2002 Vol.38 No.3 pp.305-308 DOI:

Quantum Mechanical Nature in Liquid NMR Quantum Computing

LONG Gui-Lu,[1,2,3,4] YAN Hai-Yang,[1,2] LI Yan-Song,[1,2] TU Chang-Cun,[1,2] ZHU Sheng-Jiang,[1] RUAN Dong,[1] SUN Yang,[1,2,5] TAO Jia-Xun,[6] and CHEN Hao-Ming[1]

[1] Department of Physics, Tsinghua University, Beijing 100084, China
[2] Laboratory for Quantum Computation and Quantum Measurement, Beijing 100084, China
[3] Center for Atomic and Molecular Nano-Sciences, Tsinghua University, Beijing 100084, China
[4] Institute of Theoretical Physics, the Chinese Academy of Sciences, Beijing 100080, China
[5] Department of Physics and Astronomy, University of Tennessee, Knoxville, Tennessee 37996, USA
[6] Department of Chemistry, Tsinghua University, Beijing 100084, China
(Received: 2002-2-25; Revised:)

Abstract: The quantum nature of bulk ensemble NMR quantum computing — the center of recent heated debate, is addressed. Concepts of the mixed state and entanglement are examined, and the data in a two-qubit liquid NMR quantum computation are analyzed. The main points in this paper are: i) Density matrix describes the "state" of an average particle in an ensemble. It does not describe the state of an individual particle in an ensemble; ii) Entanglement is a property of the wave function of a microscopic particle (such as a molecule in a liquid NMR sample), and separability of the density matrix cannot be used to measure the entanglement of mixed ensemble; iii) The state evolution in bulk-ensemble NMR quantum computation is quantum-mechanical; iv) The coefficient before the effective pure state density matrix, ε, is a measure of the simultaneity of the molecules in an ensemble. It reflects the intensity of the NMR signal and has no significance in quantifying the entanglement in the bulk ensemble NMR system. The decomposition of the density matrix into product states is only an indication that the ensemble can be prepared by an ensemble with the particles unentangled. We conclude that effective-pure-state NMR quantum computation is genuine, not just classical simulations.

PACS: 03.67.Lx, 89.80.+h
Key words: quantum mechanical nature, NMR quantum computing, mixed state, entanglement

[Full text: PDF]

Close