CTS WORKSHOP

on

PHYSICS OF WARPED
EXTRA DIMENSIONS

February 21-23, 2008, IIT Kharagpur

ABSTRACTS

Title: Some issues relating to Randall-Sundrum braneworld model

Author: Soumitra Sengupta (IACS, Kolkata)

Randall Sundrum braneworld model provides an elegant approach to resolve the gauge hierarchy problem using the notion of extra spatial dimension.The model is expected to acquire more significance if supersymmetry is not found in the forthcoming LHC experiments. After briefly reviewing the essence of the model, I shall describe various aspects of this model in the context of modulus stabilization, it's higher dimensional generalization, implications of presence of various bulk fields, non-zero brane cosmological constant and other related issues.

Title: Cosmological constant, brane tension and large hierarchy in a generalised Randall-Sundrum scenario

Author: Debaprasad Maity (IMSc, Chennai)

We consider a generalized Randall Sundrum (RS) brane world scenario with a cosmological constant Ω induced on the visible brane. We show that for negative but small Ω the visible brane tension can be positive alongwith a large hierarchy between the Planck and visible brane. On the other hand for positive but small value of Ω (of the order of observed cosmological constant value $\sim +10^{-124}$ in Planck units), the hierarchy problm can be resolved with modulus value close to the RS value.

Title: Localization of fields on the brane

Author: Ratna Koley (IACS, Kolkata)

Warped braneworld scenario provides an alternative to the usual Kaluza-Klein compactification of extra dimensions through the so-called *localization of fields*. Randall-Sundrum type models do not directly prove, rather, assume that all standard model fields are localized to the TeV brane. I will provide the mechanism for addressing the problem and discuss the issue of localization of fields on the brane for various types of braneworld models available in the literature.

Title: Unraveling extra dimensions at the colliders

Author: Anindya Datta (Calcutta University, Kolkata)

I will talk about the collider signatures of the models of TeV scale gravity. Particular emphasis will be given on the graviscalars which play crucial role in the collider search of Standard Model Higgs boson.

Title: Universal extra dimension

Author: Anirban Kundu (Calcutta University, Kolkata)

I will describe the phenomenology of the minimal universal extra dimension model, including the formulation, low-energy and astrophysical constraints, collider searches, and possible discrimination with supersymmetry.

Title: Excited scalars of the UED model

Author: Biplob Bhattacherjee (Calcutta University, Kolkata)

The Kaluza-Klein excitations of the Higgs bosons of the universal extra dimension model are extremely challenging to detect. We discuss the production and possible detection mechanisms of such excited scalars at the LHC. The dominant production mechanism of such scalars is from the decay of the excited third generation quarks. In particular, the charged Higgs boson has a large production cross-section over most of the parameter space. We highlight how one may detect these excited scalars. We also comment on the production and detection of excited neutral scalars.

Title: Phenomenology of spinless adjoints in two universal extra dimensions

Author: Kirtiman Ghosh (Calcutta University, Kolkata)

We discuss the phenomenology of $(1, 1)$-mode adjoint scalars in the framework of two Universal Extra Dimensions. The Kaluza-Klein (KK) towers of these adjoint scalars arise in the 4-dimensional effective theory from the 6th component of the gauge fields after compactification. Adjoint scalars can have KK-number conserving as well as KK-number violating interactions. We calculate the KK-number violating operators involving these scalars and two Standard Model fields. Decay widths of these scalars into different channels have been estimated. We have also briefly discussed pair-production and single production of such scalars at the Large Hadron Collider.

Title: Phenomenology of warped extra dimensions at LHC

Author: V.Ravindran (HRI, Allahabad)

We will give a general overview of models with warped extra dimensions. A short summary of predictions from these models at colliders will be presented. We will then concentrate on two important observables at Large Hadron Collider(LHC) namely Drell-Yan and di-photon productions to probe the effects resulting from these models.

Title: Diphoton production in the RS model at the LHC

Author: M.C.Kumar (SINP, Kolkata)

We study the diphoton production at the LHC in the RS model. The next-to-leading order QCD corrections to the diphoton production are presented in the invariant mass, rapidity and other kinematical distributions. It is found that the NLO QCD corrections to the graviton mediated process are sizable at the LHC indicating the importance of the same in the search of RS gravitons at the collider experiments.

Title: Identifying graviton signals at the LHC: a discussion

Author: Sreerup Raychaudhuri (TIFR, Mumbai)

Title: Effective Einstein equations: a review

Author: Sayan Kar (IIT Kharagpur)

The effective Einstein equations on the brane obtained by Shiromizu, Maeda and Sasaki will be reviewed. Novel features which appear in these equations will be highlighted. Consequences, in the context of cosmology, spherically symmetric spacetimes and a possible resolution of the dark matter problem will be discussed.

