Multi-Channel Hologram based on High-efficient Metasurfaces

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I. Backgrounds & Motivations

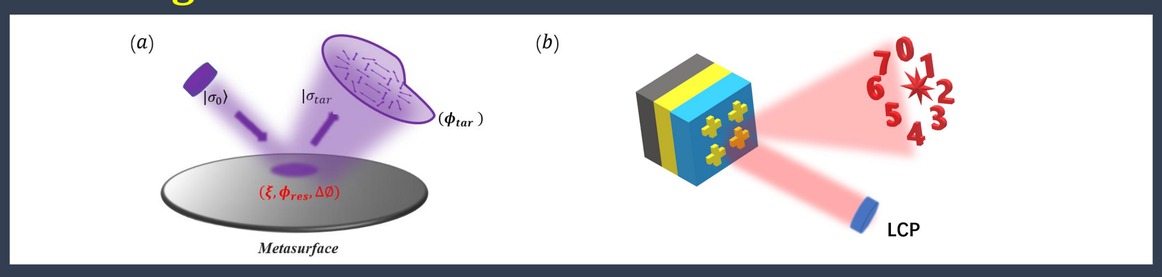

Fig. 1 (a) generating arbitrary VOFs and (b) scaler hologram based on metasurface

- **Motivations**

1. Propose a general approach to design vectorial meta-hologram with both arbitrary far-field pattern & polarization distribution
2. Use this platform to realize all kinds of holograms: single-channel hologram、delinked bi-channel hologram and multi-channel vectorial hologram

II. Basic idea

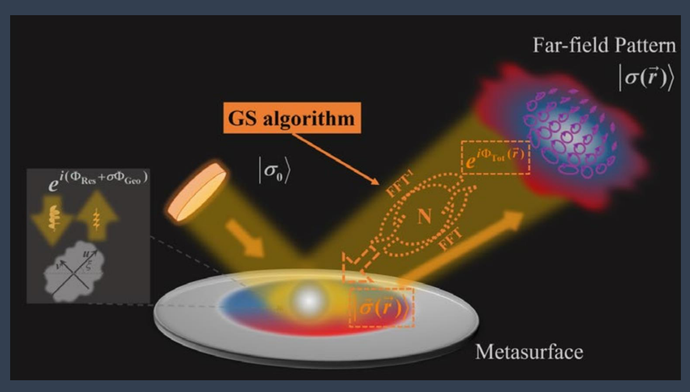

Fig. 2 Schematic of generating multi-channel vectorial hologram with simultaneous manipulation of farfield wave-front and LPDs based on metasurface

- **Key Points**

farfield-to-nearfield logics by employing a Gale-Shapley algorithm, which could calculate:

1. the appropriate phase distribution of interface phase $\Phi_{Tot}(\vec{r})$
2. local polarization distribution $|\tilde{\sigma}(\vec{r})\rangle$ on the meta-surface

III. Design strategy & Benchmark case

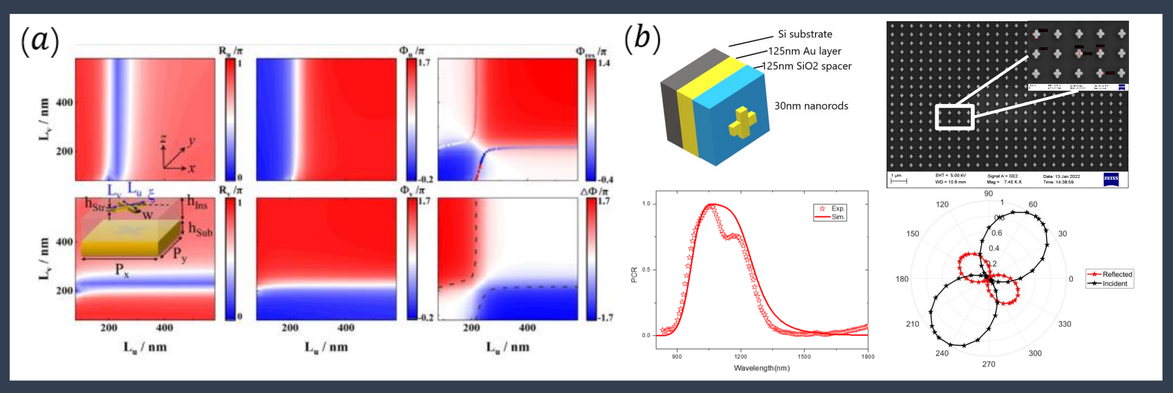

Fig. 3 (a) Meta-atom design: MIM tri-layer meta-atom for reflection geometry
(b) Meta-atoms functioning as half-wave plates

- **Design Strategy**

A set of atom ,each of which could:

1. Convert the incident polarization $|\sigma_0\rangle$ into arbitrary $|\tilde{\sigma}\rangle$
2. Provide an extra phase $\Phi_{Tot} = \Phi_{Res} + \sigma\Phi_{Geo}$ (spin − dependent Geometric phase)

- **Benchmark case**

1. Designed meta-atoms functioning as half-wave plates
2. Possess an extra resonance phase Φ_{Res}

$$\begin{pmatrix} L_u \\ L_v \\ \xi \end{pmatrix} \Leftrightarrow \begin{pmatrix} \Phi_{\mathrm{res}} \\ \Delta\Phi \\ \xi \end{pmatrix}$$

IV. Single-Channel Hologram Based on Metasurfaces

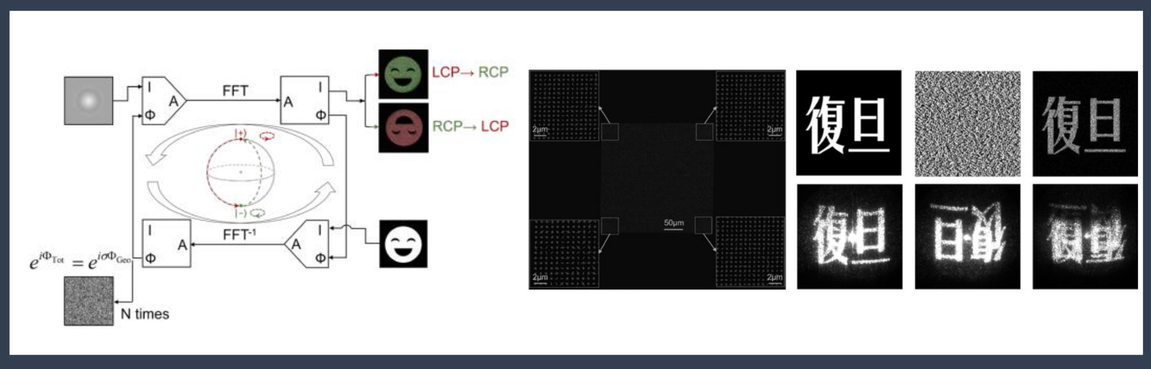

Fig. 4 Single-Channel Hologram Based on Metasurfaces

- **Key process**

For a given pattern A, the total phase Φ_{Tot} is obtained after N-times cycle

- **Meta-surface design**

1. $e^{i\Phi_{Tot}} = e^{i\sigma\Phi_{Geo}}(or\ e^{i\Phi_{res}})$
2. $\Delta\Phi = \pm\pi$: LCP→RCP， RCP→LCP

V. Delinked Bi-Channel Hologram

