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Mutual information in interacting spin systems

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Abstract:

In this thesis, mutual information is studied as a measure for many-body correlations in condensed matter systems, in particular at and around phase transitions. Mutual information was originally defined and motivated by information theory. It is here examined in the setting of interacting spin systems at finite temperature. It is found to exhibit many desirable and interesting properties: In particular, it explicitly displays area laws that exist in classical spin systems, and interesting behaviour around the phase transition between paramagnetic and ferromagnetic regimes in those models. In fully-connected quantum spin models, it generalizes the entanglement entropy, which has been studied in the quantum phase transition (QPT) in such models. We find a logarithmic divergence of the mutual information at the thermal phase transition, mirroring the logarithmic divergence of entanglement entropy in the QPT. While it is possible to give analytical results in some limits, the main body of the work consists of numerical simulations, involving a number of different techniques such as Matrix Product States, Monte Carlo sampling and various applications of numerical linear algebra.