Popular science

Ultra-cold droplets intrigue physicists

A hot topic within ultra-cold atom physics has been the recent discovery of droplets formed out of Bose-Einstein condensates, a specific form of a super cold and very dilute gas. The condensate is however very different from any gas encountered in everyday life. A normal gas can be thought of as atoms or molecules moving around in all directions. If you cool this gas, all the particles move slower until they either form a liquid or freeze and become a solid.

This is not the case for the Bose-Einstein condensate. Instead they spread through space due to quantum mechanics and together they form one entity. This entity, the so called condensate, behaves like no classical gas, as it is mainly governed by quantum mechanics and not by the random chance of a lot of small particles moving about.

To add to this strangeness, droplets now seem to form out of these condensates. The existence of these droplets was quite a surprise. Among experimentalists working with creating Bose-Einstein condensates the expected result was a collapse of the system if forces pushing the condensate together won against the forces pushing it apart. However, experimentalists revealed that some other internal force stabilized drops inside the condensate. Not only that, this force seemed to be able to create drops that could exist outside a "trap", which usually is a number of lasers and magnets that keep the condensate together. Some droplets could not be formed without a trap, but instead formed crystal structures, a very intriguing result.

This has led to an excited mood within the field of cold atom physics. But what to expect from this anti-collapse force, mainly being described as quantum fluctuations, and the droplets it creates needs further study to find out. In this thesis work we simulate the anti-collapse force and possible droplet systems solving the underlying quantum-mechanical many-particle equations numerically.

One system of interest is the very thin disc of condensate, or a quasi two-dimensional condensate. This system is excellent for rotating the condensate in. Why? Imagine having a piece of pizza dough that in this case represents a condensate. If you spin this dough as a skilled pizza maker does, the pizza will become flat due to rotational forces. The same goes for the condensate. As you rotate it it will become flat anyways and therefore having a model where our very cold gas is already flat makes it easier to simulate rotating systems.

But before you start rotating your drops, you have to find the drops. And to find the drops you have to study the forces pushing the condensate together and the forces pushing it apart. Therefore we presently aim at studying possible droplet formation in these pizza crust shaped condensates, to make way for the study of rotational excitations. Initial results show some promise that droplets can be found in these quasi two-dimensional systems.