resolved on only one of the multiple Fermi surfaces of $CeCoIn_5$, revealing a large gap on a heavy band, with a maximum value $\Delta_0 \sim 2.8\ k_B T_c$. But thermal conductivity studies have shown that the gap in $CeCoIn_5$ must be very small on some part of the Fermi surface[8]. STS is ideally suited to locate this small gap in k-space, and indeed map out how the gap magnitude varies from band to band.

Several other exciting avenues can be pursued. First, by exploiting the magnetic field dependence of coherence factors, the sign of the pairing function can in principle be accessed. Second, in the normal state of $CeCoIn_5$, the electron effective mass — a measure of the electron–electron interaction — is tuned by a magnetic field in a way that is suggestive of an antiferromagnetic quantum critical point[9,10]. Band-dependent measurements of the mass by means of quasiparticle interference as a function of field could investigate the possible links between mass enhancement and pairing strength. Third, a detailed study of the intriguing gap seen in the normal state[4] could provide insight into the enigmatic 'pseudogap' of the cuprates. A new era in the study of unconventional superconductors has just begun. ❐

Louis Taillefer is in the Département de Physique, Université de Sherbrooke, Sherbrooke, Québec J1K 2R1, Canada and the Canadian Institute for Advanced Research.
e-mail: Louis.Taillefer@USherbrooke.ca

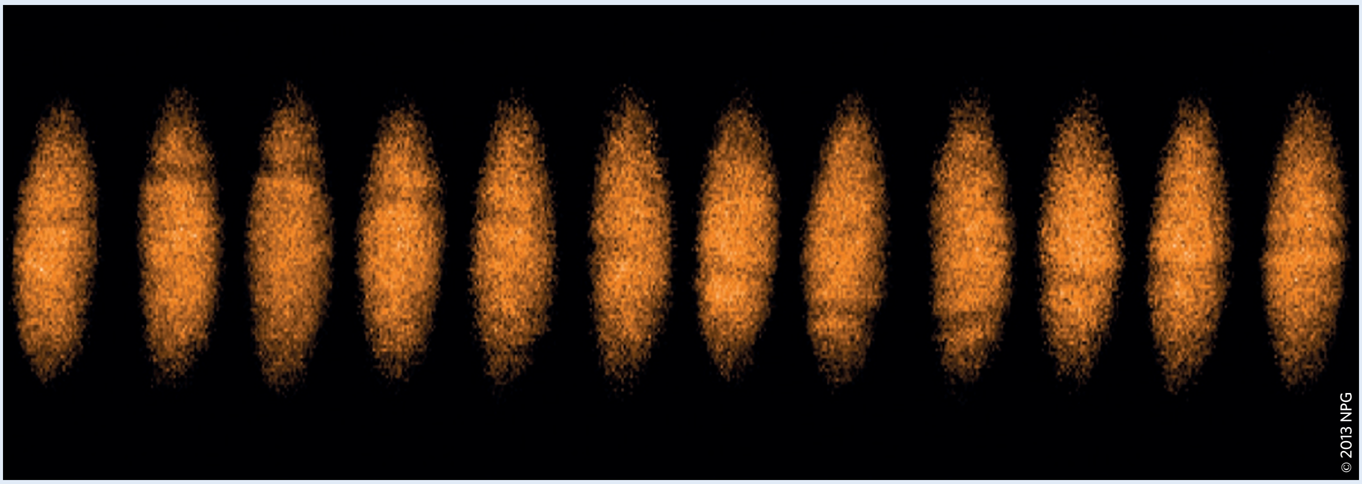
References

1. Mathur, N. D. *et al. Nature* **394,** 39–43 (1998).
2. Monthoux, P., Pines, D. & Lonzarich, G. G. *Nature* **450,** 1177–1183 (2007).
3. Allan, M. *et al. Nature Phys.* **9,** 468–473 (2013).
4. Zhou, B. *et al. Nature Phys.* **9,** 474–479 (2013).
5. Das, T. *et al. Phys. Rev. B* **87,** 174517 (2013).
6. Paglione, J. & Greene, R. L. *Nature Phys.* **6,** 645–658 (2009).
7. Chubukov, A. V. *Ann. Rev. Cond. Matt. Phys.* **3,** 57–92 (2012).
8. Tanatar, M. A. *et al. Phys. Rev. Lett.* **95,** 067002 (2005).
9. Paglione, J. *et al. Phys. Rev. Lett.* **91,** 246405 (2003).
10. Bianchi, A. *et al. Phys. Rev. Lett.* **91,** 257001 (2003).

Published online: 14 July 2013

ULTRACOLD GASES

Waves and wiggles



In 1834, young engineer John Scott Russell observed an unusual phenomenon in the Union Canal — a well-defined solitary wave travelling unchanged at constant velocity, which he called a 'wave of translation'. Fascinated by the effect, Scott Russell set about reproducing it in a water tank to study its properties, but his enthusiasm wasn't shared by his contemporaries and his work was soon forgotten. However, in the 1960s the waves of translation were resurrected in the context of nonlinear phenomena, and are now known as solitons. They appear in unexpected places, from optical fibres to superfluids and superconductors.

As Scott Russell did before them, Tarik Yefsah and colleagues are studying solitons, but rather than a water tank they have developed a much more sophisticated, modern experiment using a superfluid of fermionic atoms (*Nature* **499,** 426–430; 2013). Ultracold lithium atoms are confined in an elongated trap and, as a result of interaction with a laser beam, about half of them experience a phase shift. This creates a soliton — which in the case of a fermionic superfluid is a phase twist in the wavefunction — that can be observed directly as a density-depleted dark region. The soliton propagates back and forth through the superfluid (pictured) like an oscillating spring–mass system.

Yefsah *et al.* tracked the soliton oscillations for different particle-interaction strengths: from a Bose–Einstein condensate (BEC) of tightly bound molecules to a Bardeen–Cooper–Schrieffer (BCS) superfluid of long-range Cooper pairs. In the BEC regime, the soliton is empty — a clearly defined dark region. But as the interaction becomes more BCS-like, the soliton is filled (most probably by unpaired fermions) and its signature fades away. The oscillation period of the soliton increases with the interaction strength and the corresponding effective mass becomes two hundred times larger than the soliton bare mass — which is fifty times larger than predicted by mean-field theory.

This discrepancy could be explained in terms of a serious underestimation of the role of quantum fluctuations and number of unpaired fermions. Thus, these observations are a test of the present theory of the non-equilibrium dynamics in strongly interacting Fermi gases.

IULIA GEORGESCU