Quantum Many-Body Theory of Low Energy Nuclear Reaction Processes in Matter

Yeong E. Kim
Purdue Nuclear and Many-Body Theory Group
Department of Physics and Center for Sensing Science and Technology
Purdue University, West Lafayette, Indiana 47907, U.S.A.
E-mail: yekim@physics.purdue.edu

A review will be given for a recent theoretical model of low-energy nuclear reaction in a quantum many-body system confined in a micro/nano scale trap, which has been developed to describe the anomalous ultra low-energy nuclear reaction in matter [1,2]. Approximate ground-state solutions of many-body Schroedinger equation for a system of *N* identical charged integer-spin nuclei ("Bose" nuclei) in a harmonic trap were obtained by the recently developed equivalent linear two-body (ELTB) method [3,4]. The ELTB method [4] is based on an approximate reduction of the many-body Schroedinger equation by the use of a variational method. The solution is expected to be accurate for the large *N* system. The solution is used to derive theoretical formulae for estimating the probability and rate of nuclear fusion for *N* identical Bose nuclei confined in a trap.

These theoretical formulae yield two main predictions. The first prediction is that the Coulomb interaction between two charged bosons is suppressed for the large *N* case and hence the conventional Gamow factor is absent. This is consistent with the conjecture made by Dirac [5] that each interacting neutral boson behaves as an independent particle in a common average background for the large *N* case. The second prediction is that the fusion rate depends on the probability of the Bose-Einstein condensate (BEC) ground state instead of the conventional Gamow factor. This implies that the fusion rate will increase as the temperature of the system is lowered since the probability of the BEC state is larger at lower temperatures.

Implication of these theoretical predictions will be discussed for recent experiments involving nuclear reaction processes in matter [6] and also in acoustic cavitation. New proposed experimental test involving acoustic cavitation [7] will also be discussed.

1. Y.E. Kim and A.L. Zubarev, "Nuclear Fusion for Bose Nuclei Confined in Ion Traps", Fusion Technology **37**, 151 (2000).
2. Y.E. Kim and A.L. Zubarev, "Ultra Low-Energy Nuclear Fusion of Bose Nuclei in Nano-Scale Ion Traps", Italian Physical Society Proceedings **70**, 375 (2000).
3. Y.E. Kim and A.L. Zubarev, "Ground-State of Charged Bosons Confined in a Harmonic Trap", Physical Review A**64**, 013603 (2001).
4. Y.E. Kim and A.L. Zubarev, "Equivalent Linear Two-Body Method for Bose-Einstein Condensates in Time-Dependent Harmonic Traps", Physical Review A**66**, 053602 (2002), and references therein.
5. P.A.M. Dirac, "The Principles of Quantum Mechanics" (second edition), Clarendon Press, Oxford 1935, Chapter XI, Section 62.
6. Y.E. Kim, D.S. Koltick, R. Pringer, J. Myers, and R. Koltick, "Experimental Test of Bose-Einstein Condensation Mechanism for Low Energy Nuclear Reaction in Nanoscale Atomic Clusters", to be published.
7. Y.E. Kim, D.S. Koltick, and A.L. Zubarev, "Quantum Many-Body Theory of Low Energy Nuclear Reaction Induced by Acoustic Cavitation in Deuterated Liquid", to be published.