NATIONAL GEOGRAPHIC NEWS
NATIONALGEOGRAPHIC.COM/NEWS

Laser Cooling May Create "Exotic" States of Matter

Brian Handwerk
for National Geographic News

September 8, 2009

Laser beams are best known as weapons in science fiction and as heating and cutting tools in science fact. But a new study has flip-flopped conventional physics to show lasers in a whole new light.

In a new technique, Martin Weitz and Ulrich Vogl of the University of Bonn in Germany used a laser to bring the temperature of dense rubidium gas far below the normal point at which the gas becomes a solid.

Previous research had been able to use lasers to quickly "supercool" only very diluted gases.

But "here's a case where you shine a laser on something and it actually cools down, and not just a handful of atoms, but a macroscopic object," said Trey Porto, a physicist with the National Institute of Standards and Technology's laser-cooling group who was not involved in the new work.

The process could be used to create fascinating new states of matter, the study authors say.

"For example, if you can very quickly cool water much lower than zero Celsius [32 degrees Fahrenheit], where it would normally turn to ice, exotic crystalline and glassy states of matter would be predicted," Weitz said.

The new technique could also be used in cooling mechanisms to boost the efficiency of some stargazing equipment, he added.

"If you could cool thermal cameras that look at the stars, they may have less noise and be more sensitive."

(Read more about infrared astronomy.)

When Atoms Collide

Since a laser's color is linked to its intensity, the new technique is based on using a red laser in which the frequency has been adjusted so that the beam affects the atoms only when they collide with each other.

Weitz and Vogl shone this laser beam into gaseous rubidium atoms in a high-pressure "atmosphere" of argon.

Argon is inert, which means that it doesn't easily react with atoms of other elements.

But "during the very short period when a rubidium atom bangs into an argon atom, … [the rubidium] can absorb a photon" from the laser, NIST's Porto explained.

The absorbed photon acts like a strong spring suddenly bridging the two atoms, and this weak link causes the atoms to slow down as they try to fly apart.

But at some point the spring is stretched so far that the link breaks and the photon is released as scattered fluorescent light.

The extra energy required to slow the atoms gets carried away by the escaping photon, so the process ends up removing more energy than the laser puts in, cooling the gas.

In the experiment, described last week in the journal *Nature,* the rubidium gas fell from 662 degrees Fahrenheit (350 degrees Celsius) to almost 536 degrees Fahrenheit (280 degrees Celsius) within mere seconds.

(Related: "Laser Triggers Lightning 'Precursors' in Clouds.")

Major Departure

Much more research needs to be done before the laser-cooling process can be used in real-world applications, study co-author Weitz cautioned.

But NIST's Porto said the work already represents a major departure from traditional cooling of diluted gases, which are currently used for studying quantum effects or preparing gas samples for atomic clocks.

"I think the really amazing thing is that you can even get cooling in this regime, because it's a really dense gas and a very different mechanism," Porto said.

"Traditional cooling powers are so tiny. To cool a physical object by a measurable degree with a laser is amazing."

© 1996-2008 National Geographic Society. All rights reserved.