Influence of coherent population trapping on propagation of chirped pulses

Colin D Roy[1,2], Pooja Singh[3], Glen Perram[2], Anil K. Patnaik[2], and Yuri Rostovtsev[1,2]

[1]*Center for Nonlinear Sciences and Department of Physics, University of North Texas, Denton, TX 76203, USA*
[2]*Air Force Institute of Technology, 2950 Hobson Way, Wright-Patterson Air Force Base, OH 45433-7765*
[3]*Division of Sciences and Mathematics,Louisiana State University at Eunice, Eunice, LA 70535, USA*

Nonlinear optics related to a one-photon and a two-photon resonances with atomic or molecular levels when laser pulses excite the quantum coherence is a broad area of research. For example, Raman spectroscopy is one among many powerful techniques that has been widely used in engineering, chemical, and biological applications. In an effort to improve the raman spectroscopy, new techniques have evolved introducing modified optical pulses and models. Applying the femtosecond adaptive technique allows researchers to excite maximal vibrational coherence to improve the sensitivity of coherent Raman spectroscopy and to perform real time identification of bacterial spores and biomolecules. The femtosecond-laser-based coherent anti-Stokes Raman spectroscopy (CARS) has been used extensively in time-resolved nonlinear spectroscopy research in recent years. It is used in several fields of study, such as identifying molecules in chemistry, measuring temperature in solid-state physics, and non-invasive monitoring of muscle tissue, among other things.

It is the quantum coherent effects that have strong influence on the Raman scattering. Quantum coherence effects, such as coherent population trapping (CPT) and electromagnetically induced transparency (EIT), have been the focus of broad research activity for the last decades, as they drastically change optical properties of media. For example, for EIT in CW and pulsed regimes, absorption practically vanishes.

In this poster, we present our study of the excitation of the quantum coherence in a Λ-type molecular media. We have considered the two- and three-level molecules. The dressed state basis approach is employed, which provides deep physical insights showing interaction of "bright" and "dark" states with radiation. For the four-level model, we find two sets of the bright and dark states that show the important role of coherent population trapping between split ground states on Raman scattering in such molecular systems. The level structure of the model is common for the molecular media, where the split ground states can be viewed as rotational levels in addition to the vibrational levels with much higher frequency. We demonstrate the importance of formation of dark states between rotational levels on Raman and stimulated Raman scattering. We consider the propagation effects for the case when the vibrational-rotational coherence is induced. In particular, we consider a gas of three- and four-level atoms or molecules in the presence of two coherent optical pulses.