completed which are listed as 1 and 2 above. Issues 3 and 4 are still under investigation.

1. *Non-gravitating scalar field in the Friedmann universe:* In this work, we have studied the evolution of an interacting scalar field that is coupled non-minimally to gravity in a Friedmann universe. We have shown that for a specific choice of the parameters describing the interaction, the energy-momentum tensor of the scalar field vanishes and, as a result, the scalar field does not gravitate. The naive space dependent solution to equations of motion gives rise to a singular field profile. We have carefully analyzed the energy-momentum tensor for such a solution and have shown that the singularity of the solution leads to a subtle contribution to the energy-momentum tensor. The space dependent solution therefore is not non-gravitating. Our conclusion is applicable to other space-time dependent non-gravitating solutions as well. We have also studied a hybrid inflation scenario in this model when a purely time dependent and non-gravitating field is coupled to another scalar field.

2. *Amplification of tachyonic perturbations at super-Hubble scales:* In the slow-roll inflationary scenario, the amplitude of the curvature perturbations approaches a constant value soon after the modes leave the Hubble radius. However, recently, it was shown that the amplitude of the curvature perturbations induced by the canonical scalar field can grow at super-Hubble scales if there is either a transition to fast roll inflation or if inflation is interrupted for some period of time. In this work, we have extended the earlier analysis to the case of a scalar field described by the Dirac-Born-Infeld action. With the help of a specific example, we have shown that the amplitude of the tachyonic perturbations grows at super-Hubble scales when there is a transition from slow roll to fast roll inflation. We

have also illustrated as to how the growth of the entropy perturbations acts as the source for the amplification of the curvature perturbations during the period of fast roll inflation. Furthermore, following an earlier result for the canonical scalar field, we have obtained a general criterion for the amplification of the tachyonic perturbations.

Preprints:

1. Nabamita Banerjee, Rajeev Kumar Jain and Dileep P. Jatkar, *Non-gravitating scalar field in the FRW background,* arXiv:hep-th/0610109.

2. Rajeev Kumar Jain, P. Chingangbam and L. Sriramkumar, *Amplification of tachyonic perturbations at super-Hubble scales,* arXiv:astro-ph/0703762.

Conference/Workshops Attended:

1. *IUCAA Reference Centre Workshop on Advanced Topics in Data Analysis in Cosmology and Gravitational Wave Astronomy*, New Delhi, India, October, 2006.

2. *24th meeting of Indian Association for General Relativity and Gravitation*, New Delhi, India, February 2007.

Invited Lectures/Seminars:

1. *Amplification of tachyonic perturbations at super-Hubble scales*, 24th meeting of Indian Association for General Relativity and Gravitation, Jamia Millia Islamia, New Delhi, India, February, 2007.

Other Activities:

1. Astrophysics Journal Club Talk

   (a) *Can the tensor-to-scalar ratio be enhanced?*, Journal club talk, April, 2006.

   (b) *Symmetry and inflation*, Journal club talk, September, 2006.

2. Astrophysics Seminar

   (a) *Scale-free spectra from non-vacuum initial states*, Astrophysics Seminar, April, 2006.

3. A talk on 'Gravitation' in Rajbhasha school, HRI during May, 2006.

4. Helped in organizing and evaluating the papers (Physics) of HRI Science Talent Test 2006.