Gradient Metasurfaces as Perfect Polarization Transformer

Hamidreza Kazemi*, Mohammad Albooyeh, and Filippo Capolino
Department of Electrical Engineering and Computer Science University of California Irvine, CA 92697 USA

Metasurfaces, as electrically thin engineered electromagnetic devices, find a variety of applications such as electromagnetic cloaks, absorbers, polarizers, etc. ranging from microwave frequencies to optics. They are conceived to substitute bulky composite materials due to their easy fabrication processes and low losses. Recently, a class of metasurfaces have been introduced to manipulate the electromagnetic wave front at will (V. S. Asadchy, et.al. *Phys. Rev. B*, vol. 94, no. 7, p. 075142, 2016; N. M. Estakhri, et al., Phys. Rev. X, 6(4), p.041008 2016; J. Wong, et al., IEEE Antenn. Wireless Propag. Lett. 15, 1293, 2016). In contrast to the conventional thin layer surfaces which exploited the generalized reflection law to manipulate the incoming wave and leads to reflection/refraction of power into undesired directions (N. Yu, et al., Science, 334(6054), pp.333-337, 2011) and suffer from the control on the polarization of the transmitted waves, this new class known as gradient metasurfaces are claimed to manipulate the reflection/refracted waves perfectly.

Here we apply the theory of gradient metasurfaces to introduce a device which perfectly rotate the polarization of the reflected wave with respect to the incident one. Moreover, by exploiting spatially dispersive surface currents, our device offers a full reflection into a desired direction which may be generally different from the specular direction. Our approach is based on the realization of the desired equivalent surface polarization current densities which are connected to the total fields at both sides of the metasurface through the sheet Boundary Conditions (M. Albooyeh, et al., Annalen der Physik, 528(9-10), pp.721-737, 2016). Since we aim at changing both the polarization and the direction of the reflected wave with respect to the incident, then, we prove that besides the realization of gradient current densities we require chirality characteristics for the metasurface. We present a possible realization of the proposed device by discretizing the required surface currents and exploiting a proper physical metasurface inclusion that realizes the required current at each discretized point to enable the aforementioned functionality.