Cavity-mediated coupling of terahertz magnons and vibrational modes of molecules

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In the regime of strong light-matter coupling, polariton modes are formed that are hybrid light-matter excitations sharing properties of both, an electrodynamic cavity mode and a matter mode. In the recent decade, magnon-polaritons were intensively researched using ferromagnetic materials in the microwave range, with potential applications for quantum technology and sensors. Exploring antiferromagnetic resonance (AFMR) rises magnon-polariton frequencies into the terahertz (THz) range [1]. In this range there are many dielectric excitations like phonons, vibrational modes of molecules, plasmons in two-dimensional electron gas, etc, which are characterized with higher light-matter coupling rates than those of magnetic excitations because of their high dipole moments. Recently, we reported cavity-mediated coupling of magnons in two distant slabs of antiferromagnets [2]. Here, we are investigating AFMR in yttrium ferrite (YFO) owing to its low spin damping and temperature-dependent frequency above room temperature. We report on coupling of its quasi-antiferromagnetic mode to a vibrational mode of α-lactose. Our experimental setup consists of parallel-plane slabs of both materials, placed next to each other at a well controlled gap, forming a tunable Fabry-Perot type cavity. Frequency of AFMR was controlled by temperature of a YFO crystal. We used time-domain spectrometer to measure reflection spectra, collected as a function of YFO temperature and distance between the slabs. Frequencies of cavity modes are controlled by changing the gap between the crystals. Thus, as a function of distance, we observed narrow avoided crossings of cavity modes with AFMR and much broader avoided crossings with the vibrational mode of lactose at 0.53 GHz. At some distances between the slabs and YFO temperatures, we observed such polariton modes that are simultaneously coupled to the vibrational mode of lactose and the AFMR in the YFO crystal. Such states are hybridized magnon-vibrational modes that share properties of both matter excitations.

References:

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