Anti-Stokes Excitation of Solid-State Quantum Emitters for Nanoscale Sensing

Toan Trong Tran,[1,] Blake Regan,[1] Evgeny A. Ekimov,[2] Zhao Mu,[3] Yu Zhou,[3] Weibo Gao,[3] Prineha Narang,[4] Alexander S. Solntsev,[1] Milos Toth,[1] Igor Aharonovich[1] and* ***Carlo Bradac***[1,*]

[1]School of Mathematical & Physical Sciences, University of Technology Sydney, Ultimo NSW, 2007, Australia

[2]Institute for High Pressure Physics, Russian Academy of Sciences, Moscow, Troitsk 108840, Russia

[3]Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University, 637371, Singapore

[4]John A. Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, MA, USA

Color centers in solids are the fundamental building blocks of various applications ranging from lasers to light emitting diodes and sensors, as well as the foundation of advanced quantum information and communication technologies. Their photoluminescence properties are usually studied under Stokes excitation, in which the emitted photons are at a lower energy than the excitation ones. In this work, we explore the opposite Anti-Stokes process, where excitation is performed with lower energy photons. We report that the process is sufficiently efficient to excite even a single quantum system—the germanium-vacancy center in diamond.

As a proof of concept, we propose using anti-stokes excitation of diamond color centers for nanoscale thermometry. We leverage the temperature-dependent, phonon-assisted mechanism to realize an all-optical nanoscale thermometry scheme that outperforms any homologous optical method employed to date. We discuss other potential applications and show that our results frame a promising approach for exploring fundamental light-matter interactions in isolated quantum systems.