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Up-conversion of NMR signals from radio-frequency to optical regimes through a mechanical transducer

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Conventional reception of NMR signals relies on electrical amplification of the electromotive force caused by nuclear induction. In general, the signals cannot be transported without noise being added through the process of amplification before being acquired.

Here, we report a different approach that potentially leads to much less noise added through signal transduction. The idea is to employ up-conversion of radio-frequency NMR signals to an optical regime using a high-stress silicon nitride *membrane* that interfaces the NMR-probe circuit and an optical cavity. In this approach that we call Electro-Mechano-Optical NMR, or *EMO NMR* [1-2], A metal layer coated on the membrane serves both as an electrode of a *capacitor* and a *mirror* of an optical cavity.

- the nuclear induction signal is transcribed to the vibration of the membrane through the electro-mechanical coupling.
- In turn, the displacement of the membrane modulates the light in the optical cavity due to the opto-mechanical coupling.

In this way, optical NMR detection is realized without sacrificing the versatility of the traditional nuclear induction approach. Theories predicts that the added noise through the EMO scheme can be made smaller compared to that in the conventional NMR.

In the presentation we show demonstration of EMO NMR as well as our current efforts toward its extension, including:

- Rf-to-light signal up-conversion using a Hihg-temperature superconducting rf resonator,
- New design and fabrication of a compact rf-to-light transducer that would fit inside the bore of a superconducting magnet, and
- Development toward combination to EMO MRI and MAS.

[1] K. Takeda, K. Nagasaka, A. Noguchi, R. Yamazaki, Y. Nakamura, E. Iwase, J.M. Taylor, K. Usami, Optica. 5 (2018) 152. doi:10.1364/OPTICA.5.000152.
[2] Y. Tominaga, K. Nagasaka, K. Usami, K. Takeda, J. Magn. Reson. 298 (2019) 6–15. doi:10.1016/j.jmr.2018.11.003.

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