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Nonlinear behavior of long-wavelength graphene on TMD plasmons in a 2D plasma layer

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In an earlier work, it was shown that the gate voltage tunable intra-band plasmon dispersion, for the finite doping and the long wavelength limit, in the Van der Waals hetero-structures (vdWHs) of graphene monolayer on 2D transition metal dichalcogenide (GrTMD) substrate involves the $q^{2/3}$ (unconventional) behavior and not the well-known $q^{1/2}$ behavior. In this communication, we investigate theoretically the nonlinear behavior of these long wavelength limit plasmons in a 2D plasma layer. The work has close analogy with the important applications of nonlinear photonics in graphene, such as harmonic generation, optical and plasmonic bistability, etc. Using the stokes expansion of the electron density we show that the group velocity of the dispersive wave exhibits approximate $q^{-1/3}$ dependence rather than that corresponding to the deep water gravity waves and there is a nonlinear enhancement of the frequency due to the finite wave amplitude. The time evolution of the modulational instability of the system, giving rise to large amplitude spikes immersed in wave turbulence, throws up formation of solitonic waves initially before disintegrating into more complicated structures. A potential application of the system lies in plasmonic antenna which is suitable for applications at low power thresholds such as frequency conversion and Raman scattering.

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