PhD project within the Centre for Fusion, Space and Astrophysics
Supervisor: Dr Dirk Gericke

Diamond Formation in Giant Ice Planets

The internal structure of a planet, that the distribution of material and its density, is largely defined by hydrostatic equilibrium: in gas and icy giants like Jupiter and Neptune, respectively, the gas or plasma pressure of the compressed internal layers must hold the weight of the upper layers. Therefore, the phase and the pressure of the material as a function of compression are the main ingredient for planet modelling. While the upper layers consist of usual gases that get more and more compressed, the mantel of the planet is ionised, mostly, due to the high compression of the materials. Accordingly, we need a good understanding of both highly compressed neutral gases as well as ionised matter under large pressures and at moderate temperature (few thousand degrees).

The most dramatic change to the structure of gas and ice giants is related to phase transition at large pressures. Such transitions can prohibit convection (like the creation of clouds in the earths atmosphere) and, thus, may constitute layer boundaries with different compositions on each side. In ice giants, we find a rich composition of gases in the observable layers: methane, ammonia or water are present. Moreover, experiments and simulations have found a large range of phases when these materials are put under the extreme pressures of the deeper layers of the planets. One of the most prominent predictions was the phase separation of hydrogen and carbon from hydrocarbons. Based on this predictions, Ross ask in 1981 "Are there diamonds in the sky?". It took more than 30 years until this question could be answered positively by new laboratory experiments. However, the full range of pressures and temperatures inside a planet is too large to be tested experimentally. Here, simulations and theory estimates are needed.

The project will be based on the recent data on diamond formation in carbon (from graphite) and carbohydrates the under large pressures in icy planets and explore possible consequences of diamond formation and diamond rain for the inner structure and energy balance of icy planets which includes a number of exoplanets with high carbon content. Question to be answered are the possible size of the diamonds, the region of their occurrence, the energy release due to the sinking diamonds in the gravitational field etc. To answer these questions, a new evolutionary model needs to be developed. Gaps in the experimental records should be closed by ab initio simulations (tools exist). Moreover, the project will also support new experimental campaigns by providing predictions and determination of important parameter regions within the existing collaboration.