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Entanglement entropy in quantum fluids and gases

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We present a scalable algorithm for computing Rényi entanglement entropies in systems of itinerant bosons in the spatial continuum via quantum Monte Carlo. This method is applicable to the study of spatial mode entanglement, particle partitioned entanglement, and the entanglement of particles under a spatial partitioning. We demonstrate its utility by studying a non-trivial interacting Bose gas in one spatial dimension where we uncover a logarithmic scaling of the entanglement entropy in the number of particles and confirm bounds on it related to the experimentally measurable condensate fraction. For the first time, this method opens up the numerical study of quantum correlations in experimentally relevant quantum fluids such as helium-4 and cold atomic gases.

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