Unruly plasmas: Researchers challenge Bohr-van Leeuwen theorem

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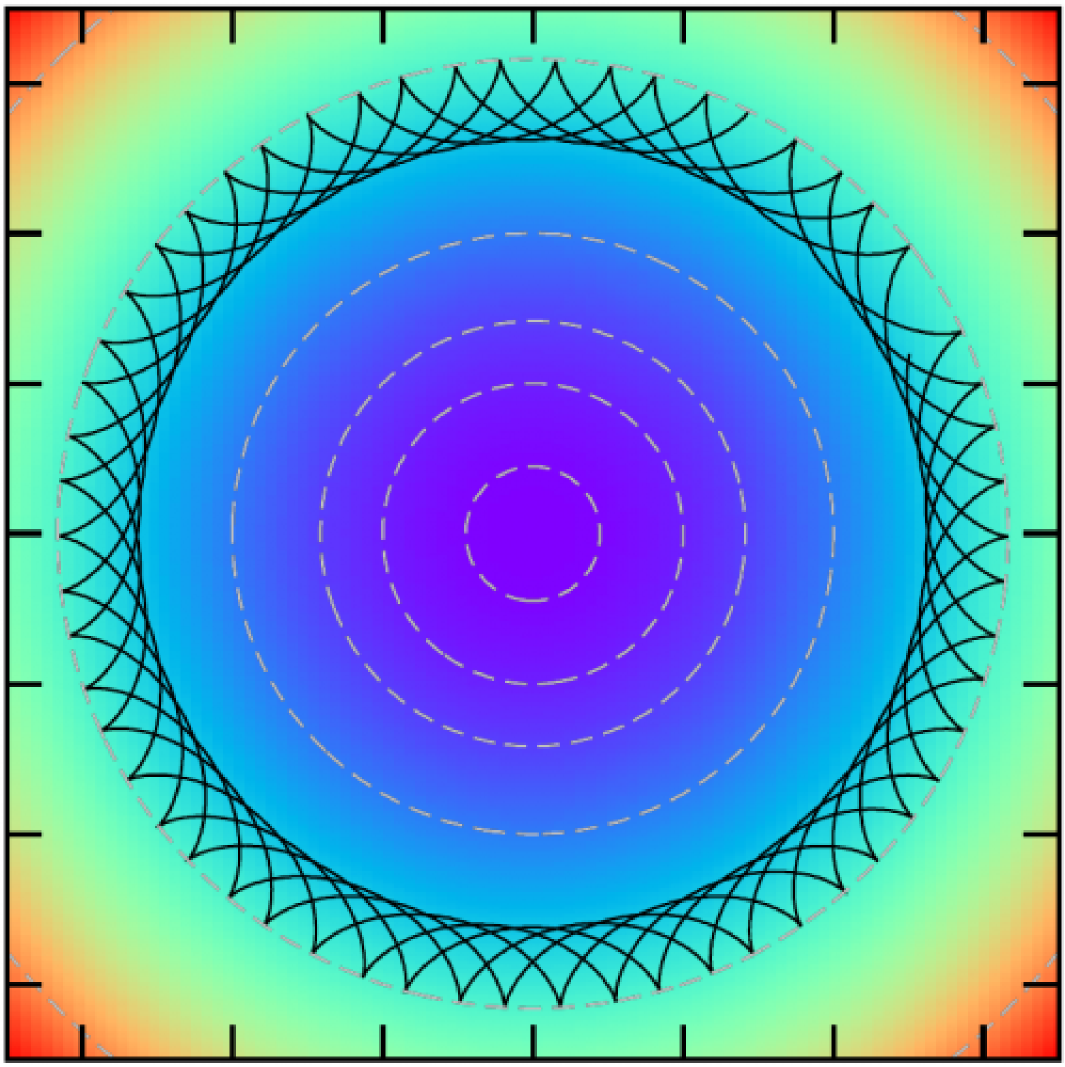

Trajectory of an arbitrary particle in the fluid. The magnetic field prevents that the particle reaches the energy minimum (in the centre). Credit: Torben Ott

Scientists of the universities in Düsseldorf and Kiel have obtained a surprising result that appears to be in conflict with standard text book knowledge. According to the fundamental Bohr-van Leeuwen theorem, the state of a classical many-particle system cannot be altered by turning on a magnetic field: in particular, a liquid will remain a liquid and a crystal will remain a crystal. In an article published in the current issue of the journal *Physical Review Letters* Dr. Torben Ott, Professor Michael Bonitz (Christian-Albrechts-Universität zu Kiel) und Professor Hartmut Löwen (Heinrich-Heine-Universität Düsseldorf) demonstrate, that this theorem can be "tricked".

The physicists performed a series of exact computer simulations of a liquid layer of charged particles (Plasma) and cooled it rapidly. According to the text book theorem the fluid would crystallize instantaneously when it is cooled, no matter whether a magnetic field is present or not. "We cooled the liquid very quickly, and in the presence of a strong magnetic field we observed a result that we first could not believe: the system remained fluid for a very long time", says Löwen.

The scientists from Düsseldorf and Kiel came up with a very simple explanation for this unexpected behaviour: the rapid cooling prevents that the particles settle in the energetically lowest state (the crystal). "Whenever the particles start to descend towards the valley, immediately their trajectory is bent upward again by the magnetic field. The particle circle the 'drain', but never reach it", adds Bonitz.

The fact that a cold system can remain fluid – which means very mobile – for a long time may have far-reaching consequences for a large number of systems that are subject to strong magnetic fields – including the evolution cycle of compact stars but also fluids in the laboratory.

More information: Ott, T., Lowen, H. and Bonitz, M. Magnetic field blocks two-dimensional crystallization in strongly coupled plasmas,

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