Physicist confines plasma components in a trap within a trap

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A University of Michigan professor has taken a step toward simulating a type of matter found in the crusts of neutron stars, in the cores of gas giant planets, and in exotic plasmas thought to be present in the earliest universe.

Physics professor Georg Raithel trapped both the electronic and ionic components of a cold plasma using electric and strong magnetic fields. Raithel confined clouds of negatively-charged electrons and positively-charged rubidium ions in what's called a nested Penning trap.

"What we observed for the first time is two charged clouds oscillating in the trapping volume," Raithel said. "They were dense enough to affect each other's oscillation patterns due to electrostatic interactions, and that's how we could tell they were both there."

Forming two clouds—a positive and a negative—is an important step toward creating a neutral, strongly-coupled plasma, found in nature in "hard to get to" astrophysical places, Raithel said.

In a strongly-coupled plasma, the particles behave more like they would in a liquid, interacting with each other more strongly than would particles in a regular plasma.

This result could pave the way for trapping antimatter, Raithel said. Nowadays, scientists only know they've created antimatter after it explodes out of existence. If they were able to trap it, they could learn more about it. And this is also a step toward simulating a quark-gluon plasma, which is a type of plasma created by heavy ion collisions. Quark-gluon plasma is often considered a fifth state of matter that scientists believe was present just after the Big Bang.

To achieve this confinement, Raithel first traps rubidium atoms in their ground state with magnets that generate a strong, precise field with a slightly weaker dimple in the middle, where the atoms get stuck. The atoms cool down in the divot due to scattering of infra-red laser light, which creates friction that Raithel calls "optical molasses". That traps the atoms.

Next, Raithel creates a plasma by exciting the trapped atoms with blue lasers. This causes electrons to break free, leaving negatively-charged electrons and positive rubidium ions.

Additional electrodes generate an electric field that works with the strong magnetic field to keep the plasma components from escaping.

"This experiment shows that we generated electron and ion numbers high enough to get correlated motions. To get to a two-component strongly-coupled plasma, we need still higher numbers of particles," Raithel said.

The paper is called "Trapping and evolution dynamics of ultracold two-component plasmas." It is published in the current edition of *Physical Review Letters.*

Source: University of Michigan