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Probing Lee-Yang Zeros and Time-domain Phase Transitions BO-BO WEI, REN-BAO LIU, Department of Physics and Center for Quantum Coherence, The Chinese University of Hong Kong, Hong Kong, China — As a foundation of statistical physics, Lee and Yang in 1952 proved that the partition functions of thermal systems can be zero at certain points (called Lee-Yang zeros) on the complex plane of magnetic field. In the thermodynamic limit, the Lee-Yang zeros approach to real numbers at the critical temperature. However, the imaginary Lee-Yang zeros have not been regarded as experimentally observable since they occur at imaginary field or temperature, which are unphysical. Here we show that the coherence of a probe spin coupled to a many-body system presents zeros as a function of time that are one-to-one mapped to the Lee-Yang zeros of the many-body system. In the thermodynamic limit, of which the Lee-Yang zeros form a continuum, the probe spin coherence presents a sudden death and a sudden birth at critical times corresponding to the edge singularities of the Lee-Yang zeros. By measuring the probe spin coherence, one can directly reconstruct the partition function of a many-body system. These discoveries establish the concept of critical times for phase transition in analogue to critical temperature, and also provide a universal approach to studying interacting many-body systems through measuring coherence of only one probe spin (or one qubit in quantum computing).

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