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Quantum Fisher information as efficient entanglement witness in many-body systems

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Large-scale entanglement in quantum many-body systems is typically difficult to quantify experimentally. Here, we discuss scenarios where many-body entanglement becomes accessible via the quantum Fisher information (QFI), a known witness for genuinely multipartite entanglement as a resource for quantum-enhanced metrology. First, we introduce a direct relation of the QFI in thermal states with linear response functions, which makes the QFI measurable with standard methods in optical-lattice and solid-state experiments [1]. Using this relationship, we show that close to continuous quantum phase transitions the QFI, and thus multipartite entanglement, is strongly divergent. Second, we demonstrate that the QFI can witness many-body localized phases, showing a characteristic growth of entanglement at long times after a quantum quench [2]. These results demonstrate that the quantum Fisher information represents a useful and efficiently measurable witness for entanglement in quantum many-body settings. [1] P. Hauke et al., arXiv:1509.01739 (2015). [2] J. Smith et al., arXiv: 1512.06172 (2015).