PX3A9-15 Black Holes, White Dwarfs and Neutron Stars

24/25

Department
  Physics
Level
  Undergraduate Level 3
Module leader
  Deanne Coppejans
Credit value
  15
Module duration
  10 weeks
Assessment
  100% exam
Study location
  University of Warwick main campus, Coventry

Description

Introductory description

We will discuss the compact objects - white dwarfs, neutron stars and black holes (BH) - that can form when burnt out stars collapse under their own gravity. The extreme conditions in their neighbourhood mean that they affect strongly all nearby objects as well as the surrounding structure of space-time. For example, they can lead to very high luminosity phenomena, such as synchrotron radiation and jets of ionised particles that we can observe from Earth.

These compact objects accrete material from surrounding gases and nearby stars. In the case of BHs this can lead to the supermassive BHs thought to be at the centre of most galaxies. In the most extreme events (mergers of these objects), the gravitational waves (GW) that are emitted can sometimes be detected on earth (the first GW detection was reported in 2015 almost exactly 100 years after their prediction by Einstein).

Module web page

Module aims

To cover the physics of black holes, white dwarfs and neutron stars highlighting the role of observation. To give an overview of the possible formation and growth channels of these objects and to discuss their interactions.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

1. Radiation processes and observational techniques: radiation from free electrons, synchrotron radiation, cyclotron radiation, thermal Bremsstrahlung from hot accretion plasmas, observational instrumentation, detectors
2. Formation of black holes, neutron stars and white dwarfs: Stellar evolution, supernovae (core-collapse and thermonuclear)
3. Physics of degenerate matter: Equation of state, electron and neutron degenerate matter, mass-radius relationship
4. Accretion onto compact objects as a source of energy: Binary stars, mass transfer, structure and the emission of accretion disks, accretion onto magnetic stars, Alfvén radius, Eddington limit - a maximum accretion rate, jets
5. Pulsar physics: Origin and evolution of magnetic field and spin rate, pulsar mechanism, millisecond pulsars
6. Black holes: Mass distribution, relativistic effects, active galactic nuclei
7. Gravitational waves: properties of gravitational waves and their effect on space-time, indirect and direct detection methods, mergers of black holes and neutron stars

Learning outcomes

By the end of the module, students should be able to:

- Identify the major emission mechanisms for electromagnetic and gravitational waves of astrophysical objects
- Quantify the physical conditions in a variety of astrophysical systems on the basis of measured data
- Describe the formation and evolutionary pathways of black holes, neutron stars, and white dwarfs in isolated and binary systems
- Describe the observational methodologies used to study gravitational waves

Indicative reading list

BW Carroll and DA Ostlie, An Introduction to Modern Astrophysics, CUP;
J Frank, AR King and DJ Raine, Accretion Power in Astrophysics, CUP;
C Hellier Cataclysmic Variables: How and why they vary, Springer

[View reading list on Talis Aspire]

Subject specific skills

Knowledge of mathematics and physics. Skills in modelling, reasoning, thinking.

Transferable skills

Analytical, communication, problem-solving, self-study

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Private study	120 hours (80%)
Total	150 hours

Private study description

Working through lecture notes, solving problems, wider reading, discussing with others taking the module, revising for exam, practising on past exam papers

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group B1

	Weighting	Study time
In-person Examination	100%	
Answer 3 questions		

- Answerbook Pink (12 page)
- Students may use a calculator

Feedback on assessment

Personal tutor, group feedback

[Past exam papers for PX3A9](#)

Availability

Courses

This module is Core for:

- UPXA-F3F5 Undergraduate Physics with Astrophysics (BSc)
  - Year 3 of F3F5 Physics with Astrophysics
  - Year 3 of F3F5 Physics with Astrophysics
- Year 3 of UPXA-F3FA Undergraduate Physics with Astrophysics (MPhys)

This module is Optional for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
  - Year 3 of G105 Mathematics (MMath) with Intercalated Year
  - Year 4 of G105 Mathematics (MMath) with Intercalated Year
- UMAA-G100 Undergraduate Mathematics (BSc)
  - Year 3 of G100 Mathematics
  - Year 3 of G100 Mathematics
  - Year 3 of G100 Mathematics
- UMAA-G103 Undergraduate Mathematics (MMath)
  - Year 3 of G100 Mathematics
  - Year 3 of G103 Mathematics (MMath)
  - Year 3 of G103 Mathematics (MMath)
  - Year 4 of G103 Mathematics (MMath)
  - Year 4 of G103 Mathematics (MMath)
- UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
  - Year 3 of G106 Mathematics (MMath) with Study in Europe
  - Year 4 of G106 Mathematics (MMath) with Study in Europe
- UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
  - Year 3 of GF13 Mathematics and Physics
  - Year 3 of GF13 Mathematics and Physics
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
  - Year 3 of FG31 Mathematics and Physics (MMathPhys)
  - Year 3 of FG31 Mathematics and Physics (MMathPhys)
- Year 4 of UPXA-GF14 Undergraduate Mathematics and Physics (with Intercalated Year)
- UPXA-F300 Undergraduate Physics (BSc)
  - Year 3 of F300 Physics
  - Year 3 of F300 Physics
  - Year 3 of F300 Physics
- UPXA-F303 Undergraduate Physics (MPhys)
  - Year 3 of F300 Physics
  - Year 3 of F303 Physics (MPhys)
- Year 4 of UPXA-F301 Undergraduate Physics (with Intercalated Year)