This project is an ambitious program to explore the stable and metastable phases of common (LiCl, NaCl, KCl) electrolyte water solutions which are relevant for many fields in science, ranging from cryobiology to planetary science, in regions up to now inaccessible to current techniques.

In particular, we propose to characterize water's polyamorphous phases (Kohl, Loerting et al., Nature 2005) in dilute solutions at moderate pressure (kbar), and the recently discovered crystalline phases developed under high pressure (GPa=10kbar) in concentrated solutions (Klotz, Bove et al. Nature Material 2009). An important and innovative part of this project will be devoted to the development of new, complementary and unique methods to characterize the thermodynamic behavior, the microscopic structure, the proton diffusion, and the dielectric and conductivity properties of these systems.

The goal of our project is twofold:

-to characterize the thermodynamic and structural behavior of dilute solutions as well as their relaxation times, as a function of increasing dilution and pressure, in order to access the properties of undercooled and glassy water in the vicinity of the glass transition. We will enter this region, inaccessible to experiments (no men's land), by the use of unique methods developed by our team, as hyperquenching (cooling rates fast enough to hinder ice nucleation) and pressure-induced amorphisation, and we will then shed light on one of the fundamental issues in condensed matter physics: the link between liquid-liquid transition and polyamorphism in water (Giovambattista, Loerting et al., Nature Scientific Reports 2012).

- to search for the existence of crystalline ice forms highly loaded with ionic species of astrophysical relevance and to characterize their new exotic properties, like the expected superionicity, a novel spectacular state of matter predicted to appear in water under extreme conditions (Cavazzoni et al., Science 1999) where the proton delocalizes and the crystalline system shows a 'liquid behaviour' concerning the proton diffusivity thus acting as a proton super-conductor. These challenging conditions will be accessible, in salty ices, to the novel experimental techniques and methodology we propose to develop. Various studies support the presence of high-pressure ice polymorphs in the interior of Galilean satellites such as Ganymede, Europa and Calisto, as well as Saturn's Titan, and there is strong evidence of subsurface salty ice crusts in some of them. If ice forms highly loaded with salts exist in nature in significant quantity, with most likely exotic properties, such as the described superionicity, their characterization would be highly relevant for the understanding of icy bodies in the Universe