Efficient manipulating on circularly polarized THz waves with transmissive metasurfaces

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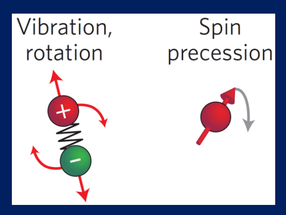
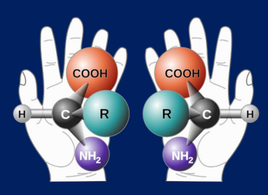
• Backgrounds:

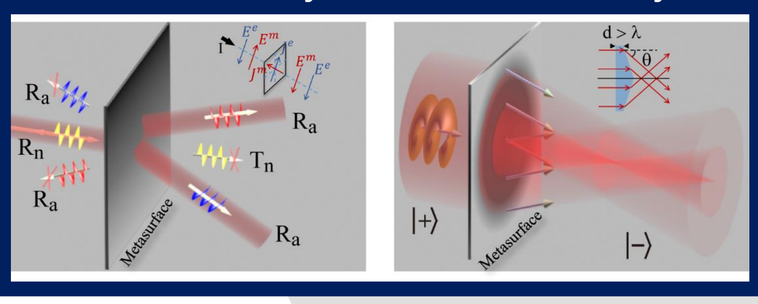
- Efficient manipulation on circularly polarized (CP) THz waves is highly desired for versatile applications: biological and medical sensing, non-destructive evaluations, etc.
- Convectional THz devices suffer from bulk size, narrow-band of operating frequencies and loss efficiency issues .





• Motivations:

- Efficient generation of CP THz waves based on Pancharatnam-Berry (PB) metasurfaces.
- Realization of Background-free CP Bessel Beam with efficient PB Metasurfaces for study of molecule chirality.



• Photonics spin hall effect (PSHE)

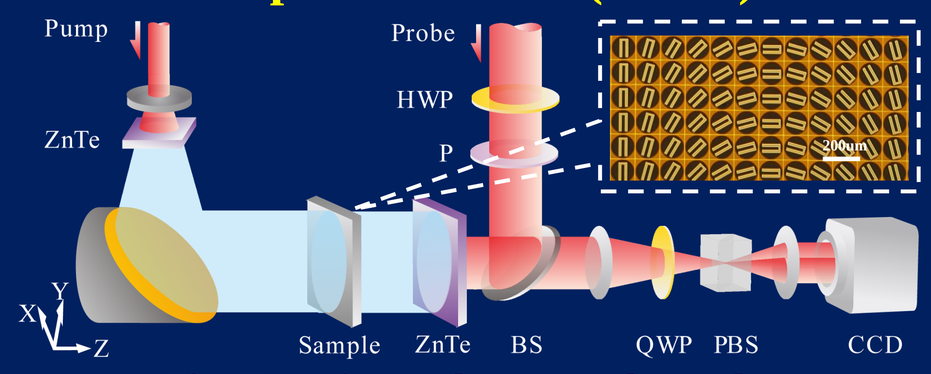


Fig. Experimental setup and sample

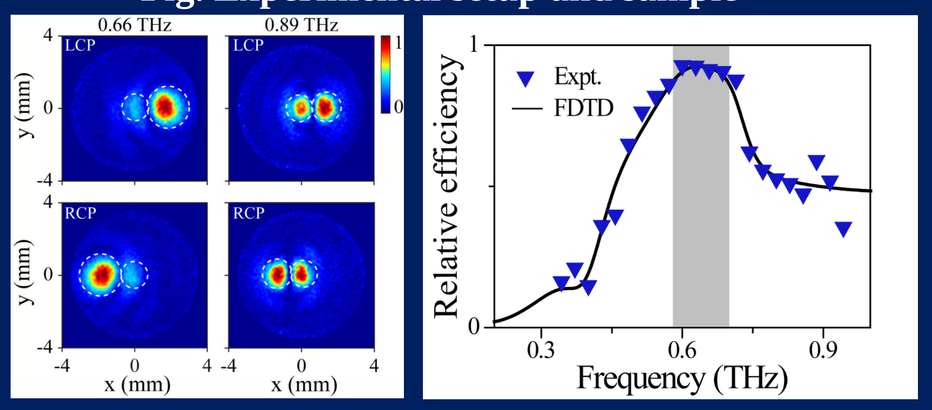
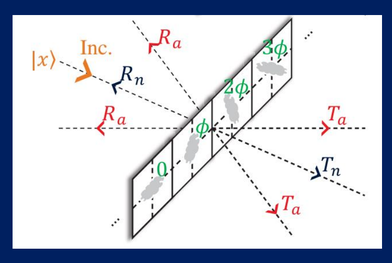
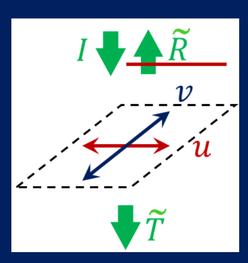


Fig. Field distribution at f=0.66 THz and 0.89 THz, and efficiency of PSHE

- PSHE is clearly observed at frequency within the working band.
- Relative working efficiency of PSHE can reach 90% at 0.66 THz.
- Working bandwidth 0.59-0.72THz

