A Course on Black Hole Physics

Lecturer: M.M. Sheikh-Jabbari

This is a PhD level course, designed for second year PhD students in Theoretical High Energy Physics (HEP-TH) area and is equivalent to 4 units (one semester course with 4 hours a day). It assumes a background knowledge of Quantum Field Theory at the level of Peskin-Schroeder book and General Relativity, basic familiarity with Schwarzchild solution and Einstein equations.

The course will have two essentially separate parts. First part will be about black holes as classical solution to Einstein equations and and the second will be on semiclassical or quantum aspects of black holes.

1 Black holes, classical aspects

Topics covered in this part are

- Black hole geometry as viewed by various observers
- Causal and singularity structure of black hole
- Various four-dimensional black hole geometries, geodesics and isometries
- Formation of black holes, gravitational collapse
- Brief discussion on astrophysical black holes
- Black holes in 3d; AdS_3 black holes.
- Black holes and black rings in 5d.

In this part I will use **Black Holes** Lecture notes by *P.K. Townsend*, DAMTP, University of Cambridge, UK, *arXiv:gr-qc/9707012*, the book by Hawking and G. Ellis, *The Large Scale Structure of Space-Time (Cambridge Monographs on Mathematical Physics, 1975)*, which is a bit old but still very good.

The usual GR books can also be useful, especially their "second halves" when they talk about black holes.

2 Black holes, semiclassical and quantum aspects

Topics covered in this part include

- Laws of black hole mechanics
- Wlad's derivation of the first law
- Quantum field theory on black hole background
- Horizons have temperature, the *Unruh effect*
- Bekenstein argument, black hole entropy,

- Hawking radiation
- Black hole complementarity
- Evaporation of black holes and Page time.
- More recent developments, firewall controversy, black holes on AdS and ...

Main references for this part of the course are:

Black Holes Lecture notes by *P.K. Townsend*, DAMTP, University of Cambridge, UK, *arXiv:gr-qc/9707012*,

An Introduction to Black holes, Information and the string theory revolution By *L. Susskind & J. Lindesay*, World Scientific, 2005.

Modeling Black Hole Evaporation By *A. Fabbri & J. Navarro-Salas*, Imperial College Press, 2005.

Date and time of lectures

Place: Lectures will be in Farmanieh Bldg of IPM.

Time: Sunday and Tuesday morning, 10-12am.

Starting date: 4th of Aban, 22nd of Oct.