the two protons being the principal focus of attention. The distribution in this angle is influenced by correlations between the two protons, either because of their interaction with each other and the daughter nucleus as they fly apart, or because of the structure of the quantum state of ^{45}Fe before the decay. In fact the observed lifetime, and the angular distribution of the 75 events that could be fully analysed, are each consistent with calculations[5,6] that take into account both of these sources of correlations. A remarkable feature of this experiment and its interpretation is that the combination of angular and lifetime information gives a sensitivity to the detailed microscopic structure of the decaying state that is not available in single-particle decays. In this case, a consistent view is emerging of the way in which the two protons are distributed among particular quantum orbits in ^{45}Fe before being emitted.

There are other nuclei that may also undergo radioactive decay by two-proton emission, and evidence has been reported for the ^{54}Zn ground state[7], as well as an isomeric state[8] of ^{94}Ag. Of particular interest is a new result[9] for ^{19}Mg, which has been found to survive, on average, for only six picoseconds (6×10^{-12} s) before emitting two protons. This is surely the shortest lifetime claimed for radioactivity, and it raises questions as to what is meant by a stable nucleus. However, as it takes only about 10^{-21} seconds for a neutron or a proton to orbit a nucleus, it could be said that 6×10^9 orbits is indeed stable — that's more times than the Earth has orbited the Sun since it was formed.

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SUPERCONDUCTIVITY

A celebration of pairs

It is fifty years since John Bardeen, Leon Cooper and Bob Schrieffer presented the microscopic theory of superconductivity. At a wonderful conference in Urbana the 'good old days' were remembered, and the challenges ahead surveyed.

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Why should we be celebrating the 50th anniversary of a theory? For the Bardeen–Cooper–Schrieffer (BCS) theory of superconductivity, I see two very good reasons. First, the work represents an era where the unity of physics was fully evident. There is the famous story of Richard Feynman putting the BCS paper away in his desk for a few months because he could not bear to read it — he knew that they must have got it right. It was a problem near and dear to his heart, as it was to a number of other founders of modern physics. It took 46 years, starting from the experiments in H. Kamerlingh Onnes' lab, to obtain a full microscopic understanding of superconductivity, and many famous scientists tried and failed along the way, Einstein and Heisenberg being notable among them. Second, all the work that came after the BCS theory was formulated reminds us that there is still much more physics to be done. There are whole classes of materials where the mechanism of superconductivity is yet to be understood. These include heavy-fermion, organic, and copper oxide superconductors; some of them have been with us for twenty to thirty years now.

AIP EMILIO SEGRE VISUAL ARCHIVES

Getting ready to celebrate. In 1972, Leon Cooper (left) and Bob Schrieffer (right) received, together with John Bardeen, the Nobel Prize in Physics for their theory of superconductivity developed in 1957.

Understanding them is as challenging today as were the classic superconductors facing Bardeen, Cooper and Schrieffer back in 1957.

No less than eight Nobel laureates attended the 50-year celebration at the University of Illinois at Urbana–Champaign, the institution where this seminal work was done, on 10–13 October 2007. And many more laureates could have been invited, giving an idea of how influential BCS has been. Most of us who attended were not even born at the time the work was done, but it still impacts on our research in a profound manner. For those who were unable to come to join the celebration, they missed some wonderful historical talks, including presentations by Cooper and Schrieffer. Particularly striking were Cooper's comments about the poor state of scientific funding in the United States, and the need to fund the best and brightest so that they can bring about the next scientific revolutions (see his Commentary on page 824 of this issue).

Ivar Giaever gave perhaps the most inspiring talk. He was a mechanical engineer who claimed he was hired at GE because of their lack of understanding of the Norwegian grading system. He did what he did because he was free of some of the prejudices that others in physics had concerning tunnelling — a good reason for us to encourage people from other disciplines to enter our field. Giaever concluded that persistence pays off, but stressed that, in the end, you have to be lucky. (However, to qualify this remark, he pointed out that as physicists we have a much better chance of winning the Nobel Prize than winning the lottery.)

Giaever's work came after BCS, but there were a number of talks about the earlier experiments, including that of Mike Tinkham who looked back at the optics work that provided the first direct evidence for the energy gap. Thinking about the energy gap is what got Bardeen and his group going along the right direction. And then there were the very pretty NMR experiments by Charlie Slichter, where the coherence factors from the BCS theory were essential for understanding why the nuclear spin relaxation rate initially goes up instead of down below the transition temperature. Slichter reported that he was doing the calculations side by side with the theorists as BCS was being developed — a reminder to us that much can be achieved if experimentalists and theorists work closely together.

