2016 Honours, Masters and Graduate Course on Astrophysical Gas Dynamics

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http://www.mso.anu.edu.au/∼geoff/AGD

1 Lectures and tutorials

- Dates:
  - First set of lectures 15 Feb – 1 April
  - Easter break: 25 March – 28 March (inclusive)
  - Mid semester teaching break: 4 April – 15 April (inclusive)
  - 2nd set of lectures 18 April – 27 May
- 4 contact hours per week. Nominally this will comprise 3×1 hr lectures plus 1 hr tutorial but the allocation may vary depending on progress in problem sets etc. In particular, I may ask students to work on a problem part way through a lecture.
- Schedule:
  - Monday: Lecture 9:30 – 10:30; Morning tea/coffee 10:30 – 11:00; Lecture 11:00 – 12:00
  - Friday: Lecture Lecture 9:30 – 10:30; Morning tea/coffee 10:30 – 11:00; Tutorial 11:00 – 12:00
  - All lectures and tutorial are in the Woolley Seminar Room.

All course material – lectures, exercises, solutions and supplementary notes will be available from the course web site: http://www.mso.anu.edu.au/∼geoff/AGD

2 Topics

Topic	Approximate No. of lectures	Content
Fundamental fluid equations	4	Derivation of gas dynamics equations from Continuum Mechanics Mass, momentum and energy flux
Sound waves	2	Sound speed and energy transport via sound waves
Simple Waves	2	Exact non-linear solutions leading to shock waves
Unmagnetised shocks	2	Theory of shocks Shocks from initial conditions
Magnetohydrodynamics	2	Additional terms in gas dynamics equations Magnetic pressure and pinch
MHD waves	2	Alfven and magnetoacoustic waves
Magnetised shocks	2	Magnetic shocks Amplification of magnetic field
Spherical winds and accretion	4	Theory of winds and accretion Critical points
Bubbles	2	Bubbles driven by winds from stars and galaxies
The Sedov solution	3	Example of a self-similar solution Atom bombs and supernova remnants
Kelvin-Helmholtz instability	2	Introduction to instabilities in fluids; KH instability
Relativistic fluids	2	Formulation of fluid equations in special relativity
Relativistic shocks	2	Theory of unmagnetized relativistic shocks
Relativistic application	2	Dynamics of radio galaxies

3 Assessment

Assessment will be via assignments consisting of about 40-50 questions in total. Assignments consisting of about 3-4 questions will be set approximately every week.

A number of assignment questions will involve a substantial computing component, e.g. numerically solving differential equations and plotting the solutions.

I need to be firm on the dates for handing in of assignments. This is so that I can post solutions for students who have completed their assignments on time.

4 Credit

This course is worth 6 units.

5 Prerequisites and assumed knowledge

You need a good knowledge of calculus, including partial derivatives, ordinary and partial differential equations and electromagnetism.

I make extensive use of Cartesian tensors, which I regard as assumed knowledge. Notes on these are available on my web page.

6 Reference books

(Hopefully) you will find that my lecture notes contain all that you will need in this course. However, the following books are valuable references, which will consolidate and take you beyond this course.

- T. J. M. Boyd and J. J. Sanderson, *The Physics of Plasmas*
- T. G. Cowling, *Magnetohydrodynamics* – an oldie (1958) but a goodie. This provided my first introduction to MHD.
- L.D.Landau and E.M. Lifshitz, *Fluid Mechanics, Second Edition: Volume 6 (Course of Theoretical Physics)* – a classic text from which I first learnt fluid mechanics.
- L.D.Landau, L. P. Pitaevskii and E.M. Lifshitz, *Electrodynamics of Continuous Media, Second Edition: Volume 8 (Course of Theoretical Physics)*
- Frank H Shu, *The Physics of Astrophysics Volume II: Gas Dynamics*