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Open problems in liquids dynamics: the role of neutron scattering

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We review recent inelastic neutron scattering experiments aimed at the investigation of still open issues in the dynamics of liquids at the nanometer and picosecond scales. It is shown that the interpretation of experimental results is put on solid grounds by the application of modern methods of analysis and lineshape modeling which ensure the fulfillment of fundamental physical properties that the spectra must obey. This last condition, especially when studying weak signals in the dynamic structure factor, becomes crucial to avoid overinterpretations of the real information conveyed by scattering data. Moreover, we highlight the different roles that neutron data presently play in relation with molecular dynamics simulations, depending on the addressed physical problem and the nature of the sample, by including in the discussion the case of quantum liquids. In particular, we show how neutron measurements remain an indispensable benchmark in assessing the present capabilities of classical and quantum simulation methods. We also illustrate the potential of statistical methods, such as Bayesian inference, when applied to neutron data analysis and the opportunity they provide in establishing the spectral features without *ab initio* assumptions on the model lineshape, i.e., on the expected dynamical processes: an effective tool aimed at avoiding biases of confirmation which conventional and physically unconstrained analyses are sometimes exposed to.

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