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Summary of quantum aspects of gravitation workshop

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Abstract. This is a summary of the presentations at the parallel session on 'Quantum Aspects of Gravitation' (QAG) of the ICGC-2004.

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1. Workshop summary

The QAG workshop was held in two parallel sessions and had a total of nine contributions with varied topics. Where possible, references have been given.

Sumati Surya discussed the Hartle–Hawking wave function of the universe in the presence of a negative cosmological constant. The semiclassical computation of the wave function involves a sum over manifolds of appropriate topology. These are 4-manifolds with a single boundary (instead of two boundaries due to the 'no boundary' proposal) consisting of a Euclidean signature portion joined with a Lorentzian signature portion ('real tunneling geometries'). Although at the extrema of the path integral, Einstein manifolds, the action gives an exponential suppression of 'large' Einstein manifolds, the number of such manifolds can lead to a compensating enhancement. Recent developments regarding the construction of 4 dimensional Einstein spaces using the 'Dehn filling' method, demonstrates such a topological dominance. In particular, it leads to sharp peaks centered on spatial 3 metrics of constant negative curvature suggesting a new mechanism for obtaining local homogeneity in quantum cosmology [1].

Parampreet Singh discussed a new mechanism for the generation of matter–antimatter asymmetry based on loop quantum gravity (LQG). Semiclassical weave states (of geometry and matter) from LQG require a new length scale much larger than the Planck length. This scale is momentum-dependent leading to Lorentz invariance breaking dispersion relations. For (massless) fermions, these distinguish

the different helicity states leading to asymmetry generation via unequal equilibrium densities. Unlike the GUT-based mechanism for asymmetry generation which tends to get washed out during inflation and needs to be regenerated during reheating, the LQG-based mechanism can be imagined to be operative even at lower temperatures and thus re-heating to GUT scales is not needed [2].

Golam M Hossain addressed the issue of Dirac observables in the context of isotropic loop quantum cosmology. He presented a construction of a discrete family of physical observables, associated with any operator diagonal in the triad representation, labeled by the eigenvalues of the triad operator. Such a family picks out a corresponding family of subspaces as domains of the operators. He proposed expressions for physical matrix elements and in particular obtained the physical expectation values of the Hubble operator of LQC [3].

Harbinder Jassal presented her joint work with L Sriramkumar concerning evaluation of the canonical entropy of a massless scalar field at the Hawking temperature in the background of a rotating BTZ black string in the brick wall model. This type of background arises as solutions describing large mass black holes bound to a 2-brane in AdS_4 with negative cosmological constant on the brane. It corresponds to a rotating BTZ black hole on the brane and a rotating black string in the bulk. In spite of additional contributions from the bulk modes, the Bekenstein–Hawking entropy law is recovered for the rotating BTZ black holes on the brane.

Sukanya Sinha discussed a framework for analyzing black hole back reaction from the point of view of quantum open systems using the influence functional formalism. Focusing on a model black hole described by a perturbed quasi-static metric conformally coupled to massless quantum scalar field in the Hartle–Hawking state, it is shown that the close-time-path effective action leads to a non-local dissipation term as well as a stochastic noise term in the corresponding Einstein–Langevine equation. Alternative derivation of CTP effective action in terms of Bogoliubov coefficients, suggests interpretation of the noise terms as measuring the difference in particle production in alternative histories [4].

K C Mani discussed moduli spaces of instantons in various background geometries. In particular he presented the computations of 'information metric' on the moduli spaces.

F Darabi presented a supersymmetric quantum mechanical construction of classes of two-dimensional static space-times such that the Dirac equation is exactly solvable. For the case of modified supersymmetric harmonic oscillator, exact eigenvalues and eigenfunctions of the Dirac operator were given and the space-time was shown to satisfy equations of 2D gravity coupled to electrodynamics [5].

A Rezaei-Aghdam and A Rastkar discussed a non-commutative geometry version of (1 + 4)-dimensional gravity with negative cosmological constant compactified in the Kaluza-Klein manner. The classical solutions were obtained as well as the non-commutative version of Wheeler–DeWitt equation was solved. A solution to the cosmological constant problem was claimed.

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