

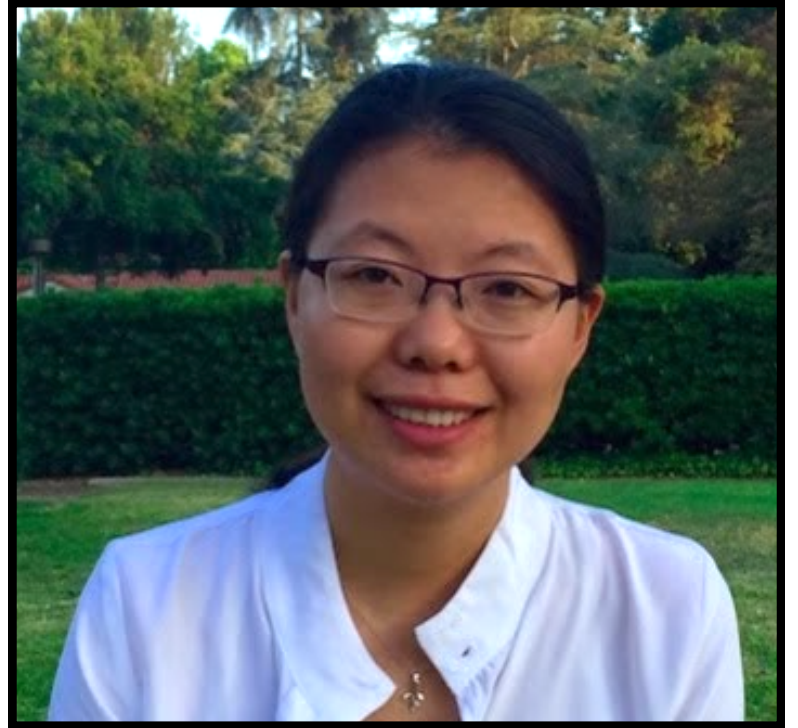
**Thursday, October 5, 2023**

Refreshments at 3:15pm outside PSF 101  
Colloquium from 3:30pm - 4:30pm in PSF 101

## **“Seeing” Multipolar Orders with Nonlinear Optics**

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### **Abstract:**

Multipoles form when there are complex arrangements of electric or magnetic dipoles, which can happen at length scales as small as atomic unit cells of solids. Multipolar orders describe the long-range patterning of such nanoscale multipoles, and importantly, are believed to widely present in many modern materials with strong interactions. However, unlike electric dipole orders (e.g., ferroelectricity) and magnetic dipole orders (e.g., ferromagnetism) that have readily available electric and magnetic fields to couple to, multipolar orders do not have a simple, available conjugate coupling field, and as a result, are hidden to most experimental probes. We propose to use nonlinear optics to couple with such multipolar orders, where we can use multiple copies of electromagnetic fields to construct the required coupling fields. We will demonstrate the success of this concept by using second harmonic generation, the lowest rank nonlinear optics, to reveal a ferro-rotational order (on the same rank as the electric quadrupole order) [1] and an all-in-all-out antiferromagnetic order (on the same rank as the magnetic octupole order) [2]. We anticipate great potential of nonlinear optics in modern materials research.

[1] Nature Physics 16, 42 (2020)

[2] Nature Photonics in press (2023)

### **Biography:**

Dr. Liuyan Zhao is an associate professor of physics at the University of Michigan. She received her PhD degree from Columbia University and BS degree from the University of Science and Technology and did her postdoctoral training at California Institute of Technology. One of her main research interests is to investigate new materials with optical techniques. She has been recognized by professional awards for her research, such as NSF CAREER award, AFOSR YIP award, Sloan Fellowship, etc. She serves as an editorial board member for Physical Review X and an editor for Progress in Quantum Electronics.