Experimental Determination of Dynamical Lee-Yang Zeros

K. Brandner[1], V. F. Maisi[1], J. P. Pekola[1], J. P. Garrahan[2,3], C. Flindt[1]

[1] Low Temperature Laboratory, Department of Applied Physics, Aalto University, 00076 Aalto, Finland.

[2] School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, United Kingdom.

[3] Centre for the Mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, University of Nottingham, Nottingham NG7 2RD, United Kingdom.

Conventional phase transitions involve abrupt changes of a macroscopic system in response to small variations of an external control parameter. This exceptional behavior can be understood from the complex zeros of the partition function of the finite-sized system: in the thermodynamic limit, these Lee-Yang zeros, which correspond to logarithmic singularities of the free energy, approach the critical value of the control parameter on the real axis.

This general scheme also applies to dynamical phase transitions in non-equilibrium systems. The partition function is thereby replaced with the moment-generating function of a stochastic process with the counting field playing the role of the external control parameter. Here, we demonstrate that the corresponding dynamical Lee-Yang zeros are not only a theoretical concept but physical observables, which encode remarkable information on the long-time statistics and the dynamical fluctuations of the system [1]. To this end, we analyze a stochastic process involving Andreev-tunneling events in a mesososcopic device consisting of a normal-state island and two superconducting leads. From measurements of the dynamical activity, we extract the Lee-Yang zeros, which reveal a smeared dynamical phase transition outside the range of direct observations. Being obtained only from short-time data, this information allows us to predict the large-deviation statistics of the dynamical activity at long times, which is otherwise difficult to measure. Our method paves the way for further experiments on the statistical mechanics of many-body systems out of equilibrium.

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