Tunable function from tunable metasurfaces

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While metasurfaces have shown powerful ability in manipulating electromagnetic wave propagation, tunable metasurfaces will give more possibilities in realizing tunable and multifunctional devices. In this talk, we will discuss the tunable and multifunctional capability of a tunable metasurface with adjustable resistor-capacitor load. As shown in Fig. 1(a), the metasurface unit cell consists of a pair of copper patches that printed on a grounded dielectric substrate and connected by a series R-C load with resistance $R_{\text{load}}$ and capacitance $C_{\text{load}}$. The tunability of the metasurface comes from the variable $R_{\text{load}}$ and $C_{\text{load}}$ values which are to be adjusted from external applied voltages. Such a tunable metasurface can show both tunable perfect absorption and tunable perfect anomalous reflection for transverse electrically (TE, with electric field parallel to $y$ direction) polarized plane waves. For example, for perfect absorption function, the two load values $R_{\text{load}}$ and $C_{\text{load}}$ are adjusted so that there is no reflected wave for a TE plane wave incidence with different incidence angles. Fig. 1(b) and (c) show the reflection amplitude for normal incidence and oblique incidence. We can see that perfect absorption happens at different $R_{\text{load}}$ and $C_{\text{load}}$ combinations for different incidence angles. Therefore tunable absorption can be achieved by tuning the load values.

Anomalous reflection means that the reflection angle is different from the incidence angle. To achieve anomalous reflection, we need the collective behavior of several unit cells forming a supercell. If we keep the incidence angle, e.g. zero degree for normal incidence, then the reflection angle will be determined by the number of unit cells in the supercell. While the tunability of the unit cell comes from the adjustable $R_{\text{load}}$ and $C_{\text{load}}$. While the unit cell geometry is unchanged, it is naturally feasible to achieve tunable anomalous reflection. For example, with 8 or 9 unit cells in a supercell, we can obtain perfect anomalous reflection at 55 degrees or 47 degrees, as shown in Fig. 2.

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