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A QUANTUM OF MATTER

Models for dynamic and thermodynamic transitions in a supercooled liquid

Shankar P. Das

School of Physical Sciences, Jawaharlal Nehru University, New Delhi 110067, India

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A thermodynamic approach to understand the metastable liquid involves study of the free energy landscape (FEL) for a suitable free energy functional $F[\psi]$, where the field $\psi(x)$ models a continuum field-theoretic description of the many-particle system, and is often identified with the local density $\rho(x)$. In the deeply supercooled state, distinct basins form in the FEL, corresponding to different local minima of the free energy. Well below the freezing point, the FEL breaks up into an exponentially large number of basins with local minima. The metastable liquid, close to vitrification, is trapped in one of these many possible basins. This fragmentation of the FEL of the supercooled liquid has been termed a spontaneous breakdown of ergodicity. In the case of structural glasses, this fragmentation of the FEL occurs without the presence of any quenched disorder, and this transition has been identified with transitions predicted in dynamical models of glass formation, like the mode-coupling theory (MCT). The relationship between this transition and the dynamic transition point in MCT will be discussed in terms of the corresponding order parameters. The calculation of the partition function is facilitated here by a composite system of m identical Replicas of the original system, and the physical limit as the replica index approaches one is finally applied. The field-theoretic model considered is based on classical density functional theory, which has also been very useful in analyzing freezing or the liquid-to-crystal transition. Using this field-theoretic formulation, we describe a model of a supercooled liquid that accounts for multi-particle correlations and discuss a calculation of the so-called Complexity, or configurational entropy, of the supercooled liquid with continuum or coarse-grained models.

Who is Shankar P. Das?

Prof. Shankar P. Das is a theoretical physicist at the School of Physical Sciences (SPS), Jawaharlal Nehru University (JNU), New Delhi. His research focuses primarily on theoretical condensed matter physics and statistical mechanics, specializing in the dynamics of supercooled liquids, fluctuating nonlinear hydrodynamics, mode-coupling theory, and the liquid-glass and freezing transitions. He is the author of the textbook *Statistical Physics of Liquids at Freezing and Beyond*.

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