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BOGOLIUBOV'S VISION: QUASIAVERAGES AND BROKEN SYMMETRY TO QUANTUM PROTECTORATE AND EMERGENCE

A. L. KUZEMSKY

Bogoliubov Laboratory of Theoretical Physics,
Joint Institute for Nuclear Research,
141980 Dubna, Moscow Region, Russia.
http://theor.jinr.ru/~kuzemsky
kuzemsky@theor.jinr.ru

In the present interdisciplinary review, we focus on the applications of the symmetry principles to quantum and statistical physics in connection with some other branches of science. The profound and innovative idea of quasiaverages formulated by N. N. Bogoliubov, gives the so-called macro-objectivation of the degeneracy in the domain of quantum statistical mechanics, quantum field theory and quantum physics in general. We discuss the complementary unifying ideas of modern physics, namely: spontaneous symmetry breaking, quantum protectorate and emergence. The interrelation of the concepts of symmetry breaking, quasiaverages and quantum protectorate was analyzed in the context of quantum theory and statistical physics. The chief purposes of this paper were to demonstrate the connection and interrelation of these conceptual advances of the many-body physics and to try to show explicitly that those concepts, though different in details, have certain common features. Several problems in the field of statistical physics of complex materials and systems (e.g., the chirality of molecules) and the foundations of the microscopic theory of magnetism and superconductivity were discussed in relation to these ideas.
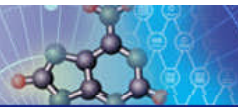
Keywords: Symmetry principles; the breaking of symmetries; statistical physics and condensed matter physics; quasiaverages; Bogoliubov's inequality; quantum protectorate; emergence; chirality; quantum theory of magnetism; theory of superconductivity.

1. Introduction

There have been many interesting and important developments in statistical physics during the past decades. It is well-known that symmetry principles play a crucial role in physics.[1–8] The theory of symmetry is a basic tool for understanding and formulating the fundamental notions of physics.[9,10] Symmetry considerations show that symmetry arguments are very powerful tools for bringing order into the very complicated picture of the real world.[11–14] As was rightly noticed by R. L. Mills, "symmetry is a driving force in the shaping of physical theory".[15] According to D. Gross, "the primary lesson of physics of this century is that the secret of nature

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http://theor.jinr.ru/~kuzemsky
Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, 141980 Dubna, Moscow Region, Russia

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