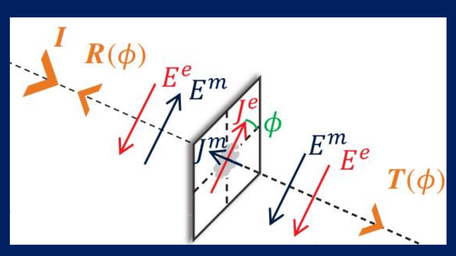
• Design principle of PB meta-atom

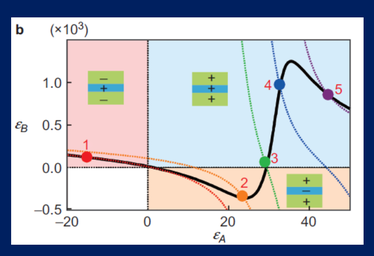




Condition of efficiency transmissive PSHE:

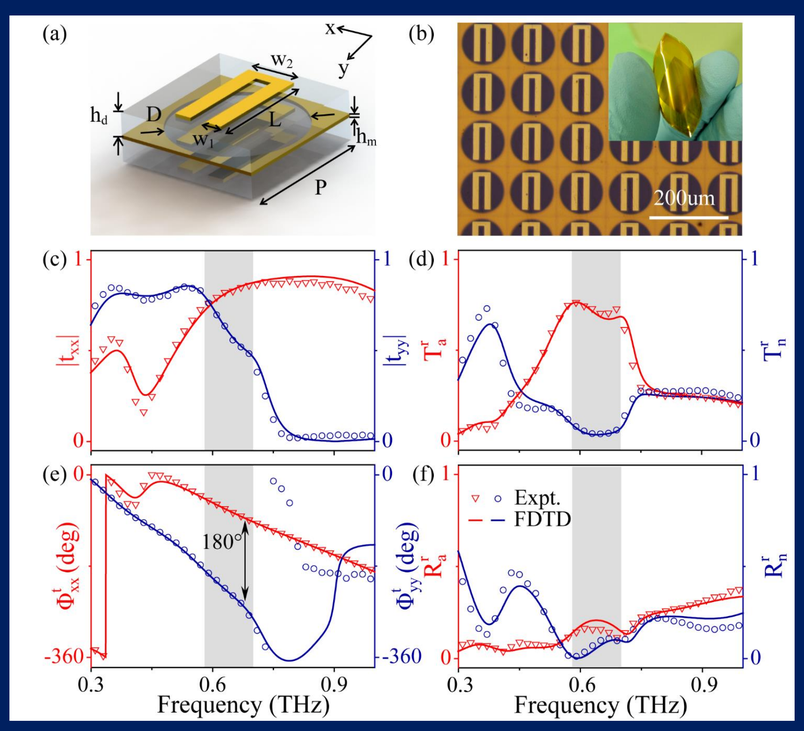
$$|r_{xx}| = |r_{yy}| = 0,\ |t_{xx}| = |t_{yy}| = 1,\ \arg(t_{xx}) - \arg(t_{yy}) = \pi$$





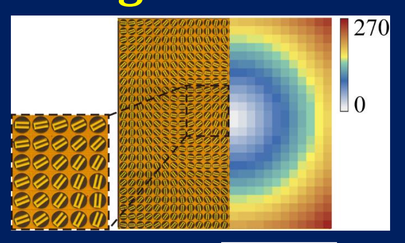
- ABA trilayer structure
- Phase difference between two orthogonally polarized wave due to different transparency mechanism

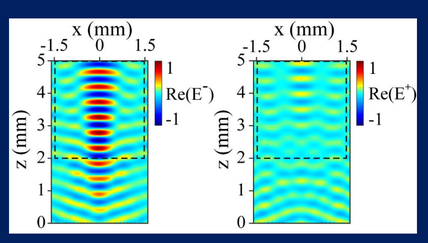
• Characterization of PB meta-atom



- Transmissive half waveplate achieved with thickness of λ/5

• Background-free CP Bessel beam





$$\varphi(x,y) = k_0\sqrt{x^2+y^2}\sin(\theta)$$

Fig. Optical image of part of Bessel beam generator and phase diagram. FDTD simulated $Re(E^-)$ and $Re(E^+)$.

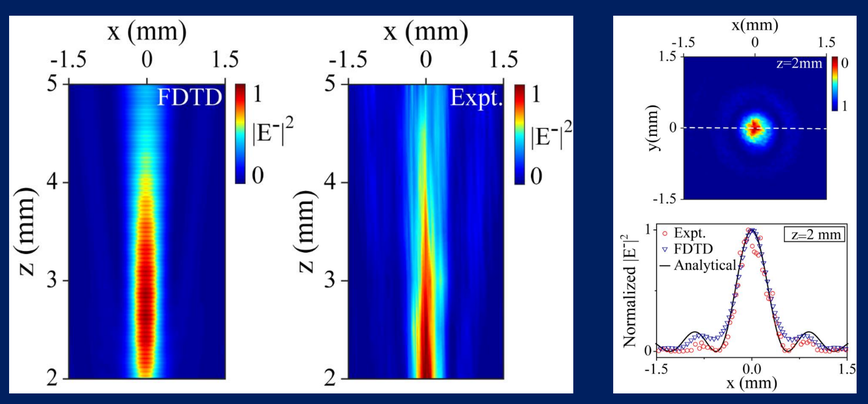


Fig. Intensity distribution on xz and xy plane.

- LCP field distribution does not exhibit any features of a BB performance
- Good agreement between Experiments and FDTD simulations
- Bessel beam performance well demonstrated at 0.66THz

• Conclusions:

- Experimental Demonstration of efficient PSHE to generate CP THz wave with efficiency of 90%
- Experimental Demonstration of Background-free THz CP Bessel Beam generator based on PB metasurface
- Our findings can stimulate the realizations of high-performance PB metadevices in THz regime for diversified promising applications.

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