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Out of the shadow of BCS

In 1986, Georg Bednorz and Alexander Müller[1] discovered superconductivity below a transition temperature, T_c, of around 30 K in a copper-oxide-based ceramic material. Until then, Nb_3Ge had reigned for 13 years as the highest-T_c compound, at 23.2 K, and the upper limit to T_c was predicted (from phonon-assisted superconductivity) to be about 30 K. When Bednorz and Müller travelled to Stockholm one year later, a flurry of activity had already driven T_c above 77 K, the temperature of liquid nitrogen, and into the realm of 'practical' applications.

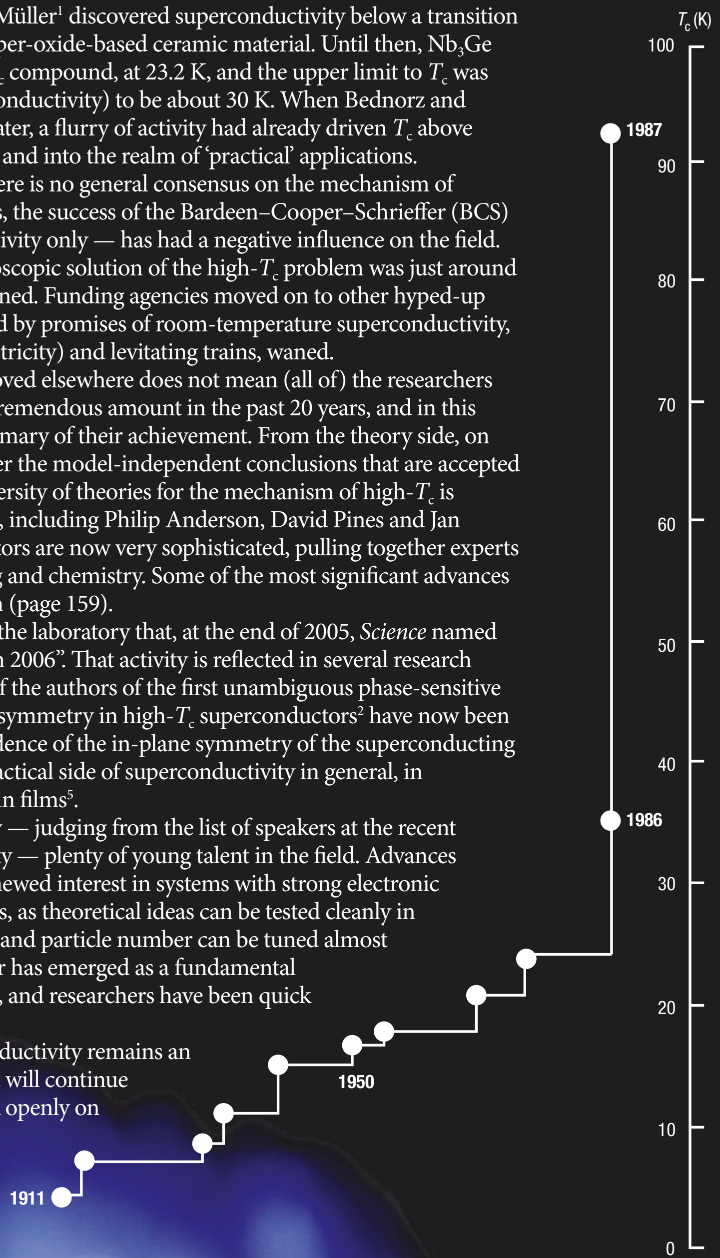
But 20 years have passed, and still there is no general consensus on the mechanism of high-T_c superconductivity. In many ways, the success of the Bardeen–Cooper–Schrieffer (BCS) theory — for conventional superconductivity only — has had a negative influence on the field. Researchers believed that a similar microscopic solution of the high-T_c problem was just around the corner. But that corner was never turned. Funding agencies moved on to other hyped-up areas. And public interest, initially piqued by promises of room-temperature superconductivity, lossless power cables (hence cheaper electricity) and levitating trains, waned.

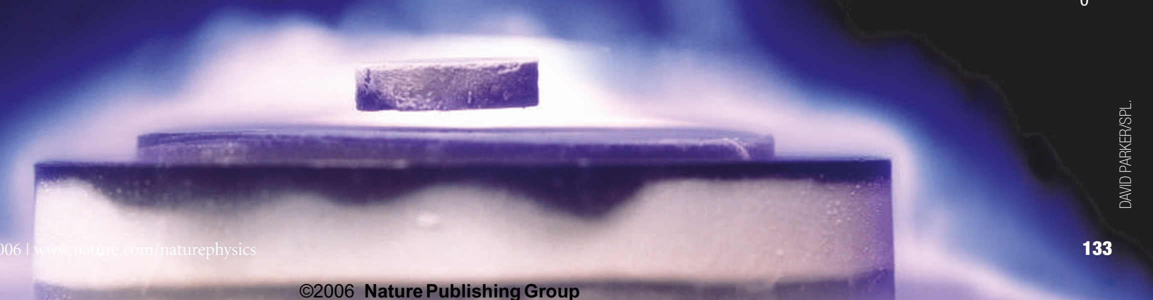
But just because the spotlight has moved elsewhere does not mean (all of) the researchers have followed suit. They have learned a tremendous amount in the past 20 years, and in this month's celebratory issue, we offer a summary of their achievement. From the theory side, on page 134 Anthony Leggett brings together the model-independent conclusions that are accepted by most in the field; on page 138, the diversity of theories for the mechanism of high-T_c is explored by some of the leading thinkers, including Philip Anderson, David Pines and Jan Zaanen. Experiments with superconductors are now very sophisticated, pulling together experts in physics, materials science, engineering and chemistry. Some of the most significant advances at high-T_c are reviewed by Douglas Bonn (page 159).

In fact, there is so much going on in the laboratory that, at the end of 2005, *Science* named high-T_c as one of seven "areas to watch in 2006". That activity is reflected in several research papers in this issue. For example, some of the authors of the first unambiguous phase-sensitive measurements that nailed down *d*-wave symmetry in high-T_c superconductors[2] have now been able to look closely at the angular dependence of the in-plane symmetry of the superconducting gap[3]. Other papers examine the more practical side of superconductivity in general, in superconducting nanowires[4] and ultrathin films[5].

There is still much to do, and happily — judging from the list of speakers at the recent Gordon Conference on superconductivity — plenty of young talent in the field. Advances in research with cold atoms have also renewed interest in systems with strong electronic correlations and competing ground states, as theoretical ideas can be tested cleanly in optical lattices, in which the interactions and particle number can be tuned almost at will. Also, on the atomic scale, disorder has emerged as a fundamental property of the high-T_c superconductors, and researchers have been quick to tap into burgeoning 'nanofunds'.

The mechanism of high-T_c superconductivity remains an intellectually challenging problem, and it will continue to attract researchers, whether they work openly on the topic, or take refuge in cold atoms or nanotechnology. But just don't expect too much too soon.





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