Course for Graduate / Undergraduate Students:
'The Structure and Dynamics of Discs In Astrophysical Systems'

Synopsis: This course will address the physics of a variety of astrophysical systems in which a disc-like structure plays an important role in the motion of matter and the transfer of energy in the system. We will commence at relatively small scales by considering the discs of magnetized plasma or 'magnetodiscs' that are observed near the equatorial plane of rapidly rotating planetary magnetospheres, focussing in particular on the planets Jupiter and Saturn, making use of relevant observations from the *Cassini* and *Galileo* space missions, and exploring the role of planetary magnetic fields and rotation. We then move to 'stellar' scales, and consider theory and observation related to the physical processes acting in accretion discs and other types of accretion structures found around stars, both unmagnetized and magnetized. Finally, we will consider the 'galactic' scale, and explore the role of stellar dynamics and gravity in shaping disc-like collections of stars found within certain types of galaxy, including our own Milky Way.

Timetable / Assessment:
The tentative suggested time for the course is during November, 2015 (4 weeks). In each week, there will be 4 hours of lectures plus two hours of tutorial / problem-solving classes (this will be extended to 3 hours in the final week). The tutorials will usually take the form of a 2-hour session where the students will work on problem sheets handed out at the first session of each week by Dr. Achilleos. Hence, there will be 25 hours of time assigned in total to course-related activities comprising lectures and consolidation of learning via problem-solving and discussions. The final assessment will be done via a written assignment, covering an appropriate breadth of the course material to be submitted within two weeks after the final course session.

Lecturer: Dr. Nicholas Achilleos has strong experience as a Physics lecturer at University College London, having delivered most recently courses in Physics of the Earth (lectured for five years) and Practical Mathematics (Numerical Methods and Computational Techniques, lectured for two years). He has also delivered lectures on planetary atmospheres and magnetospheres for summer schools in the UK aimed at graduate students. Most recently, he has delivered lectures on 'Seasonal-Planetary Connections' and 'Planetary Magnetospheres' for the Heliophysics Summer School at UCAR in Boulder, Colorado – the recordings and notes for these can be downloaded from here:
http://www.vsp.ucar.edu/Heliophysics/summer-about-schedule.shtml

Lecture Topics:
Week 1:
Planetary Magnetodiscs
- Particle Motion in Magnetospheres.
- Magnetohydrodynamics.
- The Earth's Magnetosphere.
- Giant Rotating Magnetospheres and Theory of Magnetodisc Structure.

- Magnetodisc-Planet Coupling, including Hill's Theory.

Weeks 2-3:
Planetary Magnetodiscs
- Radial Plasma Transport in Magnetodiscs, including theory of Flux Tube Interchange.
- Role of Magnetic Reconnection in Magnetospheric Dynamics.

Accretion Discs and Flows Around Stars
- Introduction to Stellar Accretion and the Eddington Limit.
- Accretion with Angular Momentum: Theory of Accretion Disc Structure.
- Role of Viscous Spreading and Radiation Pressure in Disc Structure.
- Disc Accretion onto a Magnetized Star (White Dwarf) and Disc-Star Coupling.
- Stream Accretion onto a Magnetized Star (White Dwarf).
- Formation and 'Permanence' of Accretion Discs.
- Accretion-Spin Equilibrium.
- The Soft X-Ray 'Puzzle'.

Week 4:
Galactic Discs and Course Summary
- Introduction to Potential Theory: Spherical Systems and Discs.
- Theory of Stellar Orbits
- Equilibria of Collisionless Systems.
- Overview and Comparison of Planetary Magnetodiscs, Stellar Accretion Discs and Galactic Discs.

Main Bibliography

- *'Introduction to Space Physics' (ed. Kivelson and Russell);*
- *'Basic Space Plasma Physics' (Baumjohann / Treumann);*
- *'Heliophysics 1: Plasma Physics of the Local Cosmos' textbook (ed. Schrijver / Siscoe);*
- *'Jupiter: The Planet, Satellites and Magnetosphere' book (ed. Bagenal, Dowling, McKinnon);*
- *'Physics of the Jovian Magnetosphere' (ed. Dessler)*
- *'Accretion on to Magnetic White Dwarfs', Dayal Wickramasinghe,* EPJ Web of Conferences 64, 03001 (2014)
- *'Theory of Disk Accretion onto Magnetic Stars', Dong Lai,* EPJ Web of Conferences 64, 01001 (2014)
- *Lynden-Bell D. & Pringle J. E. (1974), Mon. Not. R. Astron. Soc., 168, 603*
- *Binney, J. and Tremaine, S., 'Galactic Dynamics'*
- *Miscellaneous scientific journal articles will also be cited within the lecture notes as appropriate.*