NATURE

50 Years Ago

The report of the committee appointed in June 1958 … "to consider the present system of awards from public funds to students attending the first degree courses at universities and comparable courses at other institutions and to make recommendations" was published on June 2. Eleven out of its sixteen members reported in favour of abolishing any means test for parents … The Committee is convinced that, while Britain urgently needs the greatest possible number of highly skilled men and women, it should not depart from the ancient and sound tradition that young men and women go to a university to become all-round citizens and not merely to learn a special skill.

From *Nature* 1 October 1960

100 Years Ago

So little is known about the habits of worms that it seems desirable to place on record any new observation calculated to throw light on the subject. On September 17 I received from Mr. Edwards, curator of the Worcester Museum, a small tube containing about half a score of living worms. The letter which accompanied the tube informed me that the worms were found in a lavatory basin. It was assumed that they had found their way up through the waste-pipe, as none had been found when the plug was fixed in the bottom of the basin … Each worm was about three-quarters of an inch in length, possessed of red blood, and having five to eight setae in each bundle. These features … show the species to be *Pachydrilus subterraneus* … It has more than once been sent to me by irate persons who complained that it had been found in their drinking water.

From *Nature* 29 September 1910

suggested a paired state in which the pairs are not at rest but instead have a net momentum. This FFLO state can be viewed as a kind of microscale phase separation, containing alternating superfluid regions and normal, non-superfluid regions, in which the extra atoms of the spin species that are in excess squeeze in. Although searches for such an exotically paired FFLO state have been carried out exhaustively in condensed-matter systems, and more recently in ultracold atomic gases, unambiguous experimental evidence has remained elusive. In their study, Liao *et al.*[3] take a major step towards creating an FFLO state using ultracold fermionic atoms.

In three dimensions (3D), the FFLO state is believed to occupy only a tiny portion of the phase diagram of possible states of matter, making an observation of this state almost impossible. In one dimension (1D), however, this prospect seems more promising: a 'nesting' effect that allows the edges of the Fermi surfaces of the two system components to be connected with one another makes the FFLO state a much more robust phase in 1D[6], one that occupies large parts of the phase diagram[7]. Liao and colleagues[3] therefore confined a fermionic two-spin gas mixture of atoms in one-dimensional tubes (Fig. 1). To do this, they overlapped two perpendicular standing light waves: the interference between the two waves produces an array of one-dimensional tubes in which the atoms are trapped. In each tube, the atoms are free to move along the longitudinal direction of the tube but have their motion completely restricted in the tube's radial direction. Next, the researchers measured the radial profiles of the number-density difference between the two spin-state components, as well as the number density of the minority spin state, for a range of overall spin imbalances (polarizations) of the gas mixture.

Their data revealed a striking result. In contrast to the 3D case, for which previous observations invariably displayed a fully paired gas core, the authors[3] find that the opposite can occur in 1D: for a large range of polarizations, the wings of their gas mixture are fully paired and the core exhibits partial polarization, as indicated by an excess of one spin-state component (Fig. 1). This behaviour — and the general variation in radius of the density of both the minority spin-state component and the difference between the two spin states as a function of polarization — are in excellent agreement with theoretical calculations of a one-dimensional system with FFLO characteristics. But Liao and colleagues' work is also remarkable for another reason. Simple extensions of their experiment should allow the crossover from 1D to 3D to be investigated. In 3D, the nature of the paired states can be markedly different from that in 1D.

What remains to be demonstrated, however, is whether the partially polarized core observed by the authors[3] is indeed a superfluid FFLO state. So far, they have detected neither signs of superfluidity nor the 'smoking gun' signature of the FFLO state: the two momentum components of the superfluid that are caused by the microscale phase separation. In an extension of Liao and colleagues' experiment, this characteristic momentum distribution should be measurable in a single tube. According to theory, success in reaching the FFLO phase may also require lowering the temperature of the experiments further. More than 40 years after the original proposal, the race for the unambiguous observation of the FFLO state is therefore still on, but Liao and colleagues have opened a path towards making it a reality. ■

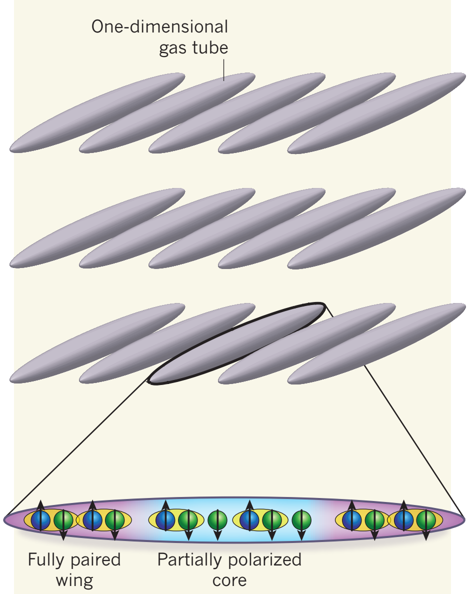

Figure 1 | Trapping and pairing atoms in one dimension. Liao *et al.*[3] trapped two-component spin mixtures of ultracold fermionic atoms in an array of one-dimensional tubes, which are produced by the interference between two optical standing waves (not shown). Each component consists of atoms that are in one of two spin states (up or down), and the system has an overall spin imbalance caused by a difference in number between the spin-up and spin-down atoms. For a wide range of spin imbalances, the authors find that the system has a partially polarized core and fully paired wings — a result that is in good agreement with theory but in striking contrast to results obtained for systems trapped in three dimensions.

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