Announcing the Final Examination of Zhichen Liu for the degree of Doctor of Philosophy in Physics

Date: March 27, 2024
Time: 9:00 a.m.
Room: PSB 160
Zoom Link: https://ucf.zoom.us/j/92877058892?pwd=YTYyU1ZRTDhIcDA3MDVUek8yZlRjZz09
Meeting ID:928 7705 8892
Passcode:148816
Dissertation title: ADVANCEMENTS IN NUCLEAR MAGNETIC RESONANCE, ELECTRON PARAMAGNETIC RESONANCE, MULTIPOLE MOMENTS, AND LIE GROUP PROPRIETIES.

Abstract:
To accurately solve the general nuclear spin state function in Nuclear Magnetic Resonance (NMR), a rotational wave approach was employed, allowing the reference frame to rotate in sync with the oscillating magnetic field. The spin state system was analogously treated as a Rubik's Cube, allowing for the diagonalization of the time-dependent part of the state function. Although Gottfried's wave function (1966) allows for transitions between specific spin states m and m′, his second rotation contradicts the conservation of angular momentum, resulting in inaccuracies for spin states with initial phase shifts or entangled states. However, Schwinger (1937) efficiently computed the coefficients for each spin state in a frequency range opposite to the Larmor frequency, using an unorthodox approach in quantum mechanics, which unfortunately led to the oversight of his work in subsequent citations. We applied that correct methodology to derive the general doubly rotated combined nuclear and electron spin ground state wavefunction useful for perturbation treatments of both NMR and Electron Paramagnetic Resonance (EPR) measurements. This is particularly relevant for accurately calculating the magnetic dipole, electron quadrupole, and magnetic octupole moments in atomic isotopes such as ${}^{14}_{7}$N and ${}^{7}_{3}$Li, or in molecules or molecular solids containing them, the expressions for which incorporate powers of $\mathbf{I}\cdot\mathbf{J}$, where $\mathbf{I}$ and $\mathbf{J}$ are respectively the nuclear and electronic spin operators. Furthermore, our study was expanded to the general Lie group for quantum spins, resulting in 12 distinct methods to achieve rotations in any arbitrary direction using these axes. The ongoing research is now concentrated on generating NMR spectra for ^{14}N in nucleic amino acids, furthering the understanding of nuclear spin dynamics in complex molecular systems.
Outline of Studies:
Major: Physics
Educational Career:
B. S. Kansas Wesleyan University, USA, 2017

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 February 28, 2024.

The public is welcome to attend.