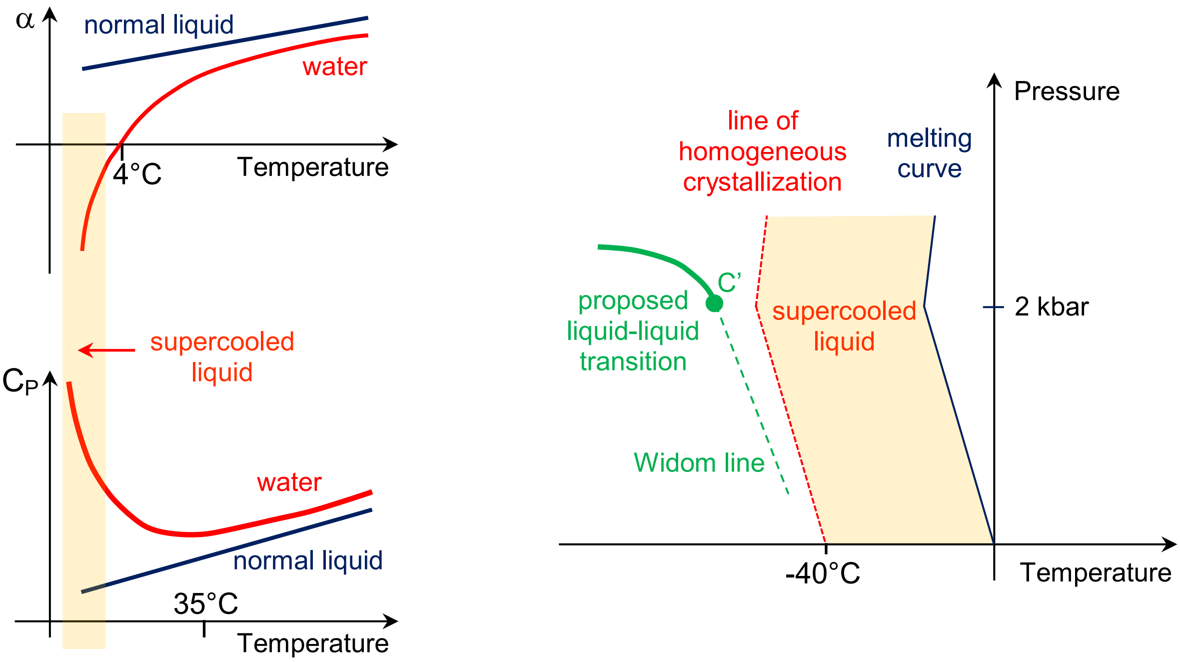
Institut Lumière Matière, Université Lyon 1 and CNRS, Lyon, France

Post-doctoral position: Viscosity of supercooled water and aqueous solutions under pressure

Water is an ubiquitous liquid, and yet its properties are still the subject of intense theoretical and experimental work. In many respects, water behaves in a way that differs from a normal liquid. Up to 67 thermodynamic and dynamic anomalies can be enumerated[1], one of the most famous being the existence of a density maximum at 4°C at ambient pressure. The anomalies become more pronounced when the liquid is supercooled, that is cooled below the melting curve (see left figure). One of the popular explanations, supported by molecular dynamic simulations[2], involves a metastable phase transition between two liquid phases with distinct structures (see right figure). This first-order transition would terminate at a critical point C'. At higher temperatures, no sharp transition exists, but the correlation length reaches maxima along the so-called Widom line. Many quantities would show a peak near the Widom line, which might thus be the origin of the observed anomalies.



Left: Example of properties (isobaric expansion coefficient and heat capacity) that show unexpected behavior in water. The anomalies become more pronounced in the supercooled liquid. Right: schematic phase diagram of water, showing the supercooled region accessible to experiment, and one of the scenarios to explain water anomalies (see text for details).

Many measurements have been performed in the supercooled liquid[3], but crystallization always occurred before a peak could be found. We propose to look for the effect of the Widom line on the viscosity. It is not

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[1] M. Chaplin's website, http://www.lsbu.ac.uk/water/index.html
[2] P.H. Poole, F. Sciortino, U. Essmann, and H.E. Stanley, Nature **360**, 324-328 (1992).
[3] for a review, see P.G. Debenedetti, *J. Phys.: Condens. Matter* **15** R1669–R1726 (2003).

expected to exhibit a peak, but its temperature dependence can be used to locate the Widom line. Surprisingly, the viscosity has been measured at large supercooling at ambient pressure only[4].

In our group, until now specialized in metastable water at negative pressure[5], we have recently initiated a program to measure the viscosity of water under positive pressure. We are currently using Brownian spheres to measure the viscosity of water in a glass capillary. We are also developing another viscosity measurement based on Poiseuille flow. We will use both experiments in combination with the 3 kbar pressure circuit recently built for this project. The effect of solutes will also be investigated.

This post-doctoral position is funded by the ERC Starting Grant *WASSR*. The offered salary is around 25000 euros net per year (ie after deduction of social security and health insurance costs), for a period of 12 months with possible extension.

We are seeking a self-motivated candidate with team spirit. The applicant is expected to hold a PhD in Physics, Physical Chemistry or Chemical Physics, and also to have excellent hands-on skills and ability to carry out independent research. Background in relevant fields (e.g. microscopy, fluid dynamics, colloidal science, kbar pressure apparatus…), and knowledge of Matlab and Labview programming will be appreciated.

Applicants are invited to submit a letter of application explicitly addressing the qualifications for this position and indicating their date of availability; detailed curriculum vitae with list of publications; a short summary of their previous researches ; and the names, email, and addresses for at least one professional reference to:

Frédéric Caupin, frederic.caupin@univ-lyon1.fr http://www-lpmcn.univ-lyon1.fr/~caupin/indexeng.html
and Bruno Issenmann, bruno.issenmann@univ-lyon1.fr

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4 J. Hallett, *Proc. Phys. Soc.* **82**, 1046 (1963).

5 see for instance M. El Mekki Azouzi, C. Ramboz, J.-F. Lenain and F. Caupin, *Nature Physics* **9**, 38-41 (2013).