Diamond Based Microwave Quantum Amplifier

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Abstract

Nitrogen vacancy (NV) color centers in single crystal diamond that are negatively charged (NV^-) are electronic triplets that are known to be optically-polarized to the $m_s=|0>$ state upon green light irradiation. At large enough static magnetic field (above ~ 1k Gauss) the |0> state is located above the |-1> state and thus the optical pumping results in a state of population inversion. This population inversion can in principle be used to amplify microwave radiation that corresponds to the $|0>\leftrightarrow|1>$ energy difference by stimulated emission (the so-called MASER effect – microwave amplification by stimulate demission of radiation). Such kind of microwave quantum amplifier can prove to be very useful in terms of its noise performance, ultimately enabling even to amplify the signal of single microwave photons in some scenarios. While this possible use of NVs in diamond is well-known, it has never been actually demonstrated in practice, due to various experimental challenges [1]. (A diamond-based MASER *oscillator* was achieved a few years ago [2], but not an amplifier). In this talk I will present our recent experiments in this field, which demonstrate for the first time the operation of diamond-based quantum microwave amplifier, including its design and construction phases, as well as tests of its performance in terms of gain, bandwidth and noise.

[1] Journal of Applied Physics 129, 144503 (2021)

[2] Nature volume 555, pages493–496 (2018)