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Nanophotonic optomechanical devices: towards coupling photons, phonons and spins

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Optomechanical devices enhance the optical radiation pressure induced interaction between light and mechanical resonators. This interaction can be harnessed to enable coherent conversion of light to mesoscopic phonons with frequencies ranging from kHz to GHz. Through control of these phonons, new approaches for manipulating and probing solid state spin systems are feasible.

In this talk I will present recent advances in creating such nanoscale "spin-optomechanical" devices. I will first present results demonstrating some of the first optomechanical devices fabricated from single crystal diamond [1, 2], which in addition to having remarkable mechanical properties (e.g. ultrahigh mechanical Q*f product), can be used for optomechanical control of single electron spins. I will then discuss silicon based nanophotonic devices that allow optomechanical probing of the magnetic properties of nanostructures, providing routine on-chip photonic readout of the nanomagnetic susceptibility of single magnetic defects [3]. Finally, I will comment on the prospect of cooling these devices into their quantum ground state, enabling studies coupling single phonons to electronic or magnetic spin systems.

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[2] M. Mitchell, B. Khanaliloo, D. Lake, P. E. Barclay, "Low-dissipation cavity optomechanics in single crystal diamond," Optica 3, 963 (2016)

[3] M. Wu, N. L.-Y. Wu, T. Firdous, F. F. Sani, J. E. Losby, M. R. Freeman, P. E. Barclay, "Nanocavity optomechanical torque magnetometry and RF susceptometry," Nature Nanotechnology (Advanced Online Publication, doi:10.1038/nnano.2016.226, 2016)

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