BOOKS

The Physics Leading up to Bose–Einstein Condensation

Bose–Einstein Condensation

Edited by Allan Griffin, David W. Snoke and Sandro Stringari
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Reviewed by Thomas Greytak

The recent realization of Bose–Einstein condensation in a dilute, ultra-cold atomic vapor by a group at the Joint Institute for Laboratory Astrophysics (see PHYSICS TODAY, August, page 17) has caused great excitement. BEC is a remarkable phenomenon: It is the only phase transition in nature that can take place in the absence of any interaction between particles. Nearly all statistical mechanics textbooks describe BEC in a homogeneous noninteracting gas; for many readers such a treatment will suffice.

Those seeking a deeper understanding will soon find that the physics of BEC can be quite subtle in realistic systems of interacting particles in spatially varying potentials. Fortunately *Bose–Einstein Condensation*, a timely collection of review articles originating from a June 1993 conference and edited by Allan Griffin, David W. Snoke and Sandro Stringari, addresses these subtleties in a thorough and systematic manner. As Snoke and Gordon Baym point out in the introduction, in its broadest sense "BEC is a common phenomenon occurring in physics on all scales, from condensed matter to nuclear, elementary particle, and astrophysics, with ideas flowing across boundaries between fields."

The question of what, in the strictest theoretical sense, constitutes BEC is discussed in articles by Kerson Huang, Phillippe Nozières and Anthony J. Leggett. Here one learns of the roles played by broken gauge symmetry, phase coherence, off-diagonal long-range order, condensates and superfluidity. Specific theoretical techniques for dealing with BEC are discussed in the articles by Franck Laloë and Sandro Stringari. There had been some concern in the community that even if the proper conditions for BEC were achieved, the nucleation time for the new state would be unacceptably long. Articles by Yuri M. Kagan and Henk T. C. Stoof present calculations of this nucleation time and find it to be pleasingly short. It has long been understood that the superfluid properties of liquid helium are intimately related to BEC. Paul E. Sokol reviews BEC in this strongly interacting system and discusses the fact that direct observation of the condensate fraction has not yet occurred.

When the 1993 meeting took place, experimental interest was focused on excitons in semiconductors and spin-polarized atomic hydrogen. The article by James P. Wolfe, Jia Ling Lin and David Snoke shows that their observation of a narrow, nonthermal component in the energy distribution of paraexcitons is consistent with BEC in the exciton gas. Experiments in other semiconductors are discussed by Andre Mysyrowicz and the theoretical aspects of excitonic BEC are covered by Leonid V. Keldysh. The search for BEC in spin-polarized hydrogen—its history, current status and future prospects—is covered in the articles by Isaac F. Silvera and this reviewer.

The one weakness of this collection is that the topic of BEC in gases of alkali metals is covered by just one review, an excellent one by Yuan Castin, Jean Dalibard and Claude Cohen-Tannoudji, focusing on light forces and laser cooling. This area has developed so quickly that one will have to look elsewhere for discussions of the recent technical advances—dark spot traps, the switch to evaporative cooling and hole-plugging schemes—that finally allowed BEC to be seen in a gas. The best way to learn about these latest advances is from the original articles cited in the most recent papers, such as the JILA paper announcing the discovery of BEC in rubidium vapor.

The book's final articles discuss BEC in terms of a broader range of phenomena. Mohit Randeria discusses the crossover from BCS superconductivity to BEC in Fermi systems, and Julius Ranninger shows how BEC of bipolarons may play a role in high-temperature superconductivity. Francesco Iachello discusses an approach to nuclear structure calculations based on a system of interacting bosons formed by pairing the fermions. Gerald E. Brown points out that in neutron stars the electrons could be replaced by kaons, which would then form a zero-momentum Bose–Einstein condensate, and he goes on to discuss the resulting equation of state.

Judging by the excitement associated with the first clear demonstration of BEC in a weakly interacting gas and by the number of groups trying to see the effect in other systems, BEC is going to be an active area for some time to come. *Bose–Einstein Condensation* will be a valuable reference for both those in the field and those who want to understand the physics behind this fascinating new state of matter.

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The First Nuclear Era: The Life and Times of a Technological Fixer

Alvin M. Weinberg
AIP, New York, 1994. 291 pp. $24.95 hc
ISBN 1-56396-358-2

Either Alvin Weinberg has a world-class memory or he started keeping a meticulous diary when he was a teenager. *The First Nuclear Era* is a detailed history of nuclear power in the United States—strictly as he perceived it. There is almost nothing about related events in other places, except as they were connected to his work, but the book is marvelously complete on the history that it does cover, and he was present for so much of it. Weinberg is particularly good at reminding us of the many roads not taken in the nuclear enterprise, any one of which might or might not have turned out splendidly. Life is full of such things, yet written history is not. This is a refreshing reminder of that deficiency.

We are reminded of aircraft nuclear propulsion (never a good idea), homogeneous reactors (always a good idea) and the often irrational reasons why some technologies survive and others don't. We are also reminded that those who go against the flow are neither always right nor always wrong and that neither rightness nor wrongness (compared to the alternatives) is uniquely correlated to the survival of an idea. Even Eugene Wigner—perish the thought—was occasionally wrong. (It may have been Paul Douglas, the former senator from Illinois, who said that no politician is either as smart or as dumb as he may appear in public. Weinberg has a lot of tolerance for most of his former antagonists, although he pulls no punches on others. I think he has too much tolerance for some of the antinuclear Luddites, who *are* in fact as dumb as they appear.)

The title of Weinberg's book expresses the underlying belief that there will be a second nuclear era, one in which the public will understand the miniscule risk of exposure to low levels of radiation. (Weinberg likes a *de minimis* standard for public exposure equal to the standard deviation of the natural background; I dislike any safety standard not based on safety.) In this new era we will leave our progeny with inexpensive, mortgage-free, long-lived nuclear power plants of such incontrovertibly safe design that no one will be concerned. (I agree that it makes little sense to decommission reactors, once built, so they should be designed with the alternative—durability—in mind. Aircraft are designed to last, with proper maintenance, as was George Washington's famous axe.) And, in Weinberg's view, the utilities will be more concentrated and more professional, divided, as the cereal industry is, into the producers and the distributors. And the waste will be stored so safely that no one will have doubts.

Perhaps and perhaps not. When the fossil fuels inevitably run out and as the world population grows, all these considerations may be seen to be minor compared to the need for electricity. Either way, all the arguments are collected here, from Weinberg's unique perspective, and anyone interested in nuclear power, past or future, or in a firsthand account of a small science that turned into a big technology, should read the book. There will be no other like it.

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The Internet for Scientists and Engineers: Online Tools and Resources

Brian J. Thomas
SPIE, Bellingham, Wash., 1995. 450 pp. $30.00 pb
ISBN 0-8194-1806-4

Many scientists are feeling somewhat uncomfortable these days: The Internet has exploded in recent years, and they find it difficult to keep up with many of its basic features. E-mail is simple, but when it comes to ftp, telnet, gopher, the World Wide Web and so on, they often need to ask a colleague or, more likely, a student for help. For such scientists, a simple, straightforward introduction to the basics of the Internet is needed.

In *The Internet for Scientists and Engineers* Brian J. Thomas aims to fill this need. His book consists of two parts. The first is a general introduction to the Internet, and the second is a thorough compendium of addresses of discussion groups, Web sites and other resources listed by discipline.

The book's first part is a straightforward, well-written description of the Internet's basic features. It explains the process of getting connected and then discusses e-mail, mail servers, discussion groups, encoding and decoding, telnet, ftp, usenet, on-line databases and the World Wide Web. The writing has a very conversational style and, unlike many similar books, is neither patronizing nor jargon-filled. Thomas covers the basics without overwhelming the reader in detail. (Recently I had to undecode a file; I used the book's instructions for undecoding and it worked the first time.) A reader should not go through the book chapter by chapter; most scientists will not need many of the sections, and a novice might get bogged down. Fortunately, *The Internet for Scientists and Engineers* has a very complete and thorough table of contents, glossary and index. (Thomas does display a "Mac" bias, but he includes examples in Windows as well.)

This general introduction is not specific to scientists and engineers. The author justifies the book's title through the second half—a massive compendium of Internet sites, primarily on the Web but including many gopher and ftp sites and many discussion groups, organized by scientific discipline.

Although this book may be one of the better introductions to the Internet yet published, it has a problem common to all books on the subject. Books are static, and the Internet is one of the most dynamic entities on the planet. By the time of this review, the book will be almost a year old and already quite outdated. For example, the author mentions that Internet access is not available through America Online or Compuserve (it has been since April). Similarly, search engines such as Lycos and Webcrawler are not mentioned, and there is only a brief reference to Netscape, the primary Web-browsing software. For a novice, however, these drawbacks are relatively unimportant, and I would expect the book's introduction to be useful for at least a few more years. The lists in the second half are also outdated; many sites are university addresses that can be found rapidly with search engines, for example, and many of the sites given are no longer functional. Nonetheless, two-year-old phone books can still be very useful, and a novice would find these lists to be valuable starting points.

For introductions to the Internet that are not outdated, one can turn to the Internet itself. One of the best is the tutorial by Patrick Crispen; it is available on the Web at http://ua1vm.ua.edu/~crispen/roadmap.html, or by sending e-mail to listserv@ua1vm.ua.edu with "get map package f=mail" in the body of the message. This set of lectures is very readable, comprehensive and current, and it will be regularly updated. It is also free. Nonetheless, many people would prefer to learn about the Internet through a medium that doesn't involve a power cord. For them, I do not know of a better introduction.

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The Beat of a Different Drum: The Life and Science of Richard Feynman

Jagdish Mehra
Oxford U. P., Clarendon, New York, 1994. 630 pp. $35.00 hc
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Membership in the community of scholars and scientists entails a commitment to ferreting out and acknowledging the efforts of others. It is therefore somewhat difficult to comprehend how one can write about Richard Feynman without mentioning