Reconfigurable helical tape waveguide and leaky-wave antenna by circular polarization handedness

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Reconfigurability will be a central theme in the next generation of microwave and millimeter-wave components. Reconfigurable or tuneable microwave devices, whose electromagnetic response can be changed on the fly, enable us to reduce complexity, size, weight, power consumption, and cost. The industry standard for such agile microwave technology relies on lumped elements (e.g., PIN diodes, varactor diodes, RF_MEMS), tunable materials (e.g., liquid crystal, ferroelectric thin film, photo-conductive), and mechanical approaches. The use of polarization as a mean for reconfigurability is less explored at microwaves and millimeter-waves even though it is a routinely approach for optical technology.

Inspired by the new advancements in fundamental physics related to spin-orbit coupling of light, we explore the use of such spin-orbit interaction to tune the electromagnetic response of a helical tape, see Fig. 1. When the incident circularly-polarized wave is of the same handedness as the helix, the helical tape behaves as a transmission line (i.e., waveguide); on the contrary, a counter-rotating circularly-polarized wave converts the helical tape into a leaky-wave antenna with a conical radiation pattern akin to a helical antenna operating on a higher-order mode (rather than on the normal or axial/beam mode). Alternatively, one can understand this mode of operation as a waveguide attenuator. The underlying mechanism is explained in terms of Floquet theorem.

Two prototypes of length 290 (~$9\lambda_0$) and 600 mm (~$18\lambda_0$) operating within the X band of the microwave spectrum are fabricated and their reflection, transmission and radiation properties are measured depending on the handedness of the incident circularly-polarized mode. Numerical (using CST Microwave Studio®) and experimental results are in good agreement.

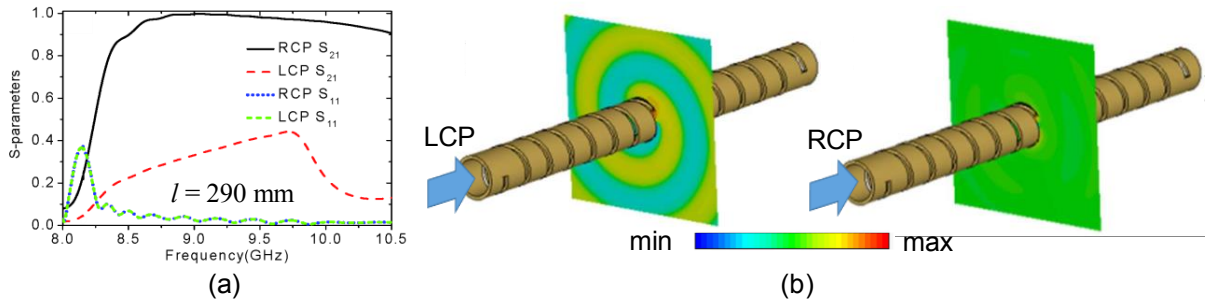

Figure 1. (a) S-parameters as a function of the circular polarization handedness. (b) E-field on the cross-sectional plane as a function of the circular polarization handedness.