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Coherent light-matter interfaces with highly-excited thermal atoms

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Abstract

Warm atomic vapors are known for their technical simplicity and potential scalability. However, despite these benefits, motional dephasing limits the strength and coherence of the light-matter interaction, as compared with laser-cooled atoms. I will present several schemes developed to realize strong, coherent, and faithful light-matter interaction at ambient conditions and to overcome motional dephasing, towards effective photon-photon interaction. These schemes can be further applied to various gas, solid and engineered systems hindered by inhomogeneous dephasing due to variations in time, space, or other domains.

First, I will describe a new protocol for an arbitrarily fast, genuinely noise-free, quantum memory in rubidium vapor. Employing a ladder level system of purely orbital transitions with nearly degenerate frequencies simultaneously enables high bandwidth, low noise, and long memory lifetime [1]. Second, I will present a scheme for protecting a qubit or a collective excitation from inhomogeneous dephasing. The scheme relies on *continuously* dressing the qubit with an auxiliary sensor state which exhibits an opposite and potentially enhanced sensitivity to the same source of inhomogeneity. We focus on motional dephasing of a spin-wave in an atomic ensemble. By employing a two-tone dressing field, we demonstrate complete suppression of inhomogeneous dephasing as well as immunity to drive noise [2]. In related works with continuous-wave spectroscopy, we demonstrate the enhancement and narrowing of spectral lines [3,4]. Finally, I will also present our effort to realize a unique optical mode by tapering down an optical fiber to the deep sub-wavelength scale. This leads to a drastic expansion of the evanescent field to over 10 times the optical wavelength, compatible with typical dimensions of the Rydberg blockade. When interfaced with atomic vapor, this configuration balances tight confinement, long atomic interaction times, and negligible surface interactions [5].

[1] R. Finkelstein, E. Poem, O. Michel, O. Lahad, and O. Firstenberg, "Fast, noise-free memory for photon synchronization at room temperature", Science Advances 4 (2018).
[2] R. Finkelstein, O. Lahad, I. Cohen, O. Davidson, E. Poem, and O. Firstenberg, "Continuous protection of a collective state from inhomogeneous dephasing", Physical Review X 11 (2021) .
[3] O. Lahad, R. Finkelstein, O. Davidson, O. Michel, E. Poem, and O. Firstenberg, "Recovering the homogeneous absorption of inhomogeneous media", Physical Review Letters 123 (2019) .
[4] R. Finkelstein, O. Lahad, O. Michel, O. Davidson, E. Poem, and O. Firstenberg, "Power narrowing: Counteracting Doppler broadening in two-color transitions", New Journal of Physics 21 (2019) .
[5] R. Finkelstein, G. Winer, D. Z. Koplovich, O. Arenfrid, T. Hoinkes, G. Guendelman, M. Netser, E. Poem, A. Rauschenbeutel, B. Dayan, and O. Firstenberg "Super-extended nanofiber-guided field for coherent interaction with hot atoms", Optica 8 (2021)

The lecture will take place on Wednesday, 21.4.21 at 12:30
In the Solid State Auditorium and via zoom https://technion.zoom.us/j/99294534939
If you intend to attend in person (<u>and only holders of a green-pass can</u>), please register before here.

Host: Assistant Professor Yoav Sagi