Can bulk plasmon be seen in a Raman spectrum? Spin-mediated direct photon scattering by plasmons

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Electronic Raman scattering in the fully symmetric channel can couples to the charge excitations in metals, including to the plasmon collective modes. However, it is well established that the spectral weight of a plasmon in the Raman response is typically suppressed by the smallness of q^2 pre-factor, where q is the momentum imparted by the photon to the plasmon, which makes it challenging, if not impossible, to directly observe Raman scattering by a plasmon [1].

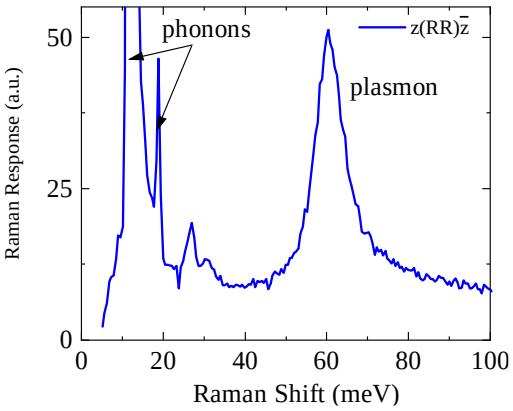

Fig.1. Plasmon mode in the resonant Raman spectrum from giant Rashba system BiTeI [2].

In this talk we will show that in an inversion-broken systems which allow for Rashba type spin-orbit interaction to affect the states at the Fermi energy as well as the transition resonances to other states, there is an additional resonant Raman coupling process enabling finite Raman scattering intensity by bulk plasmons even in the q=0 limit. We show that for materials with giant Rashba interaction the direct resonant Raman coupling to bulk plasmon could be significant. We discuss our findings in the context of recent observation of a distinct, long-lived plasmon mode in BiTeI Fig. 1 [2,3]. The observation challenges the prevailing understanding of plasmon-assisted Raman processes and highlights the necessary conditions for direct plasmon coupling in the long-wavelength limit.

The newly discovered effect of Rashba-type spin-orbit interaction, which arises due to the breaking of SU(2) invariance in the spin-flip interband transitions, not only allows plasmons to couple to optical probes but also opens up a route to explore the interplay of spin and charge degrees of freedom in metals and semiconductors.

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[1] S. Sarkar et al, Phys. Rev. B **109**, 035160 (2024).
[2] A.C. Lee et al, Phys. Rev. B **109**, L041111 (2024).
[3] A.C. Lee et al, Phys. Rev. B **105**, L161105 (2022).