Title: Cosmology with primordial black holes motivated from extra dimensions

Author: Archan S. Majumdar (SNBNCBS, Kolkata)

We review various black hole solutions in braneworld models, and investigate the cosmology of primordial black holes in these models.

We consider the evolution of primordial black holes in a generalized Jordan-Brans-Dicke cosmological model where both the Brans-Dicke scalar field and its coupling to gravity are dynamical functions determined from the evolution equations. The evaporation rate for the black holes is different from the case in standard cosmology. We show that the accretion of radiation can proceed effectively in the radiation dominated era. It follows that the black hole lifetime shortens for low initial mass, but increases considerably for larger initial mass, thus providing a mechanism for the survival of primordial black holes as candidates of dark matter. We derive a cut-off value for the initial black hole mass, below which primordial black holes evaporate out in the radiation dominated era, and above which they survive beyond the present era.

Title: Cosmological consequences of generalised RS II braneworlds

Author: Supratik Pal (ISI, Kolkata)

We discuss certain features of cosmology in a generalised RS II braneworld scenario. In this scenario, the bulk is a radiative Vaidya anti de Sitter black hole, which exchanges energy with the brane, and consequently, leads to a modified version of the brane Friedmann equations. Specifically, the local corrections to the Friedmann equations are manifest via a quadratic contribution from the brane perfect fluid whereas the nonlocal corrections supply a "Weyl fluid" which arises as an effect of the bulkbrane geometry. We show that this Weyl fluid, which is often neglected for matterfree bulk, plays a crucial role in the radiative bulk context. For illustration, we demonstrate that its presence radically changes the perturba-

tion equations, and discuss some of the implications of fluctuations involving it. This will reveal that these fluctuations may grow at late times and they may, in principle, take care of the large amount of inhomogeneities observed in the local universe. We also mention some future directions involving these modified Friedmann equations, which may lead to further interesting results and can even be investigated to find out any possible link with observations.

Title: Matter in the bulk and its consequences on the brane: a possible source of dark energy

Author: Subenoy Chakraborty (JU, Kolkata)

The usual brane world scenario with anti de-Sitter bulk has been generalized by considering a general form of energy momentum tensor in the bulk.The modified Einstein equation on the brane has been constructed.Two examples have been cited of which,the first one shows the usual brane equations when matter in the bulk is a negative cosmological constant.In the second example the bulk matter is in the form of perfect fluid and as a result an effective perfect fluid is obtained in the brane.Also it is noted that the effect of the dust bulk on the brane shows a dark energy behaviour.Finally an emergent universe model has been obtained on the brane.

Title: Brane Inflation: from supergravity to tachyonic

Author: Anjan A. Sen (JMI, New Delhi)

I shall analyse the implication of results coming from CMBR onservations for brane-world model of inflation. Two particular models will be considered: first one is the N=1 Supergravity models, where inflaton potential is dominated by either quadratic or cubic term in the inflaton field and the second one is the rolling tachyon model. We shall discuss the constraint on various model parameters considering the bound on spectral index and its running from CMBR observations.

Title: Bouncing cosmology from brane models

Author: Sudipta Mukherji (IOP, Bhubaneswar)

By considering brane moving in appropriate higher dimensional space-time we construct non-singular universe on the brane. Possible instabilities associated with this model in the semiclassical level along with recent approaches to circumvent these problems will be discussed.

Title: Extra dimensional effects on compact objects

Author: Bikash C. Paul (NBU, Siliguri)

We study compact objects in a higher dimensional space-time. The four dimensional mass to radius ratio obtained by Schwarzchild is generalized within the framework of higher dimensional space-time. We also obtain a class of relativistic solutions of compact stars which is in hydrostatic equilibrium. The effect of extra dimensions are analyzed for a compact star.

Title: Axion-photon interactions in an RS1 Braneworld and CMB anisotropy

Author: Parthasarathi Majumdar (SINP, Kolkata)

I'll begin with string-inspired axion-photon interactions and their implications for cosmic optical activity in an FRW background spacetime. This I shall follow with a discussion of these couplings in warped RS1 spacetime and exhibit the antiwarping that SenGupta and Maity first found, although I'll formulate things a bit differently. I'll discuss one further augmentation of the KR field strength which makes the antiwarping relevant for P-violating polarization anisotropies of the CMB.

Title: Constraining the Randall-Sundrum modulus in the light of recent PVLAS data

Author: Sourav Roy (IACS, Kolkata)

Recent PVLAS data put stringent constraints on the measurement of birefringence and dichroism of electromagnetic waves travelling in constant and homogeneous magnetic field. There have been theoretical predictions in favour of such phenomena when appropriate axion-electromagnetic coupling is assumed. Origin of such a coupling can be traced in a low energy string action from the requirement of quantum consistency. The resulting couplings in such models are artifact of the compactification of the extra dimensions present inevitably in a string scenario. In this work we examine the possible bounds on the value of

compact modulus that emerge from the experimental limits on the coupling obtained from the PVLAS data. In particular we focus into Randall-Sundrum type of warped geometry model and explore the bound on the modulus for a wide range of the axion mass for both the birefringence and the dichroism data in PVLAS. We show that the proposed value of the modulus in RS scenario can only be accommodated for axion mass ~ 0.3 eV.

