LOW-TEMPERATURE THERMOMETRY IN MANY-BODY SYSTEMS

Karen V. Hovhannisyan[1,2], Luis A. Correa[3]

(1) Department of Physics and Astronomy, University of Aarhus, DK-8000 Aarhus C, Denmark
(2) ICFO-Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels, Barcelona, Spain
(3) School of Mathematical Sciences, The University of Nottingham, University Park Campus, NG9 2RD Nottingham, United Kingdom

We consider the problem of estimating the temperature of a very cold equilibrium sample with an individual quantum probe in the regime of strong probe-sample interaction. It is well-known that, in the weak coupling regime, thermometry at low temperatures is inefficient exponentially with the inverse of the temperature. We show that the same holds for probes interacting with many-body samples with arbitrary strength provided that the interactions are of short range and the overall system is out of criticality. In the search for efficient low-temperature thermometry we are thus forced to turn to gapless and possibly long-range interacting many-body systems. To this end, we prove that a wide class of gapless translationally invariant one-dimensional harmonic lattices with arbitrary interactions is equivalent to the Caldeira-Leggett model with Ohmic spectral density, when viewed from the perspective of a single lattice site. This allows us to use the powerful analytical tools developed for the Caldeira-Leggett model and show, among other things, that in critical systems one can beat the exponential suppression of the temperature estimation and achieve precision only quadratically decaying with the inverse temperature.