What Temperature is Schrödinger's Cat?

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In the context of quantum thermodynamics—where thermodynamical quantities are associated with quantum systems—a question arises whether the notion of temperature can be associated with quantum features, in analogy to whether the notion of time can exhibit quantum features when it is associated with a clock that is itself a quantum system.

In this work we explore two scenarios in which the notion of a 'superposition of temperatures' may arise. In the first scenario, the probe system interacts with different baths depending on the state of another quantum system. In the second, there is a thermalising interaction with a bath, however the bath together with its purification is correlated with another quantum system. The bath state is thermal at a temperature dependent on the state of this additional, control, degree of freedom (DoF). In both cases we derive the final state of all systems and discuss conditions for thermalisation of the probe and for temperature coherence—understood as coherence in the DoF on which the temperature depends. We show that the two cases are surprisingly different: For example, in the first scenario the probe does not thermalise and the temperature coherence is reduced even when the bath states are identical, at the same temperature. In the analogous case of equal temperatures in the second scenario, the probe does thermalise and the coherence is maximal. We also find that the final probe states depend on the physical context and even physical realisation of the thermalising channels—being sensitive to the particular Kraus representations of the channels—which may explain some of the results obtained in the context of quantum interference of relativistic particle detectors thermalising with Unruh/Hawking radiation. Our results extend to partial and pre-thermalisation, which we study by introducing a collisional model of thermalising interactions between the system and the bath(s).