ULTRACOLD PLASMAS

Crank up the repulsion

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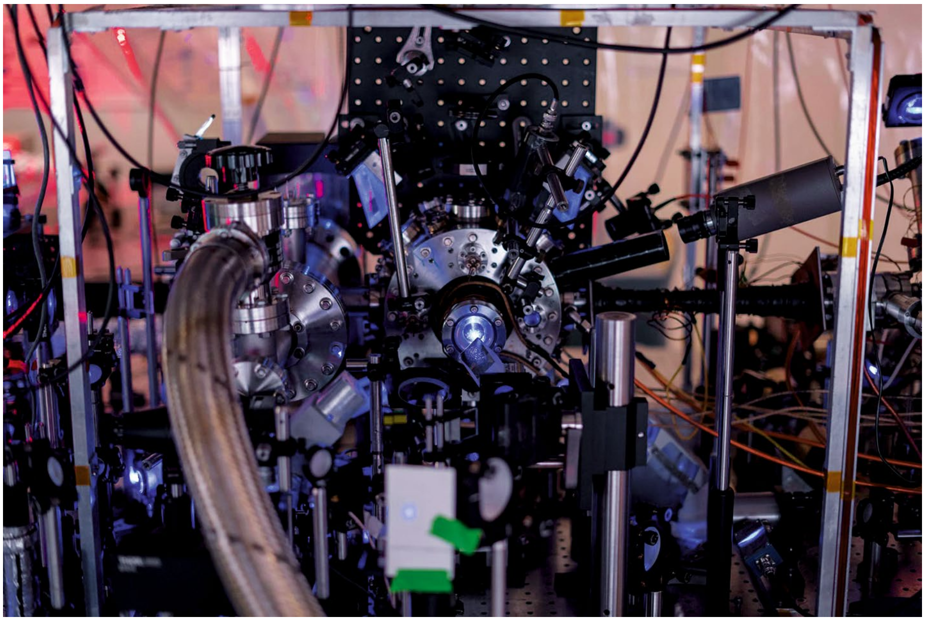

Credit: Brandon Martin/Rice University

Imagine a collection of ions arranged in a periodic lattice, except there is no crystalline lattice but beams of light, and the ratio of kinetic to potential energy is tunable. Laser cooling of ions and atoms, and trapping them within optical lattices, thus provides ideal simulators of solids and quantum systems, where coupling strengths that cannot be studied in nature become possible in the laboratory. And now to plasmas. To study strongly coupled plasmas we need high temperatures and densities — conditions typically found in giant planet cores, white dwarf stars or dusty plasmas. Tom Langin and co-workers head to an optical bench instead (pictured), where they successfully cooled the strontium ions in a neutral plasma.

These days, creating an ultracold plasma is standard practice: once the atoms are (pre)cooled and trapped, the trapping fields and cooling lasers are switched off, the atom cloud expands and then a pulse of photons ionizes about 10% of the atoms. The trick is to further cool the ions using more lasers, for which Langin et al. needed to start with much larger plasmas than those used previously (billions of Sr atoms) so that the increased characteristic expansion time constant allows for sufficient cooling time. After 135 μs of cooling, the plasma reached 50 mK — or four times cooler. This temperature is sufficient for Coulomb repulsion to dominate thermal motion. Strong coupling achieved! Studies of transport, thermalization and collective modes of plasmas under similar conditions as planetary interiors become possible, as perhaps also measurements of shear viscosity and thermal conductivity.

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