A new destructive photon echo in six-wave mixing signals from a $MoSe_2$ monolayer

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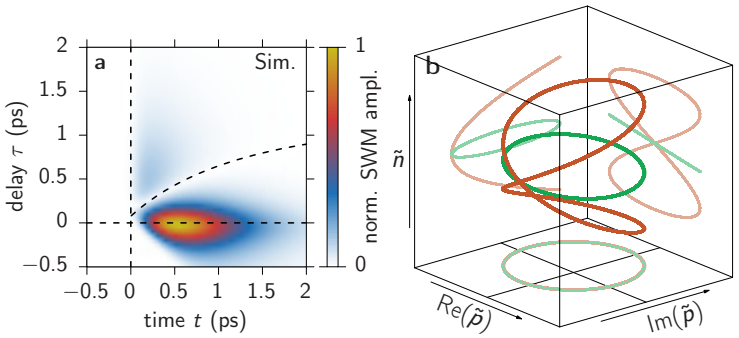
Two-dimensional semiconductors, especially in the form of transition metal dichalcogenides, are a widely investigated subject in several areas of physics for the last couple of years. One of the reasons for this is their strong excitonic optical response. This allows to efficiently perform ultrafast nonlinear spectroscopy on these systems to learn about their fundamental physical processes. We have recently studied how the spectral dynamics of pump-probe [1] and four-wave mixing signals [2] can be explained by an exactly solvable model that extends the basic Bloch equations by a local field effect. This local field coupling takes into account the interaction between the optically generated excitons in the 2D systems on a mean field level and leads to spectral shifts depending on the excitonic occupation.



We then went a step further and studied six-wave mixing signal dynamics and discovered a peculiar temporary signal depression, depending on the considered delay between the two applied laser pulses (Fig. a) [3]. In this contribution, we will report on this experimental finding and demonstrate that the observed signal dynamics can be understood as a new destructive photon echo effect. With our local field model we are able to attribute this feature to the interaction between the excitons. Inspired by the Bloch vector interpretation of the original photon or spin echo effect, we also developed an illustration on this level for the destructive echo, and show that the Bloch vectors contributing to the six-wave mixing signal form Lissajous figures (Fig. b) [3].

[1] A. Rodek et al., *Nanophotonics* **10**, 2717 – 2728 (2021).
[2] T. Hahn et al., *New J. Phys.* **23**, 023036 (2021).
[3] T. Hahn et al., *Adv. Sci.* **9**, 2103813 (2022).