Electromagnetic Sounding of Ocean Worlds

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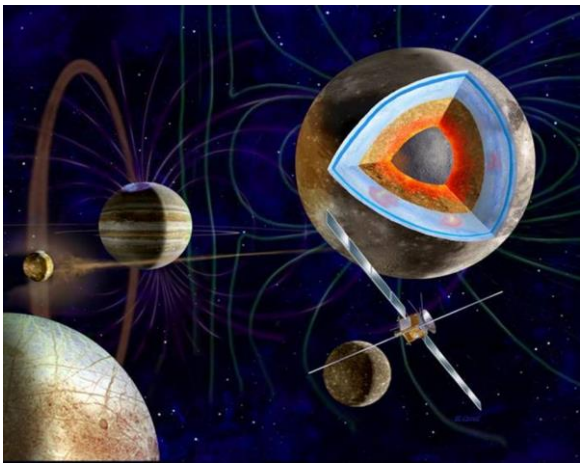

JUICE mission. Credit: ESA.

If we eventually find extra-terrestrial life in the Solar System it will probably be found inside an ocean world. These are a handful of large, almost planet-sized moons orbiting Jupiter and Saturn. Each moon has a surface layer of solid ice that is kilometres thick, and all have a layer of liquid water underneath. Because of the presence of liquid water, the stability of these environments over long timescales, and evidence of geological activity in some cases, all the known ocean worlds stand out as potential habitats. The European Space Agency's Jupiter Icy Moon Explorer (JUICE) mission launched in April 2023 and is now on its way to Jupiter, with a primary goal to assess the habitability of Jupiter's ocean worlds: Europa, Ganymede, and Callisto.

At Imperial College London we have played a leading role in discovering ocean worlds, and we have provided the magnetic field experiment (magnetometer) that is now flying on JUICE. Our instrument will measure the complex magnetic field environments in space around each ocean world, probing each ocean beneath the ice by resolving the fields that are caused by electromagnetic induction occurring in the water far below. We will effectively use well-understood variability in Jupiter's magnetic field as a "natural metal detector". Isolating and studying the induced magnetic fields will provide information about each ocean, especially at Ganymede, where we will constrain the depth and composition of the ocean once JUICE is in orbit in the 2030s.

This PhD project will involve theory and modelling of the inductive response of all ocean worlds around the giant planets, which forms the basis of electromagnetic sounding in each case. The student will assess how each electrically conducting ocean responds to external magnetic signals across a wide range of frequencies, not just the discrete frequencies that have been the focus of most work to date. The student will establish how deviations away from perfectly spherical surfaces of constant conductivity affect the induced fields produced above the surface, and as the project progresses there is potential to investigate fields arising from ocean circulation. The results of this project will directly feed into our preparations for JUICE arrival at Jupiter, as well as future science cases for exploring different ocean worlds.

The student will join a team of active researchers studying all the planets in the Solar System. This team sits within the diverse and dynamic Space, Plasma and Climate Community within the Department of Physics. More broadly, the student will also join the international JUICE and ocean world science communities. Prospective applicants are encouraged to contact the supervisor for further information.