is clear that we have now amassed so much phenomenological information on both the superconducting and normal (non-superconducting) states that any microscopic theory claiming to be 'the theory' will have to explain more than just one set of observations. Newns and Tsuei are aware of the challenge, as their model[3], on page 184, provides quantitative explanations of the dome-shaped doping dependence of the transition temperature and the oxygen isotope effect. Furthermore, their work also yields insight into the *d*-wave symmetry of the pseudogap as well as the nanoscale inhomogeneity revealed by recent low-temperature tunnelling experiments[8].

In essence, their model is based on a two-phonon process within a Fermi-liquid framework. This process is different from the single-phonon-mediated electron–electron (or hole–hole) pairing in the conventional Bardeen–Cooper–Schrieffer model, which is based on a linear interaction. Instead, the authors notice that a charge carrier within the CuO_2 plane moving along the Cu–O–Cu bond direction must be modulated by the vibration of planar oxygen atoms, involving two local phonons (Fig. 1). Thus, the fluctuating bond results in a nonlinear (anharmonic) pairing interaction. Moreover, the same interaction also leads to a charge density wave — a static or quasi-static distortion — of *d*-wave symmetry, which competes with the *d*-wave superconducting order parameter.

But how will we know if this is the correct model? Further tests are necessary. On the theoretical front, the superfluid density, for example, which is a measure of the phase 'stiffness', or the robustness of the paired electrons to changes in the superconducting order parameter, is yet to be calculated. And on the experimental side, the anharmonicity of the oxygen vibrations and the modulation in the charge density wave state — all the way up to T^*, the pseudogap temperature — need to be verified.

The theory of conventional superconductivity emerged five decades after its discovery in mercury. High-temperature superconductors have only been around for two decades. We're not there yet but we're enjoying the ride, wherever it takes us.

References

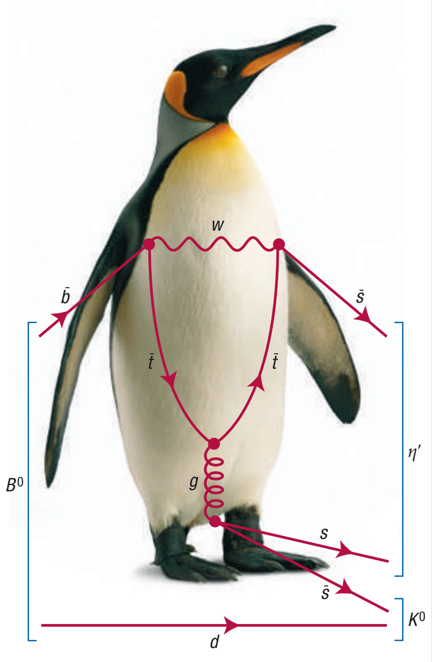
1. Vignolle, B. *et al. Nature Phys.* **3,** 163–167 (2007).
2. Byczuk, C. W. *et al. Nature Phys.* **3,** 168–171 (2007).
3. Newns, D. M. & Tsuei, C. C. *Nature Phys.* **3,** 184–191 (2007).
4. Bogdanov, P. V. *et al. Phys. Rev. Lett.* **85,** 2581–2584 (2000).
5. Lee, J. *et al. Nature* **442,** 546–550 (2006).
6. Lanzara, A. *et al. Nature* **412,** 510–514 (2001).
7. Schäfer, J. *et al. Phys. Rev. Lett.* **92,** 097205 (2004).
8. McElroy, K. *et al. Science* **309,** 1048–1052 (2005).

PARTICLE PHYSICS

B-factories pick up penguins

Antimatter mirrors matter — but not quite. The violation of charge–parity symmetry ('CP violation') in interactions mediated by the weak force means that particles and their antiparticles don't behave as exactly equal opposites. For example, a neutral *B* meson (made of a pair of quarks) constantly evolves between its particle and antiparticle states — but the rate of change of matter into antimatter is not the same as the rate for antimatter into matter. New analyses from the BaBar and Belle collaborations, published in *Physical Review Letters*, delve further into this asymmetry, investigating in particular a process described, rather entertainingly, by a 'penguin' diagram.

B mesons can decay in several ways, one possibility being the penguin process pictured — so called for its resemblance to the antarctic bird. (As the story goes, theorist John Ellis coined the name after losing a barroom bet, the forfeit being to work the word 'penguin' into his next paper, on *B* decay.) Here, an antibottom quark ($\bar{b}$) from the *B* meson decays to produce an antistrange quark ($\bar{s}$) through a loop that incudes a *W* boson and antitop quarks ($\bar{t}$). Gluon radiation (g) from that loop can produce a quark–antiquark pair (s and $\bar{s}$). Then, including the 'spectator' down quark (d) from the original *B* meson, the final-state quarks pair up into a neutral *K* meson and a particle known as η', as indicated.



What makes the penguin process so interesting is the loop in the diagram: the particles contained within it are virtual and can have very high masses; it's possible that undiscovered massive particles could enter the loop, and hence be revealed through their influence on the process. But this penguin process is also relatively rare, and it takes a careful analysis of a large data sample to isolate its signature.

The BaBar and Belle collaborations — sited at the PEP-II collider at SLAC, California, and the KEKB collider at KEK, Japan, respectively — have been taking data for several years on *B*-meson production in electron–positron collisions. The energy of the collisions is chosen to maximize the rate of production of $B\bar{B}$ pairs, hence the experiments have been called '*B*-factories'. Following up on earlier analyses, both BaBar and Belle have now found a clear signal for the penguin process $B^0 \to \eta' K^0$ in their huge datasets, comprising nearly 400 million $B\bar{B}$ pairs for BaBar (B. Aubert *et al. Phys. Rev. Lett.* **98,** 031801; 2007), and more than 500 million $B\bar{B}$ pairs for Belle (K.-F. Chen *et al. Phys. Rev. Lett.* **98,** 031802; 2007).

The CP violation in the process is clear: using this decay signature, BaBar and Belle record matter–antimatter asymmetries between B and $\bar{B}$ that have a significance of 5.5 and 5.6 standard deviations, respectively. More data is needed to probe whether there are new particles appearing within the virtual loop of the process, but as yet the possibility cannot be ruled out — leaving everything to play for in particle searches at the Large Hadron Collider, which turns on at CERN, Geneva, later this year.

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