Extreme density—approaching a poorly understood state of matter

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Warm dense matter displays characteristics of all other physical states at the same time, in apparent contradiction. The Kiel-based scientists have now developed a new simulation technique which overcomes the inaccuracies of existing theoretical models in describing this state of matter. They have published their research findings in the current edition of the journal *Physical Review Letters*.

With a density of up to a thousand times more than normal solids, warm dense matter is extremely dense. It exists, for example, as a consequence of the enormous gravitation inside dwarf stars. In lab experiments, this state can be created for short periods of time, in the nano- to microsecond range, under the influence of high intensity laser radiation. Long enough for researchers across the world to probe this state of matter with experiments or computer simulations. "Exact knowledge about warm dense matter is the key to answering many astrophysical questions. For example, it helps us to determine how old galaxies are, and is also essential for technological applications such as inertial confinement fusion or for understanding how materials behave under extreme pressure", says Bonitz, to classify the significance of the findings.

Previous theoretical models were only able to produce approximate information on the characteristics of warm dense matter. The reason for this is the particular complexity of the interaction between the constituent particles, but especially the behaviour of the electrons involved. They strongly interact with each other and, at the same time, are governed by the laws of quantum mechanics, so that until now they could not be described reliably using existing models.

Thanks to the new simulation method it is now possible to better understand the results of experiments and to make reliable predictions for new measurements. The Kiel-based research group's approach avoids the simplifications used in previous theoretical models. "It is therefore justified to regard our approach as a computer experiment that produces exact results", Bonitz continues. These findings made at Kiel University now form the basis for improving the existing and developing new numerical methods that will allow for a complete description of warm dense matter in the future.

More information: "Ab Initio Thermodynamic Results for the Degenerate Electron Gas at Finite Temperature," *Physical Review Letters* 115. dx.doi.org/10.1103/PhysRevLett.115.130402