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Localization Protected Quantum Order RAHUL NANDKISHORE, DAVID HUSE, SHIVAJI SONDHI, Princeton University, VADIM OGANESYAN, CUNY, ARIJEET PAL, Harvard University — Closed quantum systems with quenched randomness exhibit many-body localized regimes wherein they do not equilibrate even though prepared with macroscopic amounts of energy above their ground states. We show that such localized systems can order in that individual many-body eigenstates can break symmetries or display topological order in the infinite volume limit. Indeed, isolated localized quantum systems can order even at energy densities where the corresponding thermally equilibrated system is disordered, i.e.: localization protects order. In addition, localized systems can move between ordered and disordered localized phases via non-thermodynamic transitions in the properties of the many-body eigenstates. We give evidence that such transitions may proceed via localized critical points. We note that localization provides protection against decoherence that may allow experimental manipulation of macroscopic quantum states. We also identify a 'spectral transition' involving a sharp change in the spectral statistics of the many-body Hamiltonian.

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