Brief account of research

In this brief account of my research I describe in chronological order the research I have carried out during different periods of my career.

South Africa (1984-1988):

I began my research career as an applied mathematician working on wave-particle interactions in plasmas, in space and astrophysics. The work of my PhD thesis consisted of using both analytical and numerical methods to solve a range of wave propagation and hydrodynamical problems in a variety of plasma environments. I worked on a variety of topics under the guidance of my PhD supervisor (J. F. McKenzie), ranging from the propagation of electrostatic type Rossby waves in a magnetised plasma; the role of cosmic rays and Alfven waves on the galactic gas distribution and halo; and the role of Alfven waves and thermal gas pressure forces in driving stellar winds. The topics were at the time and still are of current interest in solar and stellar wind theory and my contribution extended previous work in the field and considered analytical and numerical aspects not considered elsewhere.

Germany (1989-1990):

I continued my work on problems dealing with the structure of the galactic halo, solar wind problems as well as an extension to galactic winds. I led the analysis of the compressional instability in the solar wind driven by wave dissipation and worked in conjunction with colleagues on a model that predicted a static halo cannot exist in our galaxy and that a steady outflow or galactic wind is to be expected. The propagation and damping properties of hydromagnetic waves in the Local Interstellar medium were also investigated collaboratively.

Imperial College (1991 – to date):

My research area changed direction following my move to Imperial, I became more involved in data analysis and concentrated initially on the fields of dusty and interpenetrating plasmas before moving into the area of planetary magnetospheric physics in which I now concentrate my efforts.

My initial work at Imperial began with an analysis of wave propagation in cold multi-fluid plasmas which I led (under the supervision of D. J. Southwood) showing that the behaviour of low frequency wave modes is strongly modified by the existence of heavy ion species or charged dust grains. In addition I collaborated on analysis of Phobos data from Mars and the interaction of the solar wind with a thin charged dust torus.

I then began to play a major role in the analysis of magnetic field and particle data from the Ulysses flyby of the planet Jupiter and my initial role within the team was to generate a magnetic field model in preparation for the flyby itself. I then lead the analysis of the internal Jovian field and revealed that there was no evidence for secular change in the planetary field over an 18 year period. I also discovered intense field aligned currents in the flyby data set leading to an analysis revealing that these currents were observed in the form of multiple sheets – evidence of the magnetosphere/ionosphere coupling which arises in the Jovian magnetosphere. I then initiated a comparison between the in-situ field aligned currents and remote observations by the Hubble Space telescope of Jovian aurora and for the first time at a planet other than the Earth was able to reveal a direct link between the current signatures and auroral images.

During this period I was also involved in collaborative work with a variety of magnetometer and other instrument team members on analysing null fields which seem to be a permanent feature within fast rotating magnetospheres. We proposed that such features are formed by the breaking off of material from the outer edge of the plasma sheet and they probably represent an important mechanism for outward transport and loss of material from the magnetosphere. I was instrumental in setting up a range of collaborations with a variety of Ulysses scientists initiating comparisons between the various available data sets, as evidenced by a number of collaborative papers from that time. I also continued my collaboration with colleagues analysing the Phobos Mars data sets and have also been involved in analysis of the first direct observations of Jovian auroral electrojets at Jupiter. These supersonic winds flow around the auroral oval and play a key role in the transport of energy.

More recently as I have begun to take on a supervisory and managerial role, I have initiated a number of different studies with PhD students and PDRA's. These include analysis of the wave spectrum observed in the Jovian magnetosphere via ion cyclotron waves in the first instance and longer period waves of order 10/20 and 40/80 minutes in the second. The ion cyclotron analysis has revealed a wealth of wave activity within the Jovian current sheet with a large variety of heavy ions potentially being responsible for the excitation. Such waves can be used as a diagnostic as to the different ion species which arise in the plasma and may also be used as a means of coupling different species via wave-particle interactions. The longer period waves first observed in the Ulysses and Voyager data sets have also been observed to be prevalent in the Galileo orbiter data set as well, suggesting that such low frequency waves are a global phenomenon at Jupiter, with the implication being that the entire magnetosphere is resonating at these frequencies.

In the last few years I have begun to play a major role in the Cassini magnetometer team, first as lead science Co-Investigator, then as a regular stand-in for the Principal Investigator (PI) and more recently as acting PI. The responsibilities include a managerial role, not only as regards the team based at Imperial but also in managing the large international team which we have based in the UK, Germany, Hungary and the USA. In addition I am responsible for the magnetometer science planning for the four years of orbits which the Cassini spacecraft will follow on reaching Saturn, for leading analysis of previous data sets from Saturn, for ensuring field models and software are in place before Saturn Orbit Insertion and also more recently leading the science analysis of data obtained from the recent Earth and Jupiter flybys and collaborating with the other instrument teams involved in this mission.

Initial analysis of the unique Cassini/Galileo data set from the Jupiter flyby has only just begun as evidenced by a number of collaborative papers which have already been accepted by Nature. This is just the start of a wealth of scientific discoveries which will result from this planetary mission which is going to form the basis of research in this field for the next decade. I have requested funding for 3 new PDRA places over the next 3 years to allow us to fully exploit the Saturn magnetospheric science, Titan and icy satellite science which will result from this large international mission. Re-analysis of previous flyby data sets, a study I initiated with a PhD student, has revealed a surprising modulation at the planetary rotation period which has important implications for the structure of the Saturnian internal magnetic field, an understanding of which is our primary science objective once we reach Saturn.

A very rich science harvest will result from this mission and I will lead the analysis on; the resolution of the internal Saturn field to fourth/fifth order (via the unique scalar mode of the instrument), the magnetosphere/ionosphere coupling which results within Saturn's magnetosphere, as well as an investigation of the influence which the solar wind and its interplanetary magnetic field has on the Saturnian environment. I am also particularly interested in the implications of magnetic perturbations in the vicinity of Titan and the icy satellites, which will allow us to better understand the interior structure of these bodies.