Title: Particle creation in a warped spacetime with an extra dimension

Author: Suman Ghosh (IIT Kharagpur)

Particle creation in spacetimes with a warped extra dimension is studied. In particular, we investigate the dynamics of a conformally coupled, massless scalar field in a five dimensional warped geometry where the induced metric on the 3–branes are that of a spatially flat cosmological model. We look at situations where the scale of the extra dimension is assumed to (i) be time independent and (ii) have specific functional forms for time dependence. The warp factor is chosen to be that of the Randall–Sundrum model. With particular choices for the functional form of the scale factor we obtain the $|\beta_k|^2$, the particle number and energy densities after solving (whereever possible, analytically but, otherwise, numerically) the conformal scalar field equations. The behaviour of these quantities for the massless and massive Kaluza–Klein modes are examined. Our results show the effect of a warped extra dimension on particle creation and demonstrates that TeV scale particles can indeed be produced on the brane with characteristics depending on both the nature of warping, type of cosmological evolution as well as the temporal evolution of the extra dimension.

Title: Supersymmetric neutral Higgs mass in the ED scenario

Author: Swarup K. Majee (HRI, Allahabad)

The upper limit on the mass of the lightest CP-even neutral Higgs in the minimal supersymmetric standard model is around 135 GeV for soft supersymmetry breaking masses in the 1 TeV range. We demonstrate that this upper limit may be sizably relaxed if supersymmetry is embedded in extra dimensions. We calculate, using the effective potential technique, the radiative corrections to the lightest Higgs mass induced by the Kaluza-Klein towers of quarks and squarks with one and two compactified directions. We observe that the lightest Higgs may comfortably weigh around 200 GeV (300 GeV) with one (two) extra dimension(s).

Title: Unparticle physics at hadron colliders

Author: Prakash Mathews (SINP, Kolkata)

Phenomenological implications of a recent proposal by Georgi – a scale invariant sector weakly coupled to the SM, is considered at the LHC. Signatures of this proposal is compared with some extra dimensional scenarios.

Title: Search for modified gravity and new short-range forces

Author: C.S.Unnikrishnan (TIFR, Mumbai)

I will review the modern laboratory experiments that attempt to detect proposed modifications to standard gravity, especially in the context of higher dimensional theories. Many of these experiments are also sensitive to hypothetical short-range forces coupling to various fundamental charges, and also to the quantum electrodynamical Casimir force. I will mention some future directions in this area that will effectively constrain theories with large extra dimensions of size larger than about 10 micrometer. The difficulties in getting useful constraints below this range will be discussed.

Title: Warped braneworld and flux compactification

Author: Subir Mukhopadhyay (IOP, Bhubaneswar)

I will review some aspects of braneworld model in the set up of flux compactification of string theory. Beginning with RS model, I discuss some features of flux compactification and end with possibilities of making realistic models in this context.

Title: Noncommutative brane-world and (anti) de Sitter black holes

Author: Supriya K. Kar (Delhi University, New Delhi)

We investigate a curved brane-world, inspired by a noncommutative D-brane in a type IIB string theory. We obtain (anti) de Sitter generalized Reissner-Nordstrom-like black holes in the theory. The noncommutative scaling in the frame-work is used to reassure the attractor behaviour at the black hole event horizon.

Title: Black holes in a black string braneworld

Author: Gautam Sengupta (IIT Kanpur)

Rotating black holes are described from the perspective of a single brane Randall-Sundrum brane world. These are shown to arise as intercepts of rotating bulk black strings on the brane, in a black string brane world scenario. We describe both the four dimensional Kerr black hole and the N dimensional Myers-Perry black hole in this framework. The causal structures of the resulting brane world geometries are analyzed through the first order geodesic equations.

Title: Brane world black rings

Author: Anurag Sahay (IIT Kanpur)

Five dimensional neutral rotating black rings are described from a Randall-Sundrum brane world perspective in the bulk black string framework. To this end we consider a rotating black string extension of a five dimensional black ring into the bulk of a six dimensional Randall-Sundrum brane world with a single four brane. The bulk solution intercepts the four brane in a five dimensional black ring with the usual curvature singularity on the brane. The bulk geodesics restricted to the plane of rotation of the black ring are constructed and their projections on the four brane match with the usual black ring geodesics restricted to the same plane. The asymptotic nature of the bulk geodesics are elucidated with reference to a bulk singularity at the AdS horizon. We further discuss the description of a brane world black ring as a limit of a boosted bulk black 2 brane with periodic identification.