**The role of magnetic fields in star birth and star death**

**Magnetic fields are fundamental in astrophysics.** Most gas in the universe is ionised, meaning that electrons are not bound to their parent atoms and are able to move and create electric currents which in turn create magnetic fields. This means that magnetic fields are important for nearly every problem in astrophysics, including our own Sun, gas flow in the galaxy, in the space between stars, the supernovae explosions of stars when they die and in many other problems.

**Magnetic fields are fundamental in star formation.** How stars like the Sun form is one of the biggest puzzles in astrophysics, and magnetic fields play a central role in this jigsaw. In the last decade, through work done here in Exeter, we have come to learn that stars like our Sun most likely do not form in isolation but in violent, chaotic conditions in star clusters formed from the gravitational collapse of molecular gas clouds in the spiral arms of galaxies. Observations of polarised light from star forming molecular clouds in our own Galaxy (such as the Orion nebula) show that magnetic fields are present in these clouds and are having a strong influence on the gas flow in them. In our current theoretical picture the observed magnetic fields are thought to be crucial in controlling the turbulent motion of gas in the molecular clouds from which the stars form and in slowing the spin of regions of gas which are collapsing under their own gravity.

**Magnetic fields are fundamental to how we got here.** The puzzle of star formation is part of our quest as human beings to discover how us, our wonderful planet and incredible universe came about. Understanding how stars like our own Sun can form from the gas in galaxies and how planets may then form around such stars is central to this quest. The rich array of physics involved in studying the process of star and planet formation makes this an exciting field to work in. Computer simulations mean that we can study processes which in reality take hundreds of thousands or even millions of years in a few months of supercomputer time.

**Magnetic fields produce some of the most wonderful phenomena in the universe.** They are thought to power the amazing jets and outflows seen in Hubble Space Telescope images of star forming regions and the centres of active galaxies. Magnetic fields are also thought to be the power behind the brightest explosions in the Universe since the Big Bang, the mysterious Gamma Ray Bursts. I have recently performed the world’s first simulations of magnetic fields in the collision of two neutron stars, driven together by the emission of gravitational waves – producing magnetic fields stronger than any previously known in the universe and providing the energy required to launch a burst of ultra-high-energy Gamma Rays bright enough to travel half way across the universe to be observed on Earth as a Gamma Ray Burst. I want to continue to explore the exciting and spectacular physics in these simulations.

**I am at the forefront of being able to include magnetic fields in a wide range of astrophysical simulations.** Through the development of a new method for computer simulations of gas dynamics which include magnetic fields I am in the exciting position of being able to study these effects for the first time. This opens a wide range of problems to study, with potential for spin-off applications in fundamental Earth-bound problems such as nuclear fusion research.

**I will be able to perform the first simulations of star cluster formation which take account of magnetic fields in the star formation process.** These spectacular supercomputer simulations of star formation will help us finally resolve some of the problems which have dogged star formation theory for decades. Our simulations will be the first which follow the collapse of a molecular cloud in a galaxy all the way to the formation of individual stars and brown dwarfs (stars too small to fuse hydrogen), taking account of the crucial influence of magnetic fields. We will be able to see how the magnetic fields channel the gas onto young stars and help prevent other parts of the cloud from collapsing.