50 & 100 YEARS AGO

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In my opinion the trouble with African agriculture is not that information is not properly co-ordinated, but that the basic facts are simply not known. So little fundamental agricultural research has been done ... Even attempts at developments like the Groundnut Scheme ... seem less wasteful when it is realized that for every pound lost in this and in all agricultural schemes attempted in Africa since the War, much more than a hundred pounds has been spent in subsidizing British agriculture at home. More money will have to be spent on research in Africa. We need to have more and better research workers in the laboratories and in the field; I believe they will use the limited resources better than those who fritter away so much time and money attending international conferences and endless meetings of co-ordinating committees which lack the basic facts to co-ordinate. **Kenneth Mellanby**

From *Nature* 27 February 1960.

100 YEARS AGO

The Irish Fairy Book. By Alfred Perceval Graves — There is a greater demand for fairy books than there is for works on folklore, and the readers differ greatly in taste and requirements. Some fairy books are worse than useless to the folklorist, books in which the authors treat their sources in a thoroughly irresponsible fashion. On the other hand, those who could handle such materials discreetly, learnedly, and reverently cannot be induced to write fairy books. But such books must be written, and Mr. Graves has produced one which is in every respect commendable ... Many of the tales are in proper form for scientific examination, being evidently faithful records of oral traditions ... As in Welsh folklore, the fairies are in high glee at the seasonal festivals. Puck, for instance, is definitely associated with November. Lugnassed, Lug's marriage — the old name for the August festival — survives in dialect as "Lunacy day in harvest."

From *Nature* 24 February 1910.

formula that describes the relationship between the system's thermodynamic parameters, such as pressure, volume, temperature and internal energy. From the history of physics, we know that a new formulation or modification of a system's equation of state represents an advance in our understanding of the system. The most famous equation of state, the ideal-gas law, was formulated in the early 1800s. It describes the state of an ideal gas, a hypothetical gas composed of non-interacting point particles. Despite its simple form ($PV = nRT$, where P is the pressure, V the volume, n the density, T the temperature and R a constant) the ideal-gas law provides a good description of the behaviour of many ordinary gases under normal conditions.

The procedure to obtain the equation of state for a gas is straightforward: fill a box with a 'cloud' of gas; measure how its pressure changes with temperature or volume, or vice versa; do so for all possible phases of the system; and, finally, combine and translate all of the information into an equation. In their experiment, Nascimbène *et al.*[3] did just that, but with two differences. First, their sample, a fermionic gas of lithium-6 atoms in a mixture of two spin states, was confined in a harmonic trap instead of a box. Second, they measured the shape — that is, the gas density distribution — of the cloud.

In a harmonic trap, the trapping potential changes quadratically as a function of distance from the trap centre, so a sample in the trap has an inhomogeneous density distribution: a high density at the centre and a low density in the outer regions. As a consequence, the phase of the system varies spatially across the sample. This spatial inhomogeneity makes it difficult to measure the thermodynamic properties of the system, and so the equation of state. However, because in thermal equilibrium neighbouring local points in the sample have a well-defined thermodynamic relationship, it turns out that from the precise measurement of the gas density distribution one can access the thermodynamic quantities[4]. Nascimbène and colleagues measured the equation of state for the gas in the unitary regime for both a spin-balanced (with no net spin) sample at finite temperature and a spin-imbalanced sample in the zero-temperature limit.

Interestingly, the authors find that the thermodynamic behaviour of the normal (non-superfluid) phase of the gas in the unitary regime, for both balanced and imbalanced samples, is very close to that of a Fermi liquid. In the BEC regime, fermions pair up and form spatially localized molecules before undergoing a phase transition to a superfluid; the low-temperature normal phase is a Bose liquid of thermal molecules. In the BCS regime, fermion pairing and superfluidity occur at the same time, so the normal phase is a Fermi liquid of atoms (Fig. 1). In attempts to model the BCS–BEC crossover, theorists have anticipated that the normal phase of Fermi gases in the unitary limit might be a non-Fermi-liquid phase such as the pseudo-gap state that is thought to be a precursor phase of the high-temperature superconducting state of copper oxide compounds[5]. Nascimbène and colleagues' experiment now shows unambiguously that this is not the case.

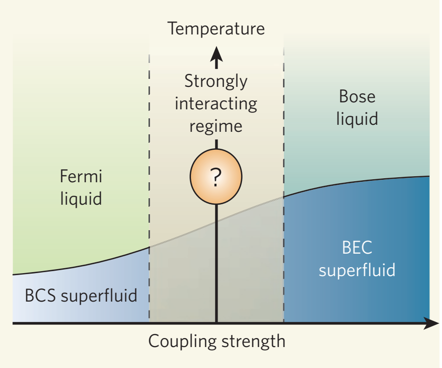

Figure 1 | Nature of the strongly interacting regime. A strongly interacting Fermi gas lies at the crossover between a Bardeen–Cooper–Schrieffer (BCS) superfluid and a Bose–Einstein condensate (BEC) superfluid. As the coupling strength between particles is increased, the BCS superfluidity (frictionless flow) of weakly interacting pairs of fermions (Cooper pairs) smoothly evolves into the BEC superfluidity of tightly bound bosonic molecules made of fermions. In the BEC regime, the low-temperature normal (non-superfluid) phase is a Bose liquid of molecules; in the BCS regime, the low-temperature normal phase is a Fermi liquid of atoms. Nascimbène *et al.*[3] demonstrate that the hitherto uncharacterized normal phase of a strongly interacting Fermi gas in the unitary regime is very close to a Fermi liquid.

One novelty of their experiment lies in the use of a Bose gas to measure the temperature of the system. Lack of accurate thermometry has long been the bottleneck for determining the thermodynamic properties of strongly interacting Fermi gases. The observation of a lattice of vortices in such a system has provided conclusive evidence of high-temperature superfluidity[6]. But until now, the critical temperature at which a balanced Fermi gas becomes superfluid has not been determined in a model-independent way. Because the heat capacity of ultracold (nanokelvin temperature) atomic gases is extremely small, a normal thermometer cannot be used as the sample would immediately vaporize. Inspired by an earlier demonstration[7], Nascimbène *et al.*[3] overcome this problem by introducing a small amount of a Bose gas into the sample and measuring its temperature. The Bose gas used by the authors has the advantage of being sufficiently weakly interacting to not perturb the sample, but strong enough to be in thermal equilibrium with it. This technique allowed the researchers to measure the temperature of their samples directly.

Ultracold atomic-gas systems have been developed to simulate a variety of quantum phenomena and to tackle long-standing problems in condensed-matter physics. Nascimbène