Collective dynamics study of liquid hydrogen and deuterium outside the hydrodynamic regime

****This PhD project aims at exploring the collective dynamics of the hydrogen (H2 and D2) liquids outside the hydrodynamic regime, taking the simultaneous opportunity of gathering accurate Double Differential Cross Section (DDCS) determinations, at variable incident energies in the thermal and cold neutron range, needed in reactor physics calculations. Indeed, despite the importance of these fundamental systems, very slow steps forward have been made towards the detailed knowledge of their neutron scattering law, or, more generally, of the space-time correlation functions (and their Fourier transforms) describing the dynamic behaviour of these quantum liquids.

Appropriate experimental proposals on the BRISP, IN5 and IN6 instruments are foreseen in order to gather a rich set of inelastic data on the hydrogens. A special concern will be devoted to deuterium because of the increased visibility, due to its coherent scattering, of the sought contributions to the global dynamic behaviour. Nevertheless, scientifically speaking, the H2 case is even more interesting because of the unpredictable but certainly more consistent quantum effects which have never been characterized and quantified, until present, as concerns the dynamic properties.

Another scientific issue of this proposed PhD programme is the possibility to verify whether fundamental dynamical parameters, such as the damping and frequency of non-hydrodynamic acoustic excitations, follow, even in quantum fluids, the nearly "universal" behaviour observed in various classical molecular and monatomic liquids.



**Total Cross Section (barn/molecule)**

*E*0 [meV]

*self* TCS only

**◼***Expt.* [W. D. Seiffert, Euratom Report No. EUR 4455d (1970)]

Furthermore, the deep study of the hydrogen liquids dynamics has become a simultaneous and urgent need to face also the present requests of accuracy in neutron DDCS evaluations and *Total Cross Section* (TCS) libraries given in use for Nuclear Physics reference databases.

The increase of the neutron cross section data accuracy is of strategic importance for the long term vision of the ILL. Indeed, in parallel to the LEU conversion that is expected around 2030, the whole RHF pile will have to be refurbished. Proposing new cold sources design will thus be crucial before the next international convention in 2023 to give our associates a long term vision. Because of knowledge of the so poor accuracy of the current databases, this design could only be done with the new more precise nuclear data (IRSN is involved in the project). The study must start now to be achieved in time.

**Fig. 1** Total scattering cross section of D2 at 19 K as measured by Seiffert (black squares). Calculations based on two possible models [6] of the *self* component (red and cyan open circles) are compared with *self*+*distinct* results (full dots). The distinct contribution was added following either the Vineyard [see e.g. 6] or the Sköld [12] approximation for classical systems.

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