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K. H. Bennemann and J. B. Ketterson (Editors)

Novel Superfluids
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This is the first of two volumes describing new developments in the field of super conductivity and superfluidity edited by Karl-Heinz Bennemann, Emeritus Professor of Theoretical Physics at the Free University of Berlin, and John B. Ketterson, Professor of Physics and Astronomy at Northwestern University. Bennemann's theoretical studies have dealt with a broad range of subjects including novel-superconductors, magnetism, electronic properties of clusters, and ultrafast dynamics. Ketterson interests also cover a wide range extending from liquid ^{3}He and ^{4}He and high-T_c-superconductors to Langumir-Blodgett organic films. Both are well-known for editing two highly acclaimed earlier compilations of review articles. Their first one entitled "The Physics of Liquids and Solid Helium" Part I (1976) and Part II (1978) is still even today the most comprehensive basic source book on the physics of helium-4 and helium-3 in the gas, liquid, solid and superfluid states, containing timeless reviews by such famous pioneers as I. M. Khalatnikov, Günter Ahlers, Gordon Baym, Christopher Pethick, P. W. Anderson, David Lee and Robert Richardson among others. Their second two-volume treatise entitled "The Physics of Superconductors" appeared in 2003 and 2004.

Their new treatise "Novel Superfluids" addresses the broad range of new exciting developments in the fields of superconductivity and superfluidity which have emerged since the 1995 advent of Bose-Einstein Condensation (BEC) in ultracold alkali atom gases. As the editors write in the preface superconductivity and superfluidity are both associated with a loss of viscosity of the underlying liquid (either electrons or atoms) and are the most dramatic of all condensed matter phenomena as indicated by the 10 Nobel Prizes garnered since Kamerling Onnes in 1913.

In view of the impact of the new experiments involving the Bose-Einstein condensation of ultracold gases (10^{-6}–10^{-9} K) it is somewhat surprising that the great strides made in this area are the subject of only two of the altogether 11 chapters. The longest of these chapters by Tsubota, Kasamatsu and Kobayashi is devoted to quantized vortices as they occur in the helium liquids and also in BEC gases including the recently created multicomponent spinor BECs with internal degrees of freedom and dipolar condensates. I was particularly interested to learn about recently disordered topological vortex formation in quenched spinor BECs via the Kibble-Zurek mechanism. The multitude of other new research areas emerging from BEC-related research with ultracold gases is covered in a relatively short chapter by Frederic Chevy and Jean Dalibard. Their review concentrates mainly on methods used to probe the condensate and low-dimensional aspects but fails to discuss the important Feshbach resonance phenomena which permits to tune the scattering lengths in ultracold gases over orders of magnitude by the application of external magnetic fields. Nor are the remarkable experiments in which ^{6}Li fermions are converted either into bosonic molecules to form a Bose-Einstein condensate or into weakly bound distant pairs which condense to a BCS state discussed. Also they do not deal with the recent demonstration that atoms in a laser-induced optical lattice can be switched from a Mott insulator to a Superfluid by simply changing the laser power. The editors have tried to make up for this by a brief discussion in the second of two introductory chapters, but a more extensive discussion would have seemed appropriate.

Ample space, on the other hand, is devoted to BEC and superfluid effects in solids, which is the subject of two chapters. The review by Kuwata-Gonokami reports on the very recent first observation of a transition of para-excitons in a 3D strained Cu_2O crystal to a Bose-Einstein condensate at 300 millikelvin. This is an exciting development since the idea that excitons may behave as an ideal gas has been around for more than 25 years. Yamamoto, one of the pioneers in studying 2D BEC of exciton-polaritons in GaAs quantum wells, describes experiments in which the excitation spectrum of Bogoliubov quasi particles and vortex-antivortex pairs could be detected for the first time. The review by Yu Bunkov and Grigori Volovik provides an extensive discussion of the different phases of magnon BEC in helium-3 and in ferromagnets. In the only chapter dealing exclusively with superfluidity in helium Yoonseok Lee and Richard Haley survey the many experiments carried out to investigate the effect of confinement largely in aerogels on the various phases of helium-3.

Another fascinating new development is the realization in 2010 of BEC of photons, reviewed by the pioneers Jan Klaers and Martin Weitz. The last two chapters in this volume go beyond the realm of experimental superfluidity. The chapter by Krishna Rajagopal and colleagues, authors of a recent publication in "Reviews of Modern Physics" on the same subject, is devoted to a degenerate liquid of quarks at sufficiently high densities and "low" temperatures below about 10 MeV. Such conditions are expected to occur in the interior of neutron stars where the quarks can form Cooper pairs and thereby spontaneously break color gauge symmetry producing what is called "color superconductivity". The final chapter by Grigori Volovik entitled " The Superfluid Universe" discusses the cosmological consequences of quantum vacuum which he points out can be viewed as a macroscopic many-body system.

For guiding the less specialized reader the editors have contributed two excellent well-written introductory chapters, one on superfluidity and superconductivity and the other with an overview of the new novel superfluids discussed in the following chapters. This feature makes the compilation readily accessible to advanced graduate students and researchers from other related fields in either condensed-matter physics or atomic and

molecular physics. Each chapter starts with a clear introduction, has numerous illustrations and extensive references. The 624 pages are clearly arranged in the usual crisp clear Oxford style. Altogether this tome contains 226 figures and about 1700 references. The large number of references presumably is the reason why the author index contains only the names of those appearing within the text and not those in the references.

For a more elementary introduction to the subject matter covered in this volume the reader is referred to the book by J. F. Annett, Oxford University Press, 2004. BEC in gases is also covered in the text books by A. Griffin, T. Nikuni, and E. Zaremba, Cambridge University Press, 2009, and in the monograph by L. P. Pitaevski and S. Stringari, Clarendon Press Oxford, 2003 and the well-known text book by C. J. Pethick and H. Smith, Cambridge University Press, 2002.

The series of reviews will be completed at the end of 2013 when in the second volume another 14 Chapters will appear covering many of the same subjects. The editors appear to have intentionally decided not to devote each of the volumes to one of the areas such as superconductivity or superfluidity. This has the unfortunate consequence that potential readers interested in one or the other area will have to purchase two of these massive volumes to get the full story.

This very timely collection written by leading experts in a broad range of expanding research areas all related by exhibiting macroscopic quantum coherence will be a valuable source book in a rapidly emerging and most exciting field of condensed-matter physics.

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