routes can be used in tumour suppression[7].

The studies[1,2] point to a potential clinical application. Counterintuitively, because tumorigenesis is not delayed by the extensive cell death seen after radiation in the absence of p53, temporary inactivation of p53 during radiation or certain drug treatments that induce DNA damage might be a relatively safe approach to protect normal cells from death, thus permitting a higher dose of these cell-killing agents. This could be particularly useful for the treatment of tumours in which p53 has been mutated or deleted. Support for this strategy comes from the observation that high-dose chemotherapy seems particularly effective in p53-deficient cancers[8]. In addition, a p53-deficient mouse strain called FVB shows a decreased apoptotic response following radiation[9], suggesting that the inactivation of p53 throughout the body can permit a higher dose of radiation or of DNA-damaging drugs.

Therefore, it will be vital to analyse a range of mouse model systems, to make sure that inactivating p53 at the same time as inducing DNA damage with radiation or drugs does not promote new tumours. But if it does not, the therapeutic avenue of inhibiting p53 concomitantly with the administration of DNA-damaging drugs or radiation is worth further exploration. The p53 status of a tumour would then become a critical parameter for deciding on treatment. In p53-containing tumours, p53 might be exploited by enhancing apoptosis[10] with low doses of DNA-damaging agents or radiation therapy. In p53-deficient tumours, the perturbation of the cell cycle by p53 loss would be used to drive tumour cells to cell death resulting from abnormal cell division, while protecting normal cells from p53-mediated apoptosis by systemic inhibition of p53. Inhibitors of p53 such as pifithrin[11] could be used to test this hypothesis. Who would have predicted that disabling p53 systemically would one day be considered as a promising treatment option? ■

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QUANTUM PHYSICS

Observing and the observed

Michael Roukes

Quantum mechanics states that the measurement process can fundamentally alter what is being measured. This 'back-action' has been observed on the macroscopic scale — in the vibrations of a tiny mechanical device.

In daily life, we continuously observe and then assimilate these observations. The cumulative effect of this process grounds our intuition; our intuition, in turn, governs our next actions. But, oddly, our deep sense of the order of things acquired in this way does not square with fundamental tenets of quantum mechanics. Many people have found this discrepancy profoundly discomforting: Einstein, for instance, famously decried one of the least intuitive consequences of quantum theory as "spooky action at a distance"[1,2]. In this issue, Naik *et al.* (page 193)[3] provide a beautiful example of how nanomechanical systems can be used to explore such quandaries. The authors induce cooling of a tiny mechanical resonator just by measuring its vibrations. Closer inspection shows that the phenomenon is a mechanical analogue of the familiar optical cooling of trapped atoms.

Quantum mechanics is about both discreteness and discreetness. On the first property, the theory states that there are fundamental limits to how precisely we can 'know' a system, and that these limits are dictated by, for example, the quantization of charge and energy. Regarding the second property, quantum mechanics says that no free 'sneak peeks' are allowed: observation always comes at the price of interaction, and this interaction will irrevocably change the fate of the object observed. (Actually, a special class of sneak peaks is possible; see, for example, ref. 4.)

For the macroscopic things of our everyday world, the consequences of these interactions generally turn out to be negligible. But at the microscopic level, they govern how the fundamental building-blocks of our world interact. The disparity between the macroscopic and microscopic realms has intrigued physicists, and fuelled heated discussions, since quantum mechanics first emerged in the 1920s.

Nanomechanical systems are one area of research in which the imprint of quantum effects is beginning to be seen on a macroscopic scale[5,6]. It might seem odd to describe these objects, which have dimensions of less than a micrometre, as macroscopic, but the crucial point is that such systems typically contain billions of constituent atoms. And yet, at low temperatures, rather than behaving classically, these large atomic ensembles can begin collectively to manifest quantum behaviour of the type commonly associated with individual atoms and molecules. The field known as quantum electromechanics focuses on such coherent mechanical systems, which are poised midway between two seemingly antithetical domains.

Naik and colleagues[3] explore the interactions between a cryogenically cooled nanomechanical resonator and a nanoscale device called a superconducting single-electron transistor (SSET; Fig. 1). The resonator itself is an object somewhat like a guitar string that, when excited, vibrates at radio frequencies (about 21 megahertz) and amplitudes typically of only atomic dimensions. The crucial step to enable observations on the system is to transduce these fast, tiny vibrations — that is, to convert them into electrical signals.

The authors' readout uses the parallel development of high-frequency motion detectors based on the conventional (non-superconducting) single-electron transistor[7], and their own previous work[8] with the SSET. Over a measurement time of a second, they achieve a record sensitivity with the SSET of just a fraction of a femtometre (a femtometre is 10^{-15} m). This is about the size of a helium nucleus, and much smaller than an atom.

An intriguing aspect of the resulting measurements[3] is the detail they reveal about the noise processes that limit the sensitivity of the measurements themselves. A tight coupling between the SSET and the resonator is the key to precise measurements, and this is achieved by creating a charge interaction between the devices. When the authors tune this electrostatic interaction to maximize the detection sensitivity, the intrinsic random fluctuations of charges within the SSET (the observer), which are an inextricable consequence of its operation, begin to affect the nanomechanical resonator (the observed). This effect is called back-action, and is predicted — in fact, guaranteed — by quantum mechanics, irrespective of how a measurement is made.

In the case in hand, as the SSET 'observes' the resonator, its charge carriers tunnel quantum mechanically to and from an isolated, nanoscale conducting island within it. These charge fluctuations produce a stochastic back-action force that randomly drives the resonator. Charge is discrete, and the associated 'granularity' of these fluctuations, and their impact on the nanomechanical resonator, reveal the underlying nature of the SSET's fundamental particles — electrons in various correlated quantum-mechanical states, known as quasiparticles and Cooper pairs.

