ORAL DEFENCE ANNOUNCEMENT

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Toroidal Resonances in Terahertz Metamaterials

Toroidal modes are unique type of electromagnetic excitations that have characteristic features different from the conventional electric and magnetic multipoles. At terahertz regime, metamaterial allows an effective way to introduce toroidal excitations, as they give flexibility in tailoring loss channels which are important for modulation, sensing, and spectroscopic applications. The introduction of toroidal dipole coupling in planar metasurface excites sharp resonances, which are of high quality factor compared to resonances of well-known planar metamaterials designs at terahertz frequencies. The experimental advantage of toroidal coupling could be seen directly in case of metasurface array of asymmetric Fano resonators, where significant line narrowing together with high figure of merit is achieved by mirroring neighboring resonators in metasurface array. This approach of near field coupling through toroidal excitations enhance device performance, which is an essential criterion for the practical implementation of metadevices.

Metamaterial devices containing mirrored configuration of adjacent resonators allows active tuning of near field coupling through selective inclusion of active elements. This near field coupling could be actively switched “on” and “off” upon optical pumping, which changes the nature of electromagnetic excitation of metasurface from toroidal dipole to electric or magnetic dipole. The excitation features of toroidal dipole are always masked by dominant electric and magnetic multipoles, which are simultaneously excited in resonating elements with toroidal topology. In this regard, multipole analysis provides a numerical approach to investigate the contribution due to different multipoles, and in estimating near field toroidal coupling features.

Moreover, the near field toroidal coupling is sensitive to nearby environment, which could be used to sense few hundred nanometers thick dielectric layers on the top of metasurface.

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