each spectrum, seems to increase with temperature. Fits to the spectra, however, demonstrate that the true gap width actually decreases with increasing temperature and that thermal broadening is responsible for the apparent growth.

Although spectra from conventional superconductors are well understood, those from high-temperature superconductors are not. In particular, as the doping of these materials is changed, the shape of the spectrum changes dramatically from a narrow gap with sharp peaks to a broad gap with no discernable peaks at all (Fig. 2). These spectra appear so different that it is unclear whether they are related to the same phenomenon. Alldredge and co-workers, however, demonstrate that they can fit all of these curves with a single simple equation. In fact, it is the same BCS equation used to fit the conventional superconductor curves of Fig. 1 with two important modifications. First, Alldredge *et al.* account for the *d*-wave nature of the gap — the fact that it ranges from its maximum value to zero as a function of angle in momentum space. This standard modification explains the roughly linear density of excitations at low energies.

Second, they add an 'inelastic scattering rate', which is also commonly done[4], and can account for various mechanisms leading to broadening in the spectra, most visible as the rounding of the peaks at the edge of the gap. But Alldredge *et al.* take a different approach. Rather than using a constant broadening term, theirs varies linearly with energy, making it possible to broaden the peaks of large gaps more than small gaps, consistent with the data.

What are we to make of a linear-in-energy scattering rate? The answer is unclear and begs theoretical study but, as a phenomenological parameter, there is no reason that the scattering rate should not have some energy dependence. More important than the details of the fitting function, though, are the implications of being able to fit the whole variety of spectra measured across a broad range (from underdoped to overdoped) of highly inhomogeneous samples. Previous suggestions of nanoscale phase segregation into two classes of spectra[5], for example, are immediately called into question given the ability to fit both classes with a single function. Although the authors stress the universality of their fitting function, the results of their fits actually highlight an important difference between overdoped (small gap) and underdoped (large gap) spectra: the existence of significant broadening. Considered as a function of doping, Alldredge *et al.* find the scattering rate increases dramatically below optimal doping, falling to negligible levels above it. The same holds true for large-gap spectra in general — their scattering rate is reliably higher than in their small-gap neighbours, indicating that the idea of two classes of spectra may not be so far-fetched.

In short, while providing an ability to place a wide variety of spectra under one roof, Alldredge *et al.* also provide a method of differentiating them. Which view is ultimately more helpful in understanding the physics of high-temperature superconductivity remains to be seen.

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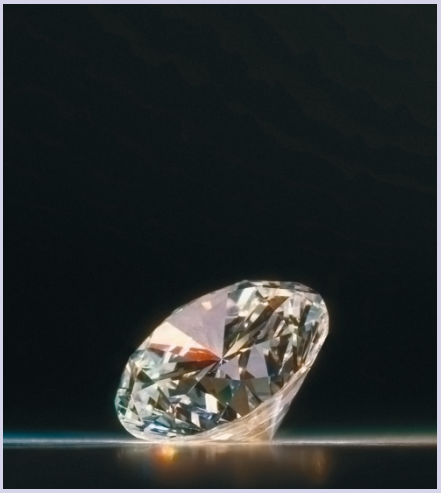
SPIN QUBITS

A host with many facets

Diamonds come in many shapes, but also in many colours, owing to crystallographic defects known as 'colour centres'. Several hundred kinds of luminescent defect are known in diamond, but one in particular is the best friend of many in the quantum-information community: the nitrogen–vacancy (N–V) centre, formed by a substitutional nitrogen atom adjacent to a lattice vacancy. These defects fluoresce bright red, but what makes them so attractive for quantum-information purposes is the electronic spin associated with N–V centres and the possibility of controlling that spin using optical and microwave excitation. Moreover, the electronic spin can couple, via the hyperfine interaction, to nearby nuclear spins of carbon-13 (which, in natural abundance, make up 1.1% of the diamond lattice). Such a system of individual electronic and nuclear spins has been shown to provide — if properly controlled — a promising basis for a quantum register that can be operated at room temperature (*Science* **316,** 1312–1316; 2007).

Whereas the electronic spins can be conveniently initialized, manipulated and read out, the nuclear spins are remarkably well isolated from their surroundings and therefore can store information, in the form of quantum states, for long periods of time. Roughly speaking, the nearby electron constitutes the 'outside world' for the nuclear spin. However, when the electron is probed, it undergoes rapid transitions between ground and optically excited states; as the hyperfine interaction with the nuclear spins is different for ground and excited states, the nuclear spin sees a rapidly changing effective magnetic field — a potential killer of the information encoded in the nuclear spin.



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Liang Jiang and colleagues have now taken a close look at this problem and report that, in a typical experiment, the fluctuations of the electron during optical manipulation are in fact so fast that the randomly accumulated phase of the nuclear spins averages out (*Phys. Rev. Lett.* **100,** 073001; 2008). Similar phenomena in which reservoir fluctuations lead to long — and not, as might be expected, short — coherence times are known in different fields, most prominently as 'motional narrowing' in nuclear magnetic resonance. For diamond-based quantum-information processing, the insight gained by Jiang *et al.* indicates that the individual advantages of the electronic and nuclear spins can be widely exploited without one getting in the way of the other.

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