STEVENS
INSTITUTE OF TECHNOLOGY
1870

Ph.D. DISSERTATION DEFENSE

Candidate:	Na Liu
Degree:	Doctor of Philosophy
School/Department:	Charles V. Schaefer, Jr. School of Engineering & Science, Department of Physics
Date:	Thursday, December 14, 2023
Time/Location:	12:30 pm Burchard 514
Title:	Magnetic proximity coupling of quantum emitters in WSe_2
Chairperson:	Dr. Stefan Strauf, Department of physics, Schaefer School of Engineering & Science
Committee Members:	Dr. Edward Whittaker, Department of Physics, Schaefer School of Engineering & Science Dr. Xiaofeng Qian, Department of Physics, Schaefer School of Engineering & Science Dr. Annie Xian Zhang, Department of Mechanical Engineering, Schaefer School of Engineering & Science

ABSTRACT

Novel quantum materials combined with controlled light-matter interaction are promising to enable implementation of desired tasks in quantum information processing and quantum sensing directly on-chip. Specifically, 2D transition metal dichalcogenides (TMDC) like WSe_2 stand out as a host for 0D quantum emitters (QE), which can be deterministically produced through site-controlled stressor substrate engineering. To effectively control the light-matter interaction, we have developed angular-resolved detection techniques to experimentally determine the dipole orientation of QE in form of intralayer and interlayer excitons in WSe_2. With the dipole orientation knowledge gained, we successfully designed and fabricated plasmonic nanocavity devices coupled with interlayer QE, demonstrating brightening of optically forbidden transitions that are further enhanced through the Purcell effect. Moreover, the distinct spin-polarized characteristics of QE in WSe_2 make them excellent candidates for quantum magnetometry applications through magnetic proximity coupling. The pronounced spin-doublet response enables the sensitive detection of local magnetic fields, revealing the characteristic signature of both ferro- and antiferromagnetic proximity coupling, originating from the interplay among ferromagnetic layers, a thin surface oxide and the spin doublets of QE. Furthermore, the utilization of 2D ferromagnets for proximity coupling holds the potential to eliminate the need for bulky external magnetic fields to achieve chiral single photons. By using Fe-doped MoS_2, the heterostructure of Fe: MoS_2/WSe_2 allows for deterministic formation of proximity coupled QE. The heterostructure displays high purity chiral single photons with circular degree of polarization of 92%, even without applying external magnetic fields. Remarkably, these chiral single photons remain robust in the presence of uncontrolled twisted angles and external stray fields. My research based on magnetic proximity coupling offers a pathway to harness the unique properties of QE for on-chip chiral single photon sources and for quantum magnetometry applications.