Chemical Potential, Virial Theorem, and BCS – BEC Crossover: Dimensional Dependence

By

R. H. Squire [a] , N. H. March [b,c] , K. Morawetz [d,e] , and G. G. N. Angilella [f]

[a] Department of Chemistry, West Virginia University, Montgomery, WV 25136, USA

[b] Department of Physics, University of Antwerp, Belgium
Groenenborgerlaan 171, B-2020 Antwerp, Belgium

[c] Oxford University, Oxford, England

Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany

[e] Max-Planck-Institute for the Physics of Complex Systems, Noethnitzer Street 38, 01187 Dresden, Germany

[f] Dipartimento di Fisica e Astronomia, Universit`a di Catania, and CNISM, UdR Catania, and INFN, Sez
. Catania, Via S. Sofia, 64, I-95123 Catania, Italy

We begin by summarizing briefly some recent progress that has been made in characterizing the BCS – BEC crossover in an admittedly simplistic one-dimensional model. Both the chemical potential and virial theorem stand out as important elements in this area. This has motivated us to seek analytical extensions to higher dimensionality. As to the virial theorem, we shall present arguments going forward from the work of Ho [1], and of Thomas et al [2]. Consideration is given to the task of making contact with (a) cold atom Feshbach resonance and (b) examples of fulleride and high T_c materials. Both classes of superconductors involve a Feshbach resonance between two electrons (Fermions) and a Boson (Cooper pair and/or an "electron diatomic molecule" of Leggett). Finally, we return to the virial theorem and inquire whether it can be used to determine the condensation energy in superconductors.

[1] Ho, T.-L. Phys. Rev. Lett. **92** 160402 (2004).
[2] Thomas, J. E., Kinast, J., Turlapov, A. Phys. Rev. Lett. **95**, 120402 (2005).