Announcing the Final Examination of Mr. Sunghyun Kim for the degree of Doctor of Philosophy in Physics

Date: April 05, 2024
Time: 09:00 a.m. Eastern Daylight Time
Room: BA1 O205
Attendance Link(Virtual):
https://ucf.zoom.us/j/2026862979?pwd=SjFTb1o1YzErM0d6UWpnVnBkVnB5dz09&omn=94581103922
Meeting ID: 202 686 2979
Passcode: 886285
Dissertation title: Doubly Rotating Coordinates: Wave Functions in Magnetic Resonance Problems

Abstract:

The nuclear spin response to a rotating field $\mathbf{H}$ has been theoretically investigated from the 1930s to the 1950s. Building upon Majorana's probability theory, the behavior of spin 1/2 is well-illustrated in the joint review by Rabi, Ramsey, and Schwinger, and their spin wave function ψ is succinctly restated by Gottfried:

$$\psi(t) = \mathrm{e}^{-i\mathrm{I_z}\omega t/\hbar}\mathrm{e}^{-i[\mathrm{I_z}(\omega_0-\omega)+\mathrm{I_x}\omega_1]t/\hbar}\psi(0). \quad (1)$$

However, the complexity involved in evaluating the wave function ψ in terms of probability amplitudes C_m, attributed to the noncommutative nature of spin operators $[\mathrm{I_z}, \mathrm{I_x}] \neq 0$, hinders the application of this well-established theory to spins with arbitrary values $I > 1/2$. In a recent study by Hall and Klemm, a conjectural form of the spin wave function was suggested.

Here, we present an alternative formulation of the wave function ψ by controlling doubly rotating coordinates:

$$\psi(t) = \mathrm{e}^{-i\mathrm{I_z}\omega t/\hbar}\mathrm{e}^{-i\mathrm{I_y}\theta/\hbar}\mathrm{e}^{-i\mathrm{I_z}\Omega t/\hbar}\mathrm{e}^{i\mathrm{I_y}\theta/\hbar}\psi(0). \quad (2)$$

This formulation facilitates the computation of general state transitions from an initial state $\psi(0) = \sum_m C_m(0)\,\psi_m(0)$ to $\psi(t) = \sum_{m'} C_{m'}(t)\,\psi_{m'}(t)$. Moreover, by assuming an analogous form of the total electron spin $\mathbf{J}$ to that of the nucleus $\mathbf{I}$, we can explore hyperfine structures in atoms and/or molecules traversing in the magnetic field $\mathbf{H}$ in terms of the nuclear-electronic spin interaction $(\mathbf{I} \cdot \mathbf{J})$.

Through this approach, we not only formulate wave functions more effectively but also bridge quantum mechanics and algebraic perspectives.

Outline of Studies:
Major: Physics

Educational Career:
M.S. In Physics, University of Central Florida, 2019
M.S. in Applied Physics, Hanyang University, 2016
B.S. in Bionano Engineering and Applied Physics, Hanyang University, ERICA, 2014

Committee in Charge:
Dr. Richard. A. Klemm (Chair)
Dr. Talat Rahman
Dr. Luca Argenti
Dr. James Harper (External Committee Member)

Approved for distribution by Dr. Richard A. Klemm, Committee Chair, on March 6, 2024.

The public is welcome to attend.