Scientists observe solitary vibrations in uranium

Los Alamos scientists, working with collaborators from around the world, recently observed experimental evidence of solitary vibrations (solitons) in a solid. First observed as localized waves on the surface of water more than a century ago, the concept of solitons in solids was only theorized as possible two decades ago. The results of their discovery of random localized vibrations in a 3-D solid will add new knowledge to the field of solid-state physics and could have implications for other areas of science and technology.

In research described in this week's issue of Physical Review Letters, Los Alamos scientist Michael Manley and his colleagues from Oak Ridge and Argonne national laboratories and the Institute for Transuranium Elements in Karlsruhe, Germany describe their use of x-ray and neutron scattering experiments to identify random localized vibrations, called lattice solitons, in uranium crystals at high temperatures, possibly caused by strong electron-phonon interactions.

According to Manley, "these results are really exciting on several levels. Although the idea of a localized energy wave goes back to the late 1800s when solitons were first observed, by the 1980s new theories proposed the possibility of seeing them in discrete solids. Scientists have been looking for localized vibrations in atomic structures ever since. No one ever imagined that they would play such an important role in the physical properties of uranium metal, so this was quite a surprise."

Scottish scientist John Scott Russell first described the soliton in August 1834 after observing the phenomenon on the surface of water in Scotland's Union canal. In the late 1980s, scientists theorized that solitons might exist in solids and molecules, calling them intrinsic localized modes or discrete breathers, but had no physical evidence of their existence.

Although the discovery will have immediate implications for uranium science and the field of solid-state physics, the potential applications of this discovery in other fields are yet to be seen. They might include new explanations of the roles that localized vibrations may play in breaking chemical bonds in biological processes. The new knowledge might also provide the scientific underpinnings for the development of future devices that exploit localized energy waves.

Source: Los Alamos National Laboratory