Irreversibility and symmetry principles in quantum theory

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The concept of irreversibility lies at the heart of physics and can often be a subtle thing to pin down. In recent years it has acquired new guises that are motivated by information-theoretic aims. For example, in the theory of entanglement intrinsically quantum-mechanical correlations may be utilised to achieve tasks such as quantum teleportation. The use of this entanglement results in its consumption, and a form of irreversibility that can be quantified and studied in a precise manner. Symmetry principles are powerful and unifying concepts in modern quantum physics, however they are normally associated with the conservation of quantities, for example via Noether's theorem. Here I will discuss a novel framework that is motivated by the theory of entanglement. This general framework allows us to study irreversibility in the quantum degrees of freedom of a multipartite system constrained by local or global symmetry principles. The approach leads to a range of results, including a novel information-theoretic perspective on gauge theories, and connections with recent work on quantum thermodynamics. In particular I will present a framework for quantum thermodynamics based on simple physical principles of stability and symmetry, and which admits a complete entropic description.