MHRD Scheme on Global Initiative on Academic Network (GIAN)

Black hole Information Loss Paradox

Overview:

Gravitation is manifested as curvature of spacetime. In particular, gravity affects the causal structure of spacetime. This can lead to the existence of regions which are causally inaccessible to a class of observers. An example of such a region is the portion of spacetime inside the event horizon of a black hole. Classically black holes do not emit anything, but once we include quantum effects, black holes are allowed to emit thermal radiation and thereby lose their mass. The existence of Hawking radiation seems to suggests that quantum evolution in the presence of a black hole could be non unitary and this leads to the black hole information loss paradox. The resolution of this paradox is a major issue in theoretical physics and requires an understanding of the quantum dynamics of gravity.

The course will present an overview of the information loss paradox within semi classical gravity and attempts to resolve the problem. In the later part of the course, we will discuss the fuzzball proposal and show how this offers a resolution of the information loss paradox in string theory.

The course will be divided in three main parts:

- Review of classical black hole solutions, Hawking radiation, Black hole thermodynamics, formulation of the information loss paradox.
- Different possible resolutions of the paradox.
- Discussion of Fuzzball Proposal and the recent development of the firewall problem.

Objectives:

The primary objectives of the course are as follows:

i) Give to the students an understanding of the basic formulation of black hole thermodynamics and derivation of the Hawking radiation.

ii) Provide a complete overview of the information loss paradox.

iii) Providing a review of the various attempts to resolve the paradox, in particular the Fuzzball proposal.

Course details:

Module A: The Formulation of the Paradox.

Day 1 -Day 2:

Introduction to classical black hole solutions, Review of various coordinate systems for black hole space time.

Day 3:

Quantum field theory in black hole space time, vacuum states, Bogoliubov coefficients. Derivation of Hawking radiation.

Day 4:

Black hole thermodynamics. Bekenstein Entropy. Second law for black hole.

Day 5:

Formulation of the information loss paradox.

Module B: Resolution of the Paradox:

Day 4- Day 5:

Review of various attempts to solve the paradox.

Day 6 -7:

String theoretic model for black holes, Micro state counting.

Day 8:

The Fuzzball proposal and information loss paradox.

Module C: The Firewall Problem:

Day 9:

Introduction to the firewall problem.

Day 10:

Fireball and Fuzzball. How to avoId the firewall problem using the fuzzball.

Teaching Faculty:

Samir Mathur is a physicist who has spent over two decades working on the black hole information paradox. His background is in string theory, general relativity, and astrophysics. He has obtained his Ph.D. at the Tata Institute in Bombay, held postdoctoral appointments at the Tata Institute and Harvard, was a junior faculty at MIT, and is now a professor at Ohio State.

Prof. Mathur has contributed significantly towards the understanding of the quantum properties of black holes. His research on black hole information loss paradox based on the ``Fuzzball” proposal is one of the most promising possible resolution of the paradox. Currently, Prof. Mathur is applying these insights to understanding the singularity at the origin of the Universe—the Big Bang.

Who can attend:

The course is primarily for Ph.D students and junior postdocs working in theoretical physics. Final year M.Sc students who has some exposure to general relativity may also apply. In addition, there will be few openings for interested Faculty members.

Course Coordinator

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