清华大学高等研究院

Institute for Advanced Study, Tsinghua University

物理学术报告

Physics Seminars (biweekly)

Title: **Electron on a Sphere: Aharonov-Bohm meet Aharonov-Casher**

Speaker: **Prof. Yshai Avishai**
(***Department of Physics, Ben-Gurion University, Israel***)

Time: **3:15pm, Wednesday, May 21, 2014**
(2:45~3:15pm, Tea, Coffee, and Cookie)

Venue: **Conference Hall 322, Science Building, Tsinghua University**

Abstract

Two seemingly distinct systems are analyzed and, somewhat unexpectedly, shown to be related.

System I - Electron in the field of a magnetic monopole: The problem is to find the states of a (spinless) electron moving on a sphere and subject to a central magnetic field $B = g\frac{\hat{r}}{r^2}$ .As was shown by Dirac in 1931 [see also Wu and Yang, Phys. Rev. D 12, 3845 (1975)] the (so far elusive) magnetic charge g and the electric charge e are related by the quantization condition 2eg = nħc (n = 1,2…is the monopole number). In the continuum version, the problem was solved in 1931 by Igor Tamm. I approach this problem from a "condensed matter point of view" using a tight binding model. The energy spectrum is calculated analytically as function of n and displays a beautiful pattern, which is entirely distinct from that of the Hofstadter buttery. The systematics of level degeneracy is unusual and its analysis requires the construction of a theory of magnetic point symmetry groups. The spectrum of an electron hopping on the sites of a Fullerene reveals a set of magic (monopole) numbers n_i .

System II - Electron in the field of a central charge: Spin-Orbit effects: The problem is to find the states of a (spinfull) electron moving on a sphere subject to a central electric field $E = q\frac{\hat{r}}{r^2}$. In a continuum geometry, spin-orbit interaction results the familiar $L \bullet S$ coupling that affects atomic spectra. In a tight binding formalism, on the other hand, it leads to peculiar **Aharonov-Casher effect**, and the spectrum (calculated analytically) displays rich and beautiful pattern with some unexpected symmetries in which physics and geometry interlace.

Connection between I and II: I expose a remarkable relation between the two seemingly distinct physical problems: The energy spectrum in system II at a certain symmetry point is *identical* with the energy spectrum in system I at n = 1. Thus, it is principally possible to test the physics of an experimentally inaccessible system (magnetic monopole) in terms of an experimentally accessible one (electron subject to spin-orbit force induced by central electric field).