The University of Oxford Department of Earth Sciences

EARTHSCIENCES

UNIVERSITY OF OXFORD

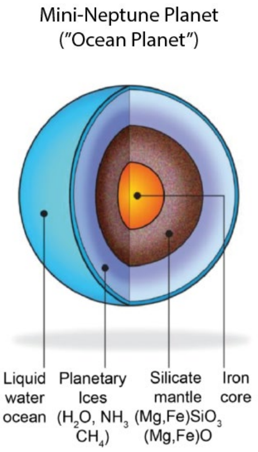
Experimental Study of Planetary Ices at High-Pressure/-Temperature Using dynamic diamond-anvil cells

Supervisory Team	**Prof. Hauke Marquardt (https://www.earth.ox.ac.uk/people/hauke-marquardt/)** **Dr. Hanns-Peter Liermann, DESY (link)**

Key Words	**Mineral physics, planetary interiors, high-pressure ices**

Overview

Understanding the composition, structure and dynamics of planetary interiors is key to model the formation, evolution and future of planetary systems. Planetary ice compounds, including H_2O, NH_3 and CH_4 ice phases, make up a significant portion of several planetary bodies, both in and outside of the Solar System. Notably, there is a breath-taking increase in the amount of observed candidate exoplanets with sizes in between the Earth and the solar gas giant planets that are lacking an analogue in the solar system. Vital to our understanding of these super-Earth and mini-Neptune exoplanets, as well as planetary bodies within our own Solar System, are accurate knowledge of the phase diagram, equation of state, phase transition kinetics, and the melting behavior of "planetary ices", particularly H_2O, NH_3, CH_4 ice.



Possible structure and composition of a mini-Neptune planet (illustration modified from NASA).

The aim of this project is to measure the phase diagrams and compression behavior of planetary ices using novel high-pressure/-temperature experiments coupled with time-resolved diagnostics.
The new measurements will constrain the phase diagram and physical properties of planetary ice compounds at high-pressure/-temperature. The results will lead to improved planetary interior models.

Methodology

The here-proposed experiments will be conducted using recently-developed heated dynamic Diamond-anvil cells (dDACs) (Jenei et al. 2019, Mendez et al. 2020) as well as traditional high-pressure optical (Brillouin) spectroscopy Physical property measurements will be performed in the Oxford laboratories using optical spectroscopy(Zhang et al. 2019, Marquardt and Thomson 2020)., at Synchrotron Facilities employing (time-resolved) x-ray diffraction (DESY, Germany and Diamond Light Source, UK), and possibly using the European X-ray Free Electron Laser Source (European XFEL).

Timeline

Year 1: Doctoral training courses, application for synchrotron beamtime, literature review, planning of experimental campaigns, and laboratory training.

Years 2 and 3: Preparation of diamond-anvil cells, Brillouin spectroscopy, synchrotron experiments (DESY and DLS), presentation of research at national conferences.

Year 4: Data integration, thesis completion, papers for international journals, presentation of research at an international conference.

Training & Skills

The supervisory team are leaders in high-pressure mineral physics and its application to the understanding of planetary interiors. They have been strongly involved in synchrotron-based research and developments in the past, including work on planetary ices.
As part of this project you will learn how to prepare (dynamic) diamond-anvil cells and conduct high-pressure experiments using a variety of techniques (XRD, optical spectroscopy). You will further be

trained in how to plan and carry out laboratory as well as synchrotron experiments, using world-leading research facilities. You will also receive training and guidance in how to model and interpret data, how to present scientific results, and how to write scientific papers for publication.

References & Further Reading

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Further Information

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