Dynamics of supercooling and superheating of the Mott transition in V_2O_3

Tapas Bar, Sujeet Choudhary, Satyabrata Raj and Bhavtosh Bansal

IISER Kolkata, Mohanpur Campus, Nadia 741246

For more than 50 years, vanadium sesquioxide (V_2O_3) has been the archetype of a material showing metal-to-insulator transition that is driven by electron correlations. This phase transition is of first order with large latent heat and thermal hysteresis. Phenomenologically, it is among many similar hysteretic first-order transitions, observed in other complex materials including manganites, transition metal oxides, shape memory alloys, etc., which show arrested kinetics, aging and other glassy behavior.

We have studied this transition from a classical thermodynamics perspective and explored how and when one phase transforms into another as the temperature is raised or lowered across the phase transition boundary with precisely controlled rates. Using both transport and latent heat measurements, we show that the transition temperature and hence the width of the thermal hysteresis loop systematically increases with the temperature quench rate. This dynamic hysteresis is observed to have a power law behavior with the exponent obeying the mean field prediction of 2/3. On the basis of this observation and systematic `quench and hold' experiments to observe the phase ordering dynamics, we conclude that the transition, despite being driven by temperature, is essentially an *athermal*spinodal transition. This implies that the phase transformation occurs only beyond the spinodal points and progresses deterministically with thermal fluctuations and phase nucleation not being important. Finally, we show that the free energy function based on compressible Ising model, when combined with the time-dependent Landau-Ginzburg model for dynamics, captures the experimental observations with only one fitting parameter.