Inelastic X-ray Scattering on High Pressure Fluids in Diamond Anvil Cells, in the THz Frequency Domain

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I will present on novel experiments aimed to investigate the dynamics of collective modes in the THz regime, with meV resolution, in high pressure fluids, through the combination of inelastic X-ray scattering and diamond anvil cells (DACs). The DAC device allows to span a very wide region of the P-T phase diagram of fluid materials, which are affected by relevant changes both in the dynamical and structural properties as traced by the inelastic and elastic X-ray scattering, respectively. I will show measurements on supercritical oxygen at room T and in the 0.9-6 GPa pressure range, where it is found that the sound velocity exceeds the hydrodynamic value by 20 %, a feature which is the fingerprint of liquidlike dynamics [1]. The comparison with literature data in several fluids suggests that the extrapolation of the liquid-vapour coexistence line in the P-T plane, beyond the critical point, should be considered as the relevant edge between liquidlike and gaslike dynamics. More interestingly, this extrapolation is very close to the non-metal-metal transition in hot dense fluid, such as O_2, N_2, and H_2, at P-T values as obtained by shock wave experiments. This result points to the existence of a connection between structural modifications and transport properties in dense fluids. In the last year we developed an experimental layout aimed to optimize the coupling of DACs to the inelastic X-ray scattering ID28 beamline of the ESRF, specifically aimed to improve the accurate measuring of the entire dynamical structure factor in high pressure fluids. The novel solution involves the use of a dedicated vacuum chamber with a slit system allowing the control and minimization of the empty cell background signal. This approach has been demonstrated to be highly powerful in the case system of supercritical fluid Argon, where it has been determined the dispersion curve, the generalized heat specific ratio and the longitudinal viscosity. Molecular dynamics simulations quantitatively reproduce the experimental findings. The new arsenal developed is now ready to face inelastic X-ray scattering studies at extreme P-T conditions on a variety of fluid materials, spanning from simple gaseous systems to complex liquids.