Entanglement Preserving Local Thermalization

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We investigate whether entanglement can survive the thermalization of subsystems. We present two equivalent formulations of this problem: 1. Can two isolated agents, accessing only pre-shared randomness, locally thermalize arbitrary inputs while maintaining some entanglement? 2. Can thermalization with local heat baths, which may be classically correlated but do not exchange information, locally thermalize arbitrary inputs while maintaining some entanglement? We answer these questions in the positive at every nonzero temperature, and provide bounds on the preserved entanglement. We provide explicit protocols and discuss their thermodynamic interpretation; we suggest that the underlying mechanism is a speed-up of the subsystem thermalization process. We also present extensions to multipartite systems. Our findings show that entanglement can survive locally performed thermalization processes accessing only classical correlations as a resource.