Quantum coherence and its spatial structure in many-body systems at equilibrium

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Quantum correlations can be loosely defined as the forms of statistical correlations between observables in quantum systems that classical physics cannot account for — or cannot imitate. Here we shall be concerned with correlations stemming from coherence, i.e. the fact that the observables of interest do not commute with the quantum state. There are several ways to assess quantum coherence of an observable in a given quantum state, the most important one being the quantum Fisher information (QFI), due to its metrological significance. Yet calculating the QFI in many-body systems is notoriously hard, as it generically requires tomography of the state. But other estimators of quantum coherence exist which offers bounds to the QFI, and which have a much more transparent physical interpretation in statistical physics. In this talk I will focus on the quantum variance [1] - and the related concept of quantum covariance [3] - which is best defined in many-body systems at thermal equilibrium as the difference between the fluctuations of an observable and its susceptibility. This quantity can be calculated with state of the art methods in quantum many-body physics (numerical methods, exact solutions, quantum field theory, etc.) and therefore it allows one to assess the role of quantum coherence in the thermodynamics of macroscopic quantum many-body systems. Making use of large-scale numerics, we highlight the special role of symmetries and of quantum criticality in making quantum correlations tangible under realistic conditions for experiments [2]; and we assist recent experiments reconstructing the spatial structure of quantum correlations (i.e. the quantum covariance) from neutron scattering on quantum magnets [4].

References

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