radiation generation, is too large to be significantly affected by microlensing once it is several parsecs from the B1 Lac core. But observations[6] of the radio-jet in the Virgo cluster galaxy M87 suggest that jet structure may be more complicated. Many filaments are evident in the M87 jet, stimulating some theoreticians to consider models in which jets contain helical filaments and the propagating shock results in emission from regions much smaller than the jet width[7], a picture which would provide additional motivation for Gopal-Krishna and Subramanian's study. Progress in our understanding of jets can be expected as the upgraded British MERLIN radio interferometer and the Australia Telescope begin to produce high-dynamic-range maps with sub-arcsecond resolution of the nearest radio-jets.

Despite the spectacular examples of the lensing phenomenon, it has proved difficult to find unambiguous statistical evidence for the influence of foreground mass concentrations, including galaxies, on our view of extragalactic background populations such as BL Lacs. In part this is because of the small number of BL Lacs and the substantial effort required simply to measure their redshifts, but more fundamentally, gravitational lensing produces a change in the observed properties of the objects. In the simplest case this may be an apparent increase in brightness for the fraction of the underlying population significantly affected by lensing. For the case of an AGN projected close to the image of an intervening galaxy, to be expected under the hypothesis that galaxies are lensing AGNs, the AGN may no longer appear to be an unresolved point of light, a criterion often used to determine whether an object is an AGN.

The probability of including objects affected by lensing in surveys can thus be altered in significant and often subtle ways, making the interpretation of anomalous numbers of AGN–galaxy projections difficult. Forearmed with this knowledge, and taking advantage of the availability of digital data, several groups are now undertaking surveys with broadly based and completely specified selection procedures. The application of the results to questions such as whether there really is an excess of BL Lacs seen close to foreground galaxies will help establish how important gravitational lensing is in affecting our view of the Universe. □

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John Bardeen (1908–1991)

THE unique honour of two Nobel prizes in physics understates, if anything, the impact which John Bardeen, who died on 30 January, had on modern science and technology.

Bardeen's undergraduate and master's degrees were in electrical engineering at Wisconsin, and he spent three years as a geophysicist before going to Princeton for a PhD with Eugene Wigner (1936), and thence to Harvard as a Junior Fellow. Thus he managed to work in his formative period with both of the founders of American solid-state theory, Wigner and John van Vleck. In these years he carried the band theory of the alkali metals, begun by Wigner and Seitz, to the level of practical calculations of equations of state, resistivity and surface barriers. It was characteristic of him from then on to refer drily to the most recondite of theoretical ideas as "calculations".

After the war, which he spent at the Naval Ordnance Laboratory, he was brought to the Bell Laboratories to work in the group that J. B. Fisk and W. Shockley hoped would produce the active semiconductor device which, indeed, W. Brattain and Bardeen discovered, in the dying days of 1947, and named the transistor. This period of work on semiconductor physics also produced several important theoretical developments such as a vital summary paper with G. Pearson introducing, *inter alia*, the impurity band, and the concept of deformation potentials, published with Shockley. Oddly enough, the specific theoretical ideas on surface states which were part of his contribution to the transistor may have been only a rough "demonstration of possibility", yet there is no doubt that this contribution was vital.

Bardeen had made the first of his three theoretical attempts at explaining superconductivity in 1944; the second came in 1950 when he learned about Serin and colleagues' results on the effect of isotopic mass on the transition temperature in mercury. This and Fröhlich's similar theory had become discredited by 1953; yet Bardeen continued, convinced that the solution was close and that the key lay in careful study both of previous theoretical insights and of the experimental picture. Many great theorists, from Einstein to Feynman to Landau, had tried to understand superconductivity, but few or none had remained as close as Bardeen to the developing experimental situation.

The need for freedom from "transistoritis", as he called it, led to his leaving Bell Laboratories in 1951 for the University of Illinois; I remember that even the 1956 Nobel prize festivities were seen by Bardeen as a not totally welcome interruption of the search for the theory of superconductivity. Finally, in early 1957, 46 years after Onnes's discovery of the phenomenon, and in company with Bob Schrieffer, his student, and Leon Cooper, a postdoctoral associate, he created the successful BCS theory. For at least a decade, a sequence of follow-up developments poured out of Bardeen and his students and associates; a second Nobel prize came in 1972.

Yet a third or fourth career came when he associated himself with the infant Xerox corporation as a consulting director in 1960, and helped oversee its transition from start-up company to corporate laboratory. Even after retirement Bardeen retained strong scientific interests. A characteristically opaque and controversial theory of sliding charge density waves enlivened his later years, and may yet win out over more conventional ideas.

It is impossible to overstate the importance of the transistor and the semiconductor physics which flowed from it. The developments far overshadow both nuclear fusion and fission and have unquestionably had the largest economic and social impact of any idea in modern physics. Almost equally important is the BCS theory, which revolutionized nuclear and particle theory as well as solid-state physics: for instance, the broken symmetry concept behind the electroweak theory originated from BCS.

Bardeen's notorious parsimony with words frustrated many an interviewer and provided fuel for countless anecdotes. Nonetheless he was a warm and faithful friend, partnered by his universally beloved wife Jane. Bardeen enjoyed the courage of his convictions, represented for example by his resignation from the White House Science Council over President Reagan's 'star wars' speech, and his personal funding of the prestigious Fritz London prize for low-temperature physics. He leaves us two well-known physicist sons, William and James. His daughter, Betsy, now engaged in organizing information systems for the State of Massachusetts, is married to yet another physicist, Thomas Greytak.

John Bardeen was a happy, quiet, gentle giant — but a giant nonetheless.

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