Physicists propose a novel approach to Bose-Einstein condensation

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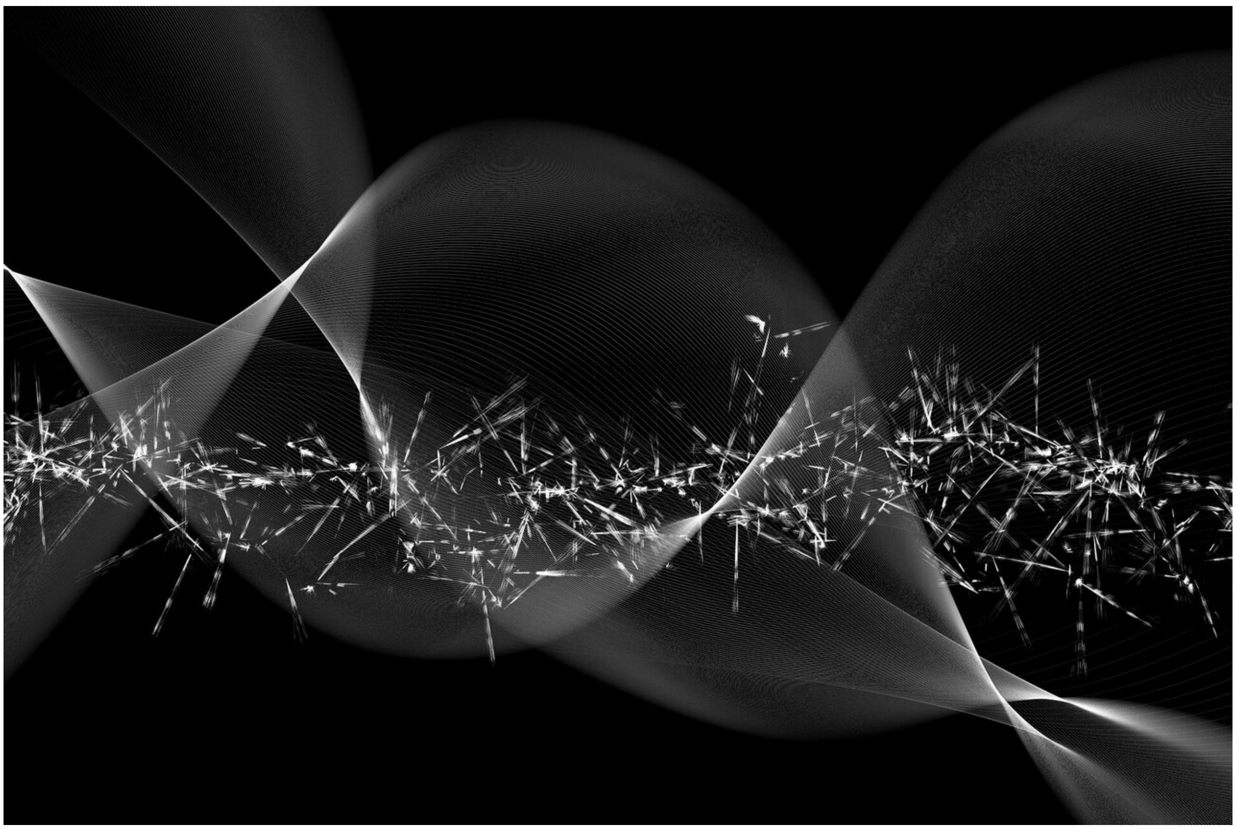

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Bose-Einstein condensates are often described as the fifth state of matter: At extremely low temperatures, gas atoms behave like a single particle. The exact properties of these systems are notoriously difficult to study. In the journal *Physical Review Letters*, the quantum physicist Christian Schilling from the Ludwig Maximilian University Munich and his collaborators from the Martin Luther University Halle-Wittenberg (MLU) have proposed a new approach to describe these quantum systems more effectively and comprehensively.

Research into the exotic state of matter dates back to Albert Einstein, who predicted the theoretical existence of Bose-Einstein condensates in 1924. "Many attempts were made to prove their existence experimentally," says Dr. Carlos Benavides-Riveros from the Institute of Physics at MLU. Finally, in 1995, researchers in the U.S. succeeded in producing the condensates in experiments. In 2001 they received the Nobel Prize for Physics for their work. Since then, physicists around the world have been working on ways to better define and describe these systems that would enable their behavior to be more accurately predicted.

This normally requires complex equations and models. "In quantum mechanics, the Schrödinger equation is used to describe systems with many interacting particles. But because the number of degrees of freedom increases exponentially, this equation is not easy to solve. This is the so-called many-body problem and finding a solution to this problem is one of the major challenges of theoretical and computational physics today," explains Benavides-Riveros. The collaboration led by Schilling has now put forward a method that is comparatively simple. "One of our key insights is that the particles in the condensate interact only in pairs," says co-author Jakob Wolff from MLU. This enables these systems to be described using simpler and more established methods.

"Our theory is in principle exact and can be applied to different physical regimes and scenarios, for example strongly interacting ultracold atoms. And it looks like it will be also a promising way to describe superconducting materials," concludes Jakob Wolff.

More information: Carlos L. Benavides-Riveros et al, Reduced Density Matrix Functional Theory for Bosons, *Physical Review Letters* (2020). DOI: 10.1103/PhysRevLett.124.180603

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