By loading both clouds of atoms from a magneto-optic trap (MOT) into a magnetic trap (where both species are spin polarised), we probe the suppression of Penning ions. Within the noise levels of our experiment we observe no increase in Penning ion production due to the presence of rubidium thus demonstrating at least a factor of 100 suppression in Penning ions due to spin polarisation. In the future we will attempt to create the first excited-state/ground-state Bose-Einstein condensate mixture. Hopefully, our initial measurements will stimulate interest amongst scattering theorists, as little is known about the molecular interactions of ultracold He* and rubidium. ■

L.J. Byron, R.G. Dall, Wu Rugway and **A.G. Truscott**, 'Suppression of Penning ionization in a spin-polarized mixture of rubidium and He*', *New Journal of Physics* **12**, 013004 (2010)

STATISTICAL PHYSICS

Logical independence

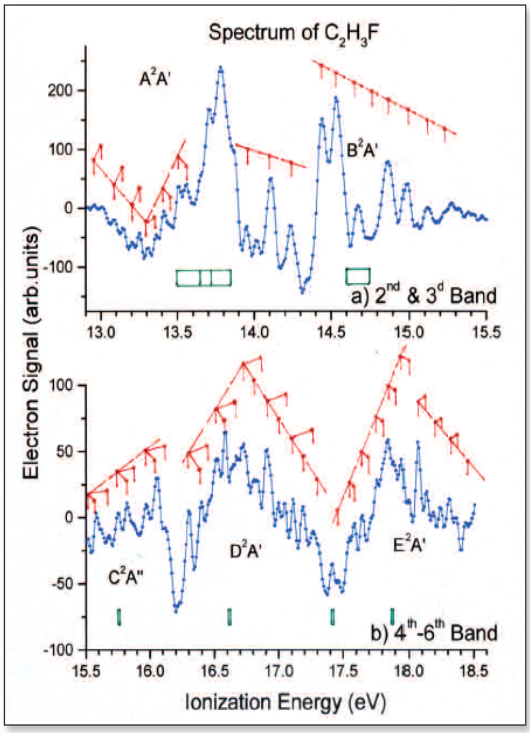
the candidate cannot refuse a question and has to give an answer to every yes-no question he is asked by the quiz master. Say, the candidate starts with the one-bit knowledge that the statement "France is in Europe" is true. However, the first question by the quiz master is about a *logically independent* statement, namely whether it is true or false that "Gordon Brown is Prime Minister of the UK". The poor person only knows about France being in Europe and thus has to randomly guess an answer "yes" or "no". The situation is similar in quantum mechanics. Electrons, for instance, are spin-1/2 particles, and their spin is always up ("yes") or down ("no") along some direction. If the spin is up along a certain direction, say *z*, then – due to Heisenberg uncertainty – it is totally undefined along the orthogonal complementary directions *x* and *y*. A group of quantum physicists (T. Paterek *et al.*) from the University of Vienna and the Institute for Quantum Optics and Quantum Information (IQOQI) propose to view the electron's situation in the same way as the quiz show candidate. They find a precise link between spin measurements along different directions and logically independent mathematical questions. The electron can encode the answer to only one of these questions. Whenever the experimenter asks a question that is logically independent from that particular one, the outcomes are random, as there is no information whatsoever to specify the result. ■

T. Paterek, J. Kofler, R. Prevedel, P. Klimek, M. Aspelmeyer, A. Zeilinger, and **C. Brukner**, 'Logical independence and quantum randomness', *New Journal of Physics* **12**, 013019 (2010)

ATOMIC AND MOLECULAR PHYSICS

Autoionization and non-adiabatic coupling in molecular photoionization

Understanding chemical reactivity requires a detailed knowledge of reactant properties at the molecular level. Ionic reactivity is at the core of powerful analytical technique such as mass spectrometry. Investigating ion production mechanisms and the partitioning of the electronic and vibrational energy is therefore essential. Photoionization is a convenient way to produce cold as well as excited molecular ions. For many ions, only the properties of the ground electronic state are known in detail. Excited states are nevertheless essential to promote reactivity. The authors present the most detailed investigation to date on the photoionization of vinyl fluoride (C_2H_3F), combining four approaches: photoelectron spectroscopy at 21.21eV, threshold photoelectron spectroscopy (TPES), constant ion state spectroscopy (CIS) and high-level *ab initio* identification of non-adiabatic couplings (avoided crossings and conical intersections) between ionic electronic states,



▲ Electron signal resulting from photoionization to electronic excited states of $C_2H_3F^+$. The vibrational structure (red markers) has been amplified by a continuum subtraction procedure. The green areas locate the fragment appearance energies.

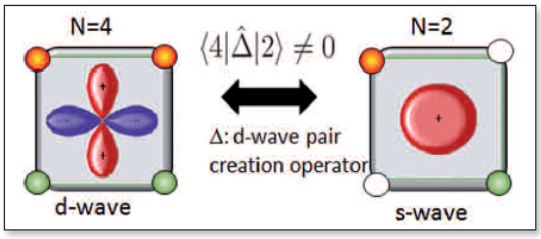
which are essential to promote internal energy conversion. In the top figure, two vibrational modes are identified for the $\tilde{A}^2A'$ state of $C_2H_3F^+$ (12.9–14.3eV) and are assigned to F-CC bending and CF stretching in line with the theoretical predictions. These vibrational progressions are strongly perturbed in the 13.6–13.9eV region by an avoided crossing between the $\tilde{A}^2A'$ and $\tilde{B}^2A'$ states. Such phenomena are responsible for 80% of the fragmentation yield. TPES and CIS spectra reveal that autoionization strongly favours the production of electronic excited states at threshold, compared to the ground state. ■

R. Locht, B. Leyh, D. Dehareng, K. Hottmann and H. Baumgärtel,
'A photoelectron spectroscopic investigation of vinylfluoride (C_2H_3F): the HeI, threshold and CIS photoelectron spectroscopy', *J. Phys. B: At. Mol. Opt. Phys.* **43**, 015102 (2010)

OPTICS

d-wave superfluidity in two-dimensional optical superlattices

While the exact pairing mechanism in cuprates and similar materials is still not understood, it is believed that the basic physics is contained in the simple 2D Hubbard model, in which fermionic particles move on a lattice and repel each other when they occupy the same lattice site. For the Hubbard model, d-wave pairing is expected to occur from an effective attraction caused by the exchange of spin fluctuations. Nevertheless, whether this pairing can give rise to long-range order and superconductivity is an open question. Here we propose an experimental scheme in which recently demonstrated methods for realizing optical lattices and superlattices are combined to create and to detect, in a controlled way an ultracold-atom d-wave superfluid. Our scheme starts from arrays of isolated plaquettes, which incorporate the required d-wave correlations on a short length scale.



▲ **A plaquette is the minimum system that exhibits d-wave symmetry. When loaded with four fermions the ground state is d-wave symmetric while when loaded with 2 the ground state exhibits s-wave symmetry. Consequently, the two states have a non-zero matrix element with the d-wave pair creation operator. Here we propose to load an array of plaquettes with cold fermionic atoms and use this set up as the starting point to engineer in a controllable way a d-wave superfluid by coupling the plaquettes.**

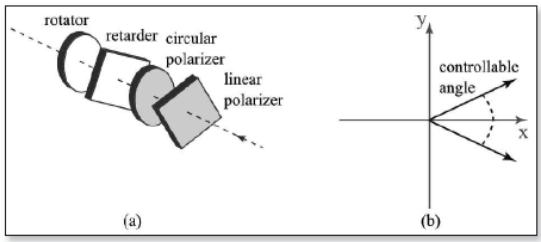
By tuning the parameters of the potentials, these plaquettes can be coupled to achieve long-ranged-wave superfluid correlations, finally arriving at the generic Hubbard model. ■

A. M. Rey, R. Sensarma, S. Fölling, M. Greiner, E. Demler and M. D. Lukin,
'Controlled preparation and detection of d-wave superfluidity in two-dimensional optical superlattices', *EPL* **87**, 60001 (2009)

OPTICS

White polarization sandwiches

To learn how light propagates through an anisotropic medium, we often look at this medium's eigen-waves. In a birefringent crystal, for example, we can decompose the light into ordinary and extraordinary eigen-waves, each with a different refraction index. The polarizations of the eigen-waves (or eigen-polarizations) are orthogonal in most optical crystals, but they may become non-orthogonal in complex optical elements that combine several anisotropy types (dichroism and birefringence). Complex anisotropy combinations cause complex behaviour of such elements and make them interesting for study in polarization optics. The present article theoretically considers a class of elements with non-orthogonal eigen-polarizations that they called white polarization sandwiches. Any white sandwich is anisotropic: it changes the polarization of incident light. But a combination of two identical white sandwiches is isotropic and does not effect the polarization. It means mathematically that white sandwiches are non-trivial square roots of unity, and they belong to the general class of non-hermitian objects considered not only in optics but in quantum mechanics and other areas of physics.



▲ **White sandwiches are synthesized by combinations of four basic elements (a). The angle between two linear eigen-polarizations of a white sandwich can be controlled (b).**

Using a general four-component model of polarization elements, one analyzed white polarization sandwiches and showed how to synthesize these elements by combinations of conventional polarization elements: polarizers, retarders, and rotators. They showed that the form, orientation, and rotation direction of the eigen-polarizations of white sandwiches can be controlled by changing the properties of the constituent elements. For example, a white sandwich consisting of a partial linear polarizer and a 90-degree retarder has two linear eigen-polarizations, the angle between which can be controlled by changing the relative absorption of the polarizer. ■

O. Sydoruk and S.N. Savenkov,
'White polarization sandwiches: optical elements with non-orthogonal eigen-polarizations', *J. Opt.* **12**, 035702 (2010)