ATOMIC PHYSICS

When ultracold is not cold enough

A technique for cooling ultracold atoms in optical lattices has been demonstrated. This advance should allow the physics of strongly correlated systems, including that of quantum magnetism, to be explored. See Letter p.500

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Experiments with ultracold neutral atoms routinely reach nanokelvin temperatures. When combined with optical lattices — light 'crystals' created with standing waves of light — ultracold atoms are an almost ideal quantum many-body system[1,2]. Thus, they are an excellent platform for simulating the physics of solid materials. Lattice-trapped atoms can simulate theoretical model systems that are relevant to understanding strongly correlated materials — systems in which electrons interact strongly. However, for some model systems, even nanokelvin temperatures can be too hot for simulating the relevant phenomena[3].

On page 500 of this issue, Bakr *et al.*[4] demonstrate a technique for cooling quantum atomic gases in optical lattices that may allow much lower temperatures to be reached than those currently attainable. This opens up the possibility of studying a number of outstanding problems in many-body physics, such as quantum magnetism and high-temperature superconductivity[1–3]. In addition, the control achievable with this technique may provide a way of producing logic gates based on two quantum bits (qubits) and creating quantum registers — the working memory needed for quantum computing — using ultracold atoms.

Bakr and colleagues' technique for cooling atomic gases relies on atom blockade. Blockade phenomena arise from the interactions between tightly confined particles. If the interaction energy is sufficiently high, it is much harder to add another particle to the system, because of the increased amount of energy required. Blockade phenomena are used in many systems. For example, Coulomb blockade of electron charges can be used to make transistors based on single electrons[5]. Blockade effects have also been proposed as a way to produce qubits[6–8].

In ultracold-atom experiments, atom blockade occurs as a result of repulsive interactions between the atoms. When trapped in an optical lattice, ultracold atoms develop an energy-band structure just like that of electrons in a solid. The higher the number of atoms in a given lattice site, the higher the interaction energy, creating a barrier to the addition of a further atom. If the optical lattice's sites are sufficiently deep, these interactions give rise to insulating behaviour, analogous to the insulating behaviour of electrons in some solids. As a result, there are a fixed number of atoms per site and tunnelling of atoms between different lattice sites is inhibited.

In their study, Bakr *et al.*[4] show that, in addition to this transport blockade, a blockade can occur if atoms are excited to different energy bands within a single lattice site. The authors introduce the phenomenon of orbital exchange blockade (OEB), which allows the entropy (and thus the temperature) of the system to be reduced.

Bakr *et al.* demonstrated OEB by first preparing a two-dimensional gas of rubidium-87

PSYCHOLOGY

Who needs a leader?

In a dance class, everyone follows the instructor. The opposite situation would be if everyone in the class performed without a designated leader — an activity known as joint improvisation. In a paper published in *Proceedings of the National Academy of Sciences*, Noy and colleagues investigate which of two such situations is the more effective (L. Noy *et al. Proc. Natl Acad. Sci. USA* http://doi.org/hbz; 2011).

Day-to-day examples of joint improvisation include two toddlers playing together. A rather structured example is improvisation in artistic performances (pictured). By the improvisers' own admission, there are 'moments of togetherness' when the level of performance is high but no one knows who is leading. But how does this work? The lack of an experimental paradigm means that this question has not been studied extensively — at least not for open-ended actions.

Noy and colleagues designed an experiment based on the mirror game, a widely used theatrical practice. Specifically, they asked two players each to move a handle along one of two parallel tracks in one dimension. The instruction was: 'Imitate each other, create synchronized and interesting motion, and enjoy playing together.' The nine one-minute rounds in each game were of two types — leader–follower rounds and joint-improvisation rounds. The authors measured the players' movements with high resolution in time (20 milliseconds) and space (1 millimetre).

They investigated the movements of expert players — artists with more than 10 years of experience in joint improvisation. In the leader–follower rounds, the follower showed jittery motion, which oscillated around the leader's confident movement. By contrast, with no designated leader the players performed better, reaching lower errors in velocity of movement and stopping times. In fact, the players jointly showed confident motion 12% of time, compared with 2% in the leader–follower situation.

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So, is having a leader really counterproductive? It depends. With novice players, Noy *et al.* obtained opposite results: these players performed much better with a designated leader. As moments of togetherness are rare in day-to-day life, having a leader is perhaps beneficial for most of us, at least while we learn a new skill. **Sadaf Shadan**