Astrophysical black holes (L16)

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Black holes are one of the most fascinating objects lying at the interface of mathematics, physics and astronomy. From the astrophysical stand point they give rise to extremely rich and complex phenomena occurring from sub-parsec to Mega-parsec scales and covering the full electromagnetic spectrum. A large body of state-of-the-art current and upcoming observational facilities and theoretical models is aimed at investigating black hole properties and their link with the larger scale environment, making this an exciting and fast paced research field. With the recent gravitational wave detections of merging black hole binaries the field has experienced further stimulus, as black holes have become unique multi-messengers to explore cosmology, gravity in the strong regime, high energy phenomena and complex (magneto)hydrodynamic flows.

This course will cover a range of concepts pertinent to astrophysical (supermassive) black holes highlighting both observational and theoretical advances in the field. The aim of the course is to give an overview of the possible formation and growth channels of these objects and to discuss various mechanisms through which black holes interact with their surroundings, with the synopsis as follows:

- Basic concepts; observational evidence for dormant and non-dormant objects (SgrA*)
- AGN properties and classification
- Formation pathways for supermassive black holes
- Black hole growth overview
- Fuelling mechanisms from kpc to sub-pc scales
- Bondi-Hoyle solution and limitations
- Accretion disk models: thin, slim and thick discs
- Outflows: basic concepts; collimated wind and jet phenomena
- Energy-, momentum- and radiation pressure-driven outflow solutions
- Impact of outflows on host properties

Prerequisites

Good knowledge of material covered in Part II courses: Astrophysical fluid dynamics, stellar dynamics and structure of galaxies, structure and evolution of stars is required. Some knowledge of (thermo)dynamics, electromagnetism and galaxy formation is advantageous but not strictly necessary.

Literature

1. Frank, J., King, A. R., & Raine, D., *Accretion Power in Astrophysics*, Cambridge University Press, 2002.

2. Netzer, H., *The Physics and Evolution of Active Galactic Nuclei*, Cambridge University Press, 2013.

3. Misner C. W., Thorne K. S., & Wheeler J. A., *Gravitation*, W. H. Freeman and company, 1973.

4. Pringle, J. E., & King, A. R., *Astrophysical Flows*, Cambridge University Press, 2007.

Additional support

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