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Graphite enters different states of matter

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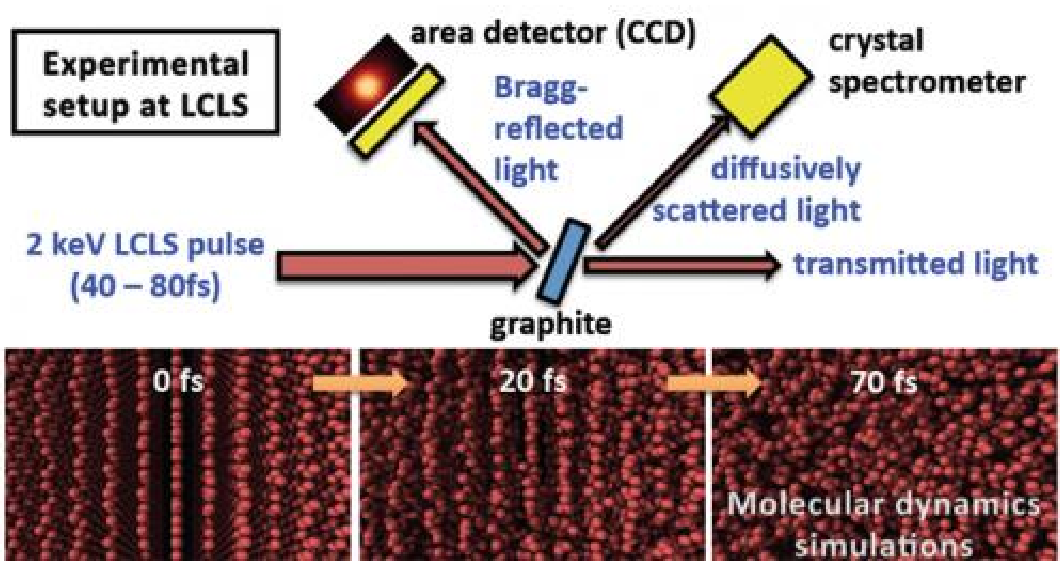

Demonstration of ultrafast disintegration of matter by 2 keV LCLS pulses: The team combined techniques commonly used in solid state physics (Bragg reflection) with techniques from plasma physics (spectroscopy of diffusely-scattered light) to characterize ultrafast heating in graphite.

(Phys.org) -- For the first time, scientists have seen an X-ray-irradiated mineral go to two different states of matter in about 40 femtoseconds (a femtosecond is one quadrillionth of a second).

Using the Linac Coherent Light Source (LCLS) X-ray Free-Electron Laser (XFEL) at SLAC National Accelerator Laboratory at Stanford, Stefan Hau-Riege of Lawrence Livermore National Laboratory and colleagues heated graphite to induce a transition from solid to liquid and to warm-dense plasma.

Ultrafast phase transitions from solid to liquid and plasma states are important in the development of new material-synthesis techniques, in ultrafast imaging, and high-energy density science.

By using different pulse lengths and calculating different spectra, the team was able to extract the time dependence of plasma parameters, such as electron and ion temperatures and ionization states.

"We found that the heating and disintegration of the ion lattice occurs much faster than anticipated," Hau-Riege said.

The research provides new insights into the behavior of matter irradiated by intense hard X-rays. Though the study ultimately serves as a breakthrough in plasma physics and ultrafast materials science, it also affects other fields such as single molecule biological imaging and X-ray optics.

For single-molecule bioimaging, the team found that in certain cases it may be substantially more difficult than anticipated because energy transfer is surprisingly fast. In X-ray optics, they found that the damage threshold is lower than anticipated.

This is the first XFEL high-energy density science experiment that used inelastic X-ray scattering as a plasma diagnostic.

The research is scheduled to appear in the May 21 edition *Physical Review Letters*.

Provided by Lawrence Livermore National Laboratory