Harvinder Kaur Jassal

Research Summary:

The present day acceleration of the universe has been described by the presence of dark energy, typically a cosmological constant or a scalar field. In the absence of significant spatial variation in the dark energy, the key difference between scalar field models and the one with the cosmological constant is that, in general, the equation of state of dark energy is a function of redshift in the former. It has been known for some time that supernova observations and constraints from structure formation can be combined to put stringent limits on models for dark energy. Several attempts have been made in the past to constrain the equation of state for dark energy, along with other cosmological parameters, using the observations of galaxy clustering, temperature anisotropies in the CMBR and the high redshift supernova. We focus exclusively on constraining the variation of equation of state for dark energy by using a combination of such observations. In particular, we study the effect of a varying equation of state on the angular power spectrum of the CMBR fluctuations. We demonstrate that the combination of WMAP observations and high redshift supernova observations is a very powerful constraint on variations in dark energy, certainly more powerful that either of the observations used in isolation.

We demonstrate that the recently released high redshift supernova data from the SNLS (SuperNova Legacy Survey) project is in better agreement with CMB observations, unlike the earlier data sets which preferred a different class of models altogether. The SNLS data set favours models similar to the ΛCDM model. We illustrate that WMAP observations are, by far, the strongest constraint on models with a varying equation of state parameter for the dark energy component in a flat universe. Further, the better quality of observations of temperature anisotropies in the CMB are less susceptible to systematic effects and this makes it a more reliable probe of cosmological parameters and dark energy.

The above approach is for generic models which can be parameterised, clearly in such an approach all the details of a specific model cannot be included and the conclusions are of a more general nature. I am presently working on applying the methods developed here to a particular class of models, e.g., the quintessence models, to make definitive statements on their viability. Details like including the perturbations in dark energy that cannot be studied in the general approach can be analysed here.

During the last few years, exact solutions that describe black holes that are bound to a two-brane in a four dimensional anti-de Sitter bulk have been constructed. In situations wherein there is a negative cosmological constant on the brane, for large masses, these solutions are exactly the rotating BTZ black holes on the brane

and, in fact, describe rotating BTZ black strings in the bulk. We evaluate the canonical entropy of a free and massless scalar field (at the Hawking temperature) around the rotating BTZ black string using the brick wall model. In this method it is assumed that quantum modes do not propagate within a 'brick wall' just outside the horizon hence doing away with the divergent coefficient of surface area. It is shown that the proper distance between the horizon and the ultraviolet cut off is independent of the mass and the angular momentum of the black hole. The rotating black hole has radiant and superradiant modes with the superradiant modes providing the sub-leading order contribution to entropy. We explicitly show that the Bekenstein-Hawking 'area' law is satisfied both on the brane as well as in the bulk.

Publications:

1. H. K. Jassal, L. Sriramkumar, *Entropy of BTZ black strings using the brick-wall approach*, Class. Quantum Grav. 24, 2589 (2007).

Conference/Workshops Attended:

1. Advanced Topics in Data Analysis in Cosmology and Gravitational Wave Astronomy, Inter-University Centre for Astronomy and Astrophysics Reference Centre Workshop, University of Delhi, India, October, 2006.
2. XXV meeting of the Astronomical Society of India, Osmania University, Hyderabad, February, 2007.
3. IUCAA-MPA workshop on Astrophysics, Inter-University Centre for Astronomy and Astrophysics, Pune, March, 2007.

Visits to other Institutes:

1. Visit to I.U.C.A.A., Pune, July 23 - 30, 2006 .
2. Visit to I.U.C.A.A., Pune, March 1 - 12, 2007.

Invited Lectures/Seminars:

1. *Constraining accelerating universe*, Lectures, Inter-University Centre for Astronomy and Astrophysics Reference Centre Workshop, University of Delhi, India, October, 2006.