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A nugget from FOCUS:

Title：Detection of new quantum phases in ultracold atomic gas

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Physicists are looking for exotic states of matter that are hard to be seen in nature. The breached pair (BP) state/phase is such an example. After a few years of debates on its stability, it has been finally agreed that the breached pair state exists under certain stringent conditions (see the story http://focus.aps.org/story/v15/st1 on Physical Review FOCUS). The ultracold polarized Fermi gas, recently realized in experiments, provides a powerful system to potentially meet these conditions. We proposed recently a scheme to detect this exotic phase in the ultracold polarized Fermi gas. (see W. Yi., L.-M. Duan, Phys. Rev. Lett. 97, 120401 (2006)).

The BP phases have been predicted to exist in theory, but it is hard to detect them experimentally. These phases show polarized superfluidity. However, even if one can confirm polarized superfluidity in the experiments, it is not an unambiguous signal for the BP phase. Many phases can have polarized superfluidity. In particular, the conventional BCS state in the polarized gas also gives polarized superfluidity at any finite temperature (which is necessarily the case for experiments) due to the polarized quasi-particle excitations. So, it is hard to distinguish the more exotic phases from the conventional thermal BCS superfluid in experiments.

We propose a method to detect the BP phases by measuring the momentum-space density profile of the minority spin component. This method has two desirable features: first, it can give an unambiguous signal for the BP phases. With the basic physical picture of the BP states shown in the following figure, we see already that there exists a finite region in the momentum-space with no minority atoms. This region, enclosed by the Fermi surface(s), is occupied only by the majority spin component. Therefore, if one measures the momentum-space density profiles, the profile for the minority atoms should be non-monotonic with a dip in the momentum distribution. This dip is an unambiguous signature of the BP phase as no other phases have that character. Second, this method can also unambiguously distinguish different kinds of BP states. (See a more detailed story at Physorg.org http://www.physorg.com/news78579164.html).

Basis picture of the BP phases in momentum space