Amitabha Lahiri

Senior Professor
Theoretical Sciences
amitabha@bose.res.in

Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Pratik Tarafdar; Accreting black hole systems as classical analogue gravity models; Awarded; Tapas K. Das, HRI (Co-supervisor)
2. Subhasish Chakrabarty; Field theoretic approach to gravity; Thesis submitted
3. Shantonu Mukherjee; Some applications of quantum field theory to superconductivity and superfluidity; Under progress
4. Indrajit Ghosh; Fermions in curved spacetime (tentative); Under progress
5. Riya Barik; Neutrino interactions induced by torsion (tentative); Under progress
6. Arnab Chakraborty; Scattering from black holes (tentative); Under progress

Teaching

1. Spring semester; PHY292: Summer Project Research I; Integrated PhD; 1 student
2. Autumn semester; PHY 203: Electromagnetic Theory; Integrated PhD; 5 students
3. Autumn semester; PHY 304: Project Research II; Integrated PhD; 1 student
4. Spring semester; PHY 408: Advanced Statistical Physics; Integrated PhD; 6 students
5. Spring semester; PHY 603: Statistical Physics; PhD; 2 students
6. Spring semester; PHY401: Project Research III; Integrated PhD; 2 students

Publications

a) In journals

1. Shantonu Mukherjee and **Amitabha Lahiri**, *Emergent vortex–electron interaction from dualization*, Annals of Physics, 418, 168167, 2020
2. **Amitabha Lahiri**, *Geometry creates inertia*, International Journal of Modern Physics D, 29, 2043020, 2020

Administrative duties

1. Head, Dept. of Theoretical Sciences (w.e.f. Feb 01, 2021)
2. Chairman, Grievance redressal committee, SNBNCBS

Awards, Recognitions, if any

1. Honorable Mention, Gravity Research Foundation Essay competition, 2020

Membership of Learned Societies

1. Member, Editorial Board, Physics News

Areas of Research

Quantum Field Theory, Gravitation, Mathematical Physics

Gravitation: I studied the dynamics of spin-half fermions on curved spacetimes, using Einstein-Cartan theory of

gravitation in a first order formulation due to Sciama and Kibble. This is equivalent to General Relativity plus a field called torsion, which does not have any dynamics of its own but couples to fermions, leading to a new effective interaction between fermions. Left and right-handed components of fermions couple differently to torsion, which modifies the effective mass of fermions propagating through matter. One can thus say that the geometry of spacetime itself contributes to the inertia of matter particles.

Quantum Field Theory: I also studied, with a student, the dynamics of electrons in presence of vortex strings in the Abelian Higgs model. This can be thought of as a model of type II superconductor with itinerant fermions, analogous to the boson-fermion model of high-T_c superconductor. We investigated a dual formulation of the system and found a nonlocal interaction term between a dual tensor field and the electron field. We calculated the effective field theory by including one-loop quantum effects of the electrons, which produces a topological mass term, giving rise to an effective mass for the photon as well as the tensor field. In addition there is a Coulomb potential between the electrons, but with a large dielectric constant produced by the one-loop effects.

Plan of Future Work Including Project

1. Quantum Field Theory: With a student, I plan to investigate further the interactions of electrons with vortex strings in the Abelian Higgs model. It is known that the non-local interaction can lead to a linear potential between electrons in some cases. We plan to check if that potential can arise in some special cases of the model we have considered. We also plan to do a similar analysis for a 2+1-dimensional system of vortices and electrons, which may be applicable in the theory of fractional quantum Hall effect.
2. Gravitation: With a colleague and a student, I plan to use the energy-momentum conservation equation in a form that includes the effect of a time-varying Newton's constant G, and find the effect on the late time cosmology of a Friedmann-LeMaître-Robertson-Walker universe. With students, I plan to further investigate the effect of space-time torsion on neutrino oscillations.
3. Mathematical Physics: I also plan to continue, with colleagues elsewhere, a long running programme of investigation of categorical geometry, in particular categorical fiber bundles based on a generalization of principal fiber bundles on the space of directed paths on a manifold, and connections on them.

Any other Relevant Information including social impact of research

1. Like all research in basic science, my work will add to what we know about the universe and the theories that describe it. It will lead to new ideas about the origins of neutrino mass and oscillation and the dynamics of spin-half particles like electrons and neutrinos in curved space-time. It will provide a new understanding of the interactions between electrons (or holes) and vortex lines in type II superconductors, possibly new predictions as well. In mathematics my work will contribute to the geometrical understanding of the description and dynamics of extended objects like charged strings. During the course of my research, many new students are trained who in turn will train more students in future and carry forward scientific research in the country.