ENTOMOLOGY

To catch a bee

Many organisms rely on other species to transport them from one spot to another — particularly in harsh environments where such meagre resources as there are tend to occur in clumps. As Leslie S. Saul-Gershenz and Jocelyn G. Millar report (*Proc. Natl Acad. Sci. USA* doi:10.1073/pnas.0603901103; 2006), one species of the blister beetle *Meloe franciscanus* is a particularly innovative passenger: it can hail its taxi ride.

This blister beetle lives in the deserts of the southwestern United States. It feeds and lays its eggs under a plant that also provides nectar for the beetles' host and transporter species, a solitary bee of the species *Habropoda pallida*.

Larvae of the beetle cooperatively form a spherical mass on the plant (right image), and simply hitch a ride when a male bee intent on mating with a female makes contact (left image). When the infested male copulates with a real female, the larvae are transferred and carried to the bee's nest. There they set up camp, and complete their development into adults nourished by the pollen and nectar stores of the nest and by the bee's egg.

Saul-Gershenz and Millar set out to test what lures the bees to make contact with the larvae in the first place. They found that visual models of the larval aggregations held no interest for the bees — but if the models were scented with an organic extract from either the larvae or the female bee's head, the bees found them just as enticing as real larvae.

Comparison of chemical profiles of the larval and bee extracts identified two alkene molecules common to the larvae and female bees that were not present in the males. And this heady blend of alkenes did indeed attract the male bees. It seems the beetle larvae have evolved a way to exploit the bee's sexual communication system as a means of calling a cab.

Helen Dell

Quantum electromechanics is still an emerging field. In experiments with nanomechanical devices, making the transition from the classical realm to the quantum world means that the random thermal fluctuations must be frozen out, allowing the so-called zero-point motion to come to the fore. This is achieved by cooling the devices to such low temperatures that the occupation of the fundamental vibrational energy modes is suppressed. But it is precisely in this cryogenic regime that thermal contact between these modes and the outside world falls precipitously[9], making it increasingly difficult to cool a device into the quantum regime.

An unexpected consequence of the latest work[3] may help in this matter. Naik and colleagues show that orchestrating a strong coupling between the cooled SSET and the nanomechanical resonator actually chills the latter. In other words, the very act of observing can make an observed object colder. Closer analysis shows that this surprising effect is formally analogous to the phenomenon of 'optical' trapping and cooling of atoms by laser light[10–12]. Both effects rely on back-action from an ensemble of discrete particles — whether correlated electrons or laser photons. These particles interact resonantly at a rate that depends on the motion of the observed object (the nanoresonator or atoms to be cooled).

In both cases, the back-action forces are engineered to damp, rather than excite, the object's motion. The overall effect is that the fluctuating interactions with the object provide it with a 'thermal bath', at a temperature lower than ambient, into which its energy can be absorbed. The puddle of barely moving atoms that resulted from optical cooling and trapping earned the name 'optical molasses'. In recognition of the inspiration drawn from that work, which won the 1997 Nobel physics prize, the authors call their effect 'Cooper-pair molasses'. From here, further advances along these lines will engender even deeper penetration into the strange realm of quantum electromechanics, which lies at the junction between the classical and quantum worlds. ■

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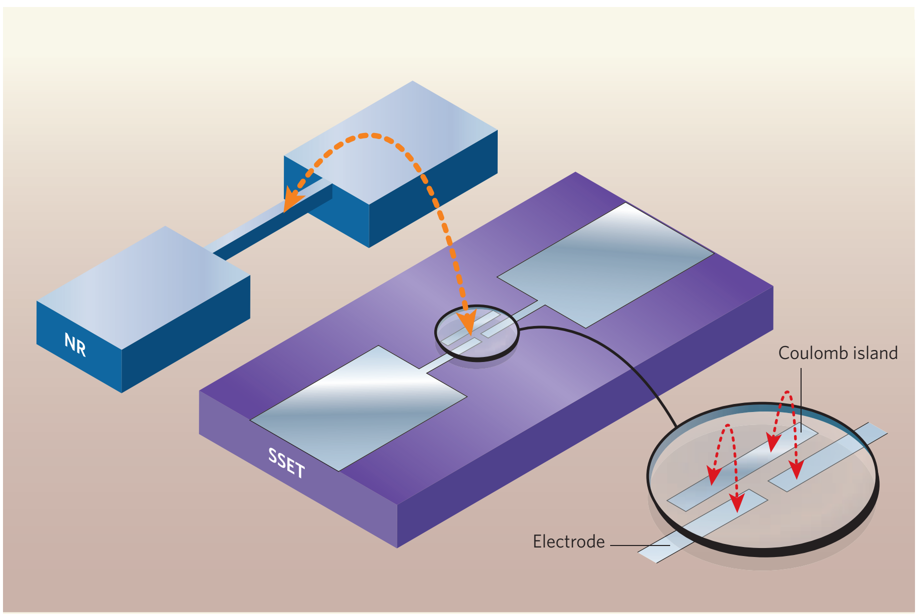

Figure 1 | Cooper-pair molasses in action. Naik and colleagues' experimental set-up[3] consists of a nanomechanical resonator (NR) comprising a suspended, doubly clamped, nanometre-scale beam electrostatically coupled (orange arrow) to a superconducting single-electron transistor (SSET). Back-action arises from the intrinsic charge fluctuations during the operation of the device. These fluctuations are due to discrete quantum-mechanical tunnelling events of quasiparticles or Cooper pairs (red arrows) between the electrodes and an isolated, conducting 'Coulomb island'.

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