Labex MATISSE

Axe

Investigating the Phase Diagram of aqueous electrolyte solutions under extreme conditions Adriaan Ludl IMPMC & PHENIX



Hosting laboratories, teams and and thesis supervisors names:

- 1. IMPMC, Physique des Systèmes Simples en Conditions Extrêmes, Livia E. Bove, A. Marco Saitta
- 2. PHENIX, Equipe Electrochimie et Liquides Ioniques, Mathieu Salanne

Research project

The aim of this PhD project is to explore the phase diagram of common electrolyte solutions (LiCl-water, LiBr-water, NaCl-water) under the pressure and temperature conditions relevant for icy bodies in the Universe, and to search for the existence of high-pressure ice phases containing considerable amounts of salt in their lattice. Probing the existence of these salty ices, and characterizing their exotic (pressure-induced) properties, such as polyamorphism, hydrogen bond symmetrisation, plasticity or ionic conductivity is a valuable piece of information for both chemical-physics of water and planetary science. We performed this study by the combined use of Neutron and X-ray diffraction, Raman light scattering, and Molecular Dynamics simulations.

Scientific results & impacts

We established the existence of other phases of LiCl-ices (ice VI, ice X), with respect to the one already discovered (ice VII).

We developed a new in-lab device to rapidly quench (T cooling rate $>10^4$ K/s) viscous solutions, with which we succeeded in amorphizing NaCl *R* D2O solutions at ambient pressure.

We investigated the existence of ice VII in NaCl and LiBr solutions under high pressure P>4GPa. Incorporation of salt in ice VII lattice is still under study.

Main key facts

1. Structural characterization of eutectic aqueous NaCl solutions under variable temperature and pressure conditions A.-A. Ludl, L. E. Bove, A. M. Saitta, M. Salanne, T. C. Hansen, C. L. Bull, R. Gaal and S. Klotz, PCCP (2015) Accepted Manuscript DOI: 10.1039/ C5CP00224A

2. Effect of salt impurities in ice on the H-bond symmetrization at high pressure L. E. Bove, R. Gaal, Z. Raza, A. A. Ludl, S. Klotz, A. M. Saitta, A. F. Goncharov, and P. Gillet, PNAS under review (2015).

Talks :

Invited : Salty Ice under High Pressure: Polyamorphism and Crystallization, 7th International Discussion Meeting on Relaxation in Complex Systems, Barcelona, (Spain), 2013

Phase Diagram of Salty Ice under Pressure, WaterEurope International Conference, CECAM, Zaragoza, (Spain), 2013 Phase Diagram of Salty Ice Under Pressure, Gordon Research Seminar Water & Aqueous Solutions, Holderness (USA), 2014 **Posters:**

- Salty Water under Pressure, School and Conference on Analysis of Diffraction Data in Real Space, Grenoble (France), 2013

 Salty Water under Pressure, Water: Fundamentals as the Basis for Understanding the Environment and Promoting Technology, International School of Physics "Enrico Fermi", Varenna (Italy), 2013

 Phase diagram of Salty Ices, WATER 2014 - Metastability and nucleation in water: theory, experiments, and applications, Ecole de Physique des Houches (France) 2014

Phase diagram of Salty Ices, Gordon Conference Water & Aqueous Solutions, Holderness (USA), 2014

 Dynamics of Salty Solutions under Pressure, Dynamics in water and aqueous solutions Mini-colloquium, Condensed Matter in Paris CMD 25 – JMC 14, Paris (France), 2014



