1 Parallel Session GT4+GT6

1. **Can wormholes have negative temperatures?**

   Sung-Won Kim - South Korea Ewha Women's University

   Soon-Tae Hong

   We study (3+1) Morris-Thorne wormhole to investigate its higher dimensional embedding structures and thermodynamic properties. It is shown that the wormhole is embedded in (5+2) global embedding Minkowski space. This embedding enables us to construct the wormhole entropy and Hawking temperature by exploiting Unruh effects. We also propose a possibility of negative temperature originated from exotic matter distribution of the wormhole.

2. **Semiclassical wormholes**

   Nail Khusnutdinov - Russia Kazan State Pedagogical University

   Smooth-throat wormholes are treated on as possessing quantum fluctuation energy with scalar massive field as its source. Heat kernel coefficients of the Laplace operator are calculated in background of the arbitrary-profile throat wormhole with the help of the zeta-function approach. Two specific profile are considered. Some arguments are given that the wormholes may exist. It serves as a solution of semiclassical Einstein equations in the range of specific values of length and certain radius of wormhole's throat and constant of non-minimal connection.

3. **Stability of thin-shell wormholes**

   Ernesto Fabian Eiroa - Argentina IAFE and Universidad de Buenos Aires

   Gustavo E. Romero

   The stability of spherically symmetric thin-shell wormholes is studied by linearization around a static solution. The presence of large values of charge increases the possibility of obtaining stable wormhole spacetimes with respect to non-charged ones, imposing less severe restrictions on the equation of state of the exotic matter on the throat.

4. **Wormhole dynamics: Rio update**

   Sean Hayward - Korea Ewha Womans University

   This presentation summarizes several recent papers on dynamical properties of traversible wormholes supported by exotic matter with well defined field equations. Firstly, a general dynamical definition of traversible wormhole was proposed and a general theory of wormhole dynamics developed. Secondly, a two-dimensional dilaton gravity model allowed simple examples of various dynamical wormhole processes. Thirdly, the first traversible wormhole described by Morris and Thorne, supported by a ghost Klein-Gordon field, was subjected to pulses of radiation in the first numerical

simulation of wormhole dynamics. The wormhole was found to be unstable, collapsing to a black hole or exploding to an inflationary universe, if the total input energy is respectively positive or negative. Unexplained critical behaviour was found as perturbations tend to zero: a relation between collapse time and initial energy, and a minimal black-hole mass or Hubble parameter. Fourthly, using a recently discovered static wormhole solution supported by pure ghost radiation, and the idealization of impulsive radiation, analytic solutions have been found describing the construction of a traversible wormhole from a Schwarzschild black hole and the enlargement or reduction of such a wormhole.

5. **Interaction of Hawking Radiation With Static Sources in de Sitter Spacetime and Outside a Schwarzschild-de Sitter Black Hole**

   Ivan Costa e Silva - Brasil Instituto De Fsica Terica (Ift-Unesp)

   J. Castieiras

   We study the response of a static source interacting with Hawking Radiation of a massless, conformally coupled Klein-Gordon field in deSitter and Schwarzschild-deSitter spacetimes. We compare the two results between themselves and with the known cases of Schwarzschild and Rindler spacetimes.

6. **Vorticity and Kinks**

   Tina Harriott - Canada Mount Saint Vincent University

   J.G. Williams

   Simple examples of kink spacetimes in 2+1 dimensions are presented. These spacetimes have constant curvature, non-zero vorticity and perfect fluid sources. An analagous example is given in 3+1 dimensions, although the source is a scalar field rather than a fluid.

7. **Perfect fluid sources endowed with slow rotation**

   Ronald Wiltshire - UK University of Glamorgan, UK

   Einstein's equations are presented for the case in which a non-stationary fluid source is endowed with slow rotation. The equations are valid up to and including second order terms in an angular velocity parameter. The conditions for the match of the solutions of the equations with a second order approximation of the Kerr exterior solution are presented. In addition solutions of Einstein's equations satisfying the junctions conditions are developed by means of a series solution approach and a particlar example of the method is discussed. The research discussed here is an extension of Jame's Hartles work on slowly rotating relativistic stars.

8. Action principle formulation for motion of extended bodies in General Relativity

   Parampreet Singh - India Inter-University Centre for Astronomy and Astrophysics

Jeeva Anandan, Naresh Dadhich

We present an action principle formulation for the study of motion of an extended body in General Relativity in the limit of weak gravitational field. This gives the classical equations of motion for multipole moments of arbitrary order coupling to the gravitational field. It also yields the gravitationally induced phase shifts in quantum interference experiments due to the coupling of arbitrary multipole moments.

9. **Gravitomagnetic measurement of the angular momentum of celestial bodies**

   Angelo Tartaglia - Italy Dip. Fisica, Politecnico di Torino

   M. L. Ruggiero

   The asymmetry in the time delay for light rays propagating on opposite sides of a spinning body is analyzed. A frequency shift in the perceived signals is found. A practical procedure is proposed for evidencing the asymmetry, allowing for a measurement of the specific angular momentum of the rotating mass. Orders of magnitude are considered and discussed.

10. **Gravitoelectromagnetism and Inertial Forces in General Relativity**

    Donato Bini - Italy Istituto per le Applicazioni del Calcolo "M. Picone", CNR

    Robert T. Jantzen

    Applications of GEM to the definition of Inertial Forces in General Relativity are considered. Explicit examples are given for black hole spacetimes.

11. **Intrinsic gravitational field and the geodesic deviation equation in the form of a Lorentz force**

    Nikolai V. Mitskievich

    In $D > 3$ spacetimes one can express the Riemann–Christoffel curvature tensor as a sum of the Weyl conformal curvature tensor and simple constructions containing the Ricci tensor and scalar curvature; this suggests a corresponding splitting of the right-hand side of the geodesic deviation equation which now includes terms describing a direct influence of the intrinsic gravitational field (in the Pirani–Schild sense) and the distributed matter on a flow of free particles. We show that the Weyl tensor (intrinsic gravitational) part of the geodesic deviation equation automatically and exactly takes the Lorentz force-type form (with natural additional tensor valences) containing the gravitoelectric and gravitomagnetic parts of the Weyl tensor, in a strict analogy with the electric and magnetic terms in the electromagnetic Lorentz force. In fact, the covariant space-time splitting of the gravitational field equations (rewritten as divergence of the curvature tensor) itself shows an exact and nontrivial analogy with Maxwell's equations.