Cracking a controversial solid state mystery

February 6 2009

(PhysOrg.com) -- Scientists can easily explain the structural order that makes steel and aluminium out of molten metal. And they have discovered the molecular changes that take place as water turns to ice. But, despite the fact that glass blowers have been plying their trade since the first century BC, we have only just begun to understand what makes molten glass solid.

One hundred and fifty years after the construction of Crystal Palace at the Great Exhibition, scientists at The University of Nottingham and the University of California, Berkeley in collaboration with the University of Bath, have presented an explanation of how atoms behave as glass cools and hardens. Their research has just been published online in *Science Express*, in advance of publication in *Science*.

The secret of glass making came to Britain with the Romans in 55 BC. But only now do scientists believe they are a step closer to unravelling the controversy that surrounds the question: what makes solid glass different from the molten liquid from which it is formed?

Juan Garrahan, Professor of Physics, in the School of Physics and Astronomy at Nottingham said: "Snapshots taken with x-rays show that in ice, water molecules fit together in an ordered array, which is called a crystal, while in liquid water, the molecules are jumbled. Scientists can understand why ice is rigid and liquid water is fluid largely from these structural differences. Glass, on the other hand, does not offer this explanation because a snapshot of the molecular structure of solid glass is almost indistinguishable from that of the molten liquid. Both appear to be jumbled random collections of atoms. This observation is at the heart of the problem: if the solid state of glass has a molecular structure just like that of the liquid, how can it be so rigid? Controversy has resulted from the absence of a clear answer to this question."

Using computer simulations, researchers were able to test the theoretical and computational process of melting and hardening glass. They have not yet solved the glass transition problem however they have provided evidence for a new perspective on glassy phenomena which may eventually lead to its solution.

Dr. Robert Jack, from the Department of Physics at the University of Bath, said: "By focusing on the ability or inability of molecules to flow we have provided evidence for a new kind of sudden transition between the flowing liquid and the solid glass. This transformation is apparent only when the system is viewed in both space and time."

Ultimately, the answer is important because the principles that underlie the glass transition can guide scientists and engineers towards methods for producing better glass — stronger and longer lasting. Disordered glassy solids are ubiquitous in everyday materials including ceramics and plastics. For over a century, principles of thermodynamics have aided the design of ordered solids, materials like steel and aluminium alloys. No such principles are yet settled for production of glassy solids. The current work is believed to be a significant step towards these principles.

Provided by University of Nottingham