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Collective excitations and optical response of ultrathin carbon nanotube films

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Abstract

We present a theoretical study of the collective quasiparticle excitations responsible for the electromagnetic response of ultrathin plane-parallel homogeneous periodic single-wall carbon nanotube arrays and weakly inhomogeneous single-wall carbon nanotube films. We show that in addition to varying film composition, the collective response can be controlled by varying the film thickness. For single-type nanotube arrays, the real part of the dielectric response shows a broad negative refraction band near a quantum interband transition of the constituent nanotube, whereby the system behaves as a hyperbolic metamaterial at higher frequencies than those classical plasma oscillations have to offer. By decreasing nanotube diameters it is possible to push this negative refraction into the visible region, and using weakly inhomogeneous multi-type nanotube films broadens its bandwidth.

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