Black Holes (L24)

Professor H. Reall

A black hole is a region of space-time that is causally disconnected from the rest of the Universe. Black holes are of huge importance both in astrophysics and in attempts to develop a quantum theory of gravity.

This course will build on the General Relativity course to develop the mathematics required to study classical properties of black holes. It will then build on the Quantum Field Theory course to discuss quantum aspects of black holes. Topics to be discussed will include:

- Upper mass limit for relativistic stars. Schwarzschild black hole. Gravitational collapse.
- Causal structure, null geodesic congruences, Penrose singularity theorem.
- Penrose diagrams, asymptotic flatness, cosmic censorship.
- Reissner-Nordstrom and Kerr black holes.
- Energy, angular momentum and charge in curved spacetime.
- The laws of black hole mechanics.
- Quantum field theory in curved spacetime. The Hawking effect and its implications.

Prerequisites

Familiarity with the Michaelmas term courses *General Relativity* and *Quantum Field Theory* is essential.

Literature

1. H. S. Reall, *Part 3 Black Holes*: lecture notes available at `www.damtp.cam.ac.uk/user/hsr1000`
2. R.M. Wald, *General relativity*, University of Chicago Press, 1984.
3. S.W. Hawking and G.F.R. Ellis, *The large scale structure of space-time*, Cambridge University Press, 1973.
4. V.P. Frolov and I.D. Novikov, *Black holes physics*, Kluwer, 1998.
5. N.D. Birrell and P.C.W. Davies, *Quantum fields in curved space*, Cambridge University Press, 1982.
6. R.M. Wald, *Quantum field theory in curved spacetime and black hole thermodynamics*, University of Chicago Press, 1994.

Additional support

Four examples sheets will be provided and four associated examples classes will be given. There will be a one-hour revision class in the Easter Term.