The impact outside condensed-matter physics was also apparent from these talks. It was the year after BCS that Aage Bohr, Ben Mottelson and David Pines realized that the pairing predicted by BCS could also explain a lot in nuclear physics; anyone following the field today knows that pairing plays a fundamental role in the physics of exotic nuclei. Perhaps even better known is the impact BCS had on particle physics. In 1958, Phil Anderson showed that the theory could be made manifestly gauge-invariant, with the photon becoming massive. Several years later, Anderson translated this scenario to particle physics, leading to a prediction of what is now known as the Higgs particle, a central focus of particle physics today. This translation of the spontaneous symmetry breaking described in the BCS theory to particle physics — by Anderson and Yoichiro Nambu — was recognized in a public lecture given by Steve Weinberg. What struck me, though, was that even back then, there was not much communication between the particle and condensed-matter physics communities. (Weinberg was candid concerning the fact that Anderson's work had little impact on his own work.) This trend is even more pronounced today, and one wonders what kind of breakthroughs could be made if these two communities spent more time talking to one another.

Perhaps most inspiring to me is to realize how much further we have to go. As Paul Chaiken illustrated in his talk, the whole of condensed-matter physics is contained in organic superconductors, yet we do not understand their mechanism. And Dale van Harlingen presented the wonderful work of his and the IBM group that found the *d*-wave phase of the copper-oxide pairs from Josephson tunnelling, but he had to admit that the goal of discovering the pairing symmetry in the heavy-fermion superconductor UPt_3 still eludes them. A sobering thought given that this question has been with us since 1984.

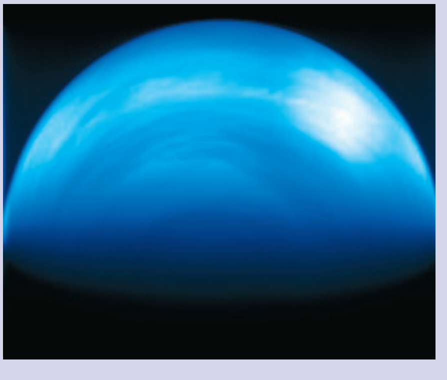
Finally, an entire day was devoted to the copper oxide superconductors. Despite the civility of the panel of theorists debating this subject, it is clear that we have a long way to go before we have a generally accepted microscopic theory of these materials. Even such basic questions as the nature of the pseudogap phase that precedes superconductivity is still unsettled after twenty years. And as Paul Chu pointed out, we do not know whether room-temperature superconductors are or are not possible — and we won't know until we go out and look for them. Certainly, this should be an inspiration for the next generation of young scientists. 50 years after 'conventional' superconductivity has been explained, there is still plenty of physics left to be done.

PLANETARY ATMOSPHERES

Stormy weather

Debate has raged for decades over whether there is lightning on Venus. From the Venera and Pioneer Venus missions in the 1970s there seemed to be evidence in favour of it, and similarly from Galileo in 1990. But during two flybys, in 1998 and 1999, Cassini found nothing. New data from the European Space Agency's Venus Express offer the latest proof that the cloudy skies of Venus are indeed riven by electromagnetic discharges.

Among a clutch of mission papers now published in *Nature*, C. T. Russell *et al.* report the detection of whistler-mode waves, propagating from the planet's atmosphere to its ionosphere (*Nature* **450,** 661–662; 2007). The waves are nearly circularly polarized, are at frequencies close to 100 Hz and appear in bursts lasting



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between 0.25 and 5 seconds — exactly as would be expected, say the authors, of lightning in venusian clouds.

Venus Express arrived at the planet in April 2006, after a 153-day journey from Earth. Russell and colleagues' evidence is derived from 37 orbits made during May and June 2006. Extrapolating the rate of lightning observed using the magnetometer on board Venus Express to a rate experienced across the whole planetary surface suggests that lightning is triggered half as often on Venus as on Earth (only about 50 times per second). Nevertheless, its very presence is tantalizing: the high temperatures around the lightning discharge make possible some chemical processes that might not otherwise occur.

The mission is scheduled to last until May 2009, at which point Venus Express will have been in orbit for roughly four venusian sidereal days.

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