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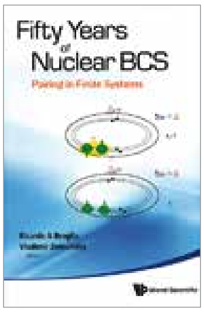

R. A. Broglia and V. Zelevinsky

Fifty Years of Nuclear BCS
Pairing in Finite Systems

World Scientific, Singapore, 2013;
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Since the early days of quantum many-body theory of fermion systems, nuclear and condensed-matter theoretical physics have pursued remarkable progress along parallel tracks with innumerable and prolific exchanges. This book, bringing together 46 chapters written by eminent specialists in the field, is the perfect complement of the previous "BCS: 50 Years", edited by Leon N. Cooper and Dmitri Feldman also for World Scientific in 2010 (see Il Nuovo Saggiatore 27, 5-6, 2011). Together, the two books provide a clear illustration of how the seminal papers by Bardeen, Cooper and Schrieffer (1957) and by Aage Bohr, Ben Mottelson and David Pines (1958), along with the immense contribution of the Russian school, notably Bogoliubov, Migdal, Galitsky and Belyaev, have opened new routes in theoretical physics, encompassing all domains, from ultra-cold gases and exotic superconductivity, to nuclei, neutron stars and high-energy particle physics. Pairing in reduced dimensions, from quasi-2D and -1D to finite systems, is the basic mechanism and the common unifying paradigm. Countless physical analogies occur between nuclei, on the one hand, and atomic clusters and droplets on the other hand, which have motivated, in the past as well as nowadays, various meetings and projects bringing together nuclear and condensed matter physicists.

The subject of the book, after a dedication to the memory of Aage Bohr and Aage Winther, "giants in the quest of understanding the role played by pairing in nuclear structure and reactions", is introduced by an illuminating Editors' Preface and a masterful historical survey by one of the pioneers, Spartak Belyaev. On the experimental side the historical breakthroughs supporting a nuclear BCS and the role of nuclear rotations are nicely told by Ole Hansen. The great experimental progress has triggered off a parallel progress in nuclear theory, up to a predictability within the experimental error! The two-nucleon transfer mechanism, explaining the structure and reaction of certain exotic nuclei sitting beyond the drip lines, finds its analog in the tunnelling theory of the Josephson effect. The concept of preformed single pairs undergoing a Bose condensation is also an important finding in high-temperature superconductors, and the issue BCS *versus* BEC in finite systems also concerns ultra-cold gases in laser traps. Nevertheless, the study of BCS pairing in nuclei has also enlighted some fundamental differences between finite and extended fermionic systems, some of which are universal and others are peculiar of nuclear matter. They are nicely summarized in the Preface, thus providing an Ariadne's thread through the first 42 chapters of the book. There is no space to highlight their excellent content. Only a few words on the last four Chapters of the book, grouped into a section on the nuclear BCS pairing paradigm in other many-body systems, and devoted to various topics of condensed matter physics having the tightest links with the theoretical aspects exposed in the book. Vladimir Kresin, who ran a memorable course at Erice on pairing in finite systems, describes how this concept applies to finite electronic systems, like nanoclusters and organic molecules, and how it may lead to room temperature superconductivity. Yoram Alhassid illustrates the close correspondence between metal nanoparticles and nuclei as appears from the thermal signatures of pair correlations measured in heat capacity and spin susceptibility, while Roland Combescot discusses the above-mentioned issue of BCS-BEC crossover in ultracold Fermi gases.

The concluding chapter by Ricardo Broglia resumes the celebrated Phil Anderson's motto "more is different" as the leit-motiv of the first nuclear BCS 50 years. More, but not that much, is already different: in this respect, the discussion on the role of single Cooper pairs and their tunneling in reactions involving exotic Li nuclei ("only" 9 to 11 nucleons) is eloquent. But it is not all: spontaneous symmetry breaking and emergent properties, *e.g.*, domain walls producing local elementary structures, are fundamental aspects of Nature which may provide a key to understanding misteries like protein folding and other basic phenomena in biochemistry. For many years Ricardo Broglia has been pioneering these fascinating extensions; nuclear physics, which has first explained the mechanisms of virtually infinite nuclear systems as ordinary and neutron stars, now lends its powerful theoretical tools to finite, albeit highly complex and hard-to-understand, systems like proteins: "*per astra ad aspera*"!

Giorgio Benedek
Università di Milano-Bicocca