中央大學物理學系

Department of Physics, National Central University

**Dr. Dennis Rätzel**
**Center of Applied Space Technology and Microgravity - ZARM, University of Bremen**

# *Gravitational Quantum Optics & Quantum Optics with Free Electrons*

**Date:** 2023/12/20 (Wed)
**Venue:** S4-208 (Online)
**Time:** 13:30-15:00 (Taiwan)

Abstract:
In this presentation, I will discuss several topics from my two main research fields.

In Gravitational Quantum Optics, my focus will be the application of quantum sensing to test gravitational theory. Over 100 years since the introduction of general relativity, we continue to encounter an ever-increasing number of predicted, yet unobserved, phenomena and unsolved scientific puzzles around gravity. Numerous proposals suggest applying quantum sensors to test for such phenomena or to experimentally resolve some of these puzzles. I will present my work on three proposals based on optomechanical systems: measurement of the gravitational field of relativistic particle beams (e.g. at the Large Hadron Collider), obtaining bounds on dark energy models, and finding empirical evidence for quantum properties of the gravitational field.

Turning to my second research field, Quantum Optics with Free Electrons, I will introduce a novel proposal to utilize electron beams with modulated currents for coherent control of spin systems that I have developed with my experimental collaborators. This approach may provide a pathway towards groundbreaking spectroscopic techniques as well as spectrally selective control of quantum state transitions with unprecedented spatial resolution in electron microscopes.

Finally, I will outline my future research programs in both fields. I will discuss my plan to develop models for cascaded quantum sensors and quantum many-body systems in curved spacetime (e.g. quantum memories and sensors based on ultra-cold atoms) and apply these models, for example, to the measurement of weak relativistic gravitational effects and satellite-based quantum communication. I will also talk about my plan to further explore the interaction of modulated electron beams with quantum systems, spin resonance spectroscopy in electron microscopes and the creation and utilization of entangled electron-photon pairs.