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Two-component Structure in the Entanglement Spectrum of Highly Excited States ZHI-CHENG YANG, CLAUDIO CHAMON, Boston University, ALIOSCIA HAMMA, Tsinghua University, EDUARDO MUCCIOLO, University of Central Florida — We study the entanglement spectrum of highly excited eigenstates of two known models which exhibit a many-body localization transition, namely the one-dimensional random-field Heisenberg model and the quantum random energy model. Our results indicate that the entanglement spectrum shows a "two-component" structure: a universal part that is associated to Random Matrix Theory, and a non-universal part that is model dependent. The non-universal part manifests the deviation of the highly excited eigenstate from a true random state even in the thermalized phase where the Eigenstate Thermalization Hypothesis holds. The fraction of the spectrum containing the universal part decreases continuously as one approaches the critical point and vanishes in the localized phase in the thermodynamic limit. We use the universal part fraction to construct a new order parameter for the many-body delocalized-to-localized transition. Two toy models based on Rokhsar-Kivelson type wavefunctions are constructed and their entanglement spectra are shown to exhibit the same structure.

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