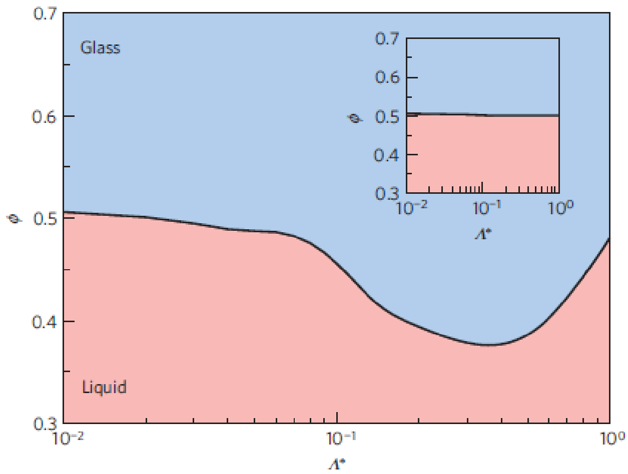
Quantum fluctuations can promote or inhibit glass formation

Eran Rabani

School of Chemistry, Tel Aviv University, Tel Aviv 69978, Israel

Understanding the transformation of liquid into glass is one of the outstanding problems in the physical sciences. The major difficulty in understanding the glass transition is the fact that glass itself is an ill-defined state of matter: unlike a crystal, a glass is not a thermodynamic phase. Quantum mechanical systems ranging from electron liquids to superfluid helium appear to form glasses, but as yet no unifying framework exists connecting classical and quantum regimes.

Here we present new insights from theory and simulation into the impact of quantum fluctuations on glass formation. As intuition may suggest, we observe that large quantum fluctuations serve to inhibit glass formation as tunneling and zero-point energy allow particles to traverse barriers facilitating movement. However, as the classical limit is approached a regime is observed in which quantum effects slow down relaxation making the quantum system glassier than the classical system. This dynamical 'reentrance' occurs in the absence of obvious structural changes and has no counterpart in the phenomenology of classical glass-forming systems.



Dynamic phase diagram calculated from a quantum mode-coupling theory for a hard-sphere fluid

T. E. Markland, J. A. Morrone, B. J. Berne, K. Miyazaki, E. Rabani and D. R. Reichman, "Quantum Fluctuations Can Promote or Inhibit Glass Formation", *Nature Physics* **7**, 134-137 (2011).