Quantized Bubble Nucleation

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Non-equilibrium dynamics of slow quenches across continuous phase transitions have been understood very successfully under the unifying theory of Kibble-Zurek mechanism. However, relatively less attention has been paid to understanding dynamics across first order quantum phase transitions(FOQPT). In an attempt to mitigate this, here I will show the consequences of a slow dynamical ramp across the FOQPT transition line present in the Ising model with both transverse and longitudinal fields [1]. The existence of potential barrier, quintessential to the FOQPTs, gives rise to metastability in the dynamical state. Such metastability can wear off either by dynamical instability due to disappearance of the potential barrier, or by nucleating bubbles of the true ground state driven by quantum fluctuations. While the former scenario have been studied across certain first order phase transitions under the framework of Kibble-Zurek theory, here I will present our analysis of the generic situation of the breakdown of metastability by nucleation of bubbles. Specifically, we identify special resonant regions in the longitudinal field, where the metastable state can easily tunnel to nucleate bubbles of specific sizes (quantized). Further I will describe our attempt to explain the entire non-adiabatic process under the umbrella of Landau-Zener theories. In recent times, quantum simulations of non-equilibrium dynamics of many-body spin systems have met with remarkable success owing to improvement in atom trapping technology and long life-time of Rydberg atoms[2,3,4], with the potential to observe different ordered phases with broken symmetry. Such tremendous experimental achievements make possible to investigate quantized nature of bubble nucleations in one and higher dimensions. Our work therefore is of relevance for both current theoretical as well as experimental endeavours.

References:

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