Simple model explains crystal formation of exceptional atoms

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Scientists from the FOM Foundation, Eindhoven University of Technology and the University of Buenos Aires have discovered why fluctuations in the number of Rydberg atoms that forms in an ultracold gas decreases as the interaction between the atoms becomes stronger. They published the results on 22 July in *Physical Review Letters*.

Rydberg atoms contain electrons at a large distance from the atomic nucleus and are not strongly bound to it. Consequently, Rydberg atoms have several strange properties. For example, they respond strongly to electrical and magnetic fields. The Rydberg atoms also have an incredibly strong interaction with each other. That results in the so-called 'blockade effect': in the vicinity of a Rydberg atom, no other Rydberg atoms can arise. By making smart use of these blockades, researchers can build spatial structures with the atoms, such as crystals. The new research throws new light on this crystal formation.

Mathematical model

In their publication the researchers translate the complex problem into a simpler graph model. This mathematical model consists of a collection of points, the atoms, which are connected with each other. The atoms change at random time intervals into Rydberg atoms. In doing this they prevent neighbouring particles from turning into Rydberg atoms at the same time. The particle system ultimately ends up in a stable situation in which all of the particles are Rydberg atoms or are blocked. By studying

how this model system becomes jammed, the researchers revealed why the number of Rydberg atoms that forms in the real gas shows relatively little variation .

Theory and experiment

"We were surprised that the theoretical results agreed so strongly with the experimental results. That is because the model ignores important spatial aspects, such as the position of each particle," says group leader Servaas Kokkelmans. Due to the model's success, the team thinks physicists will also be able to use it to describe other particle systems in which complex interactions play a role.

More information: "Sub-Poissonian Statistics of Jamming Limits in Ultracold Rydberg Gases" *Phys. Rev. Lett.* 115, 2015. arxiv.org/abs/1504.02624

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