T_cSAM Bi-Weekly Brown Bag Seminar

Texas Center for Superconductivity and Advanced Materials

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"Rutherford Scattering of Identical Ions – A Test of Quantum Mechanics at MeV Energies with Massive Particles"

Friday, February 20, 2004

Room 102, University of Houston Science Center

12:00 p.m. – 1:00 p.m.

Abstract

Elastic Rutherford scattering between positively charged ions is mediated by the repulsive Coulomb potential. Its differential cross section according to classical mechanics[1] comes out to be the same as the exact quantum mechanical result. Its characteristic 1/E2 energy dependence and cosec4(θ/2) angular dependence have been well established since 1911. Not predicted by Rutherford then, and missed in Goldberger and Watson[2] even as late as 1964, these results break down when the scattering ions are identical, and oscillations in the differential cross section as a function of the scattering angle appear instead of the familiar smooth dependence. This behavior is thoroughly discussed in Landau and Liftshiz[3] (1965), but the oscillations were summarily declared to vanish "on averaging over even a small range of values of θ." This oscillatory behavior is a hallmark of quantum mechanical interference. Dictated by the exchange symmetry of the scattering particles and without a classical counterpart, it constitutes a test for the validity of quantum mechanics versus classical mechanics, a test that can be conducted using massive particles at MeV energies, at room temperature. Here, we report preliminary results on the observation of quantum interference in the Rutherford scattering of carbon from carbon at incident energies between 1 and 4 MeV.

[1] Goldstein, Classical Mechanics, 3rd Edition, pp. 106 – 110. The Coulomb scattering problem can be completely solved with the first integrals obtained by application of the conservation of energy and angular momentum. Conservation of linear momentum reduces the two-body problem to a one-body problem. Initial conditions are irrelevant in the determination of scattering cross sections.

[2] Goldberger and Watson, Collision Theory, pp. 151 – 152, especially Fig. 4.1.

[3] Landau and Liftshiz, Quantum Mechanics, Non-relativistic Theory, 2nd Edition, pp. 523 – 525 and references to earlier sections in the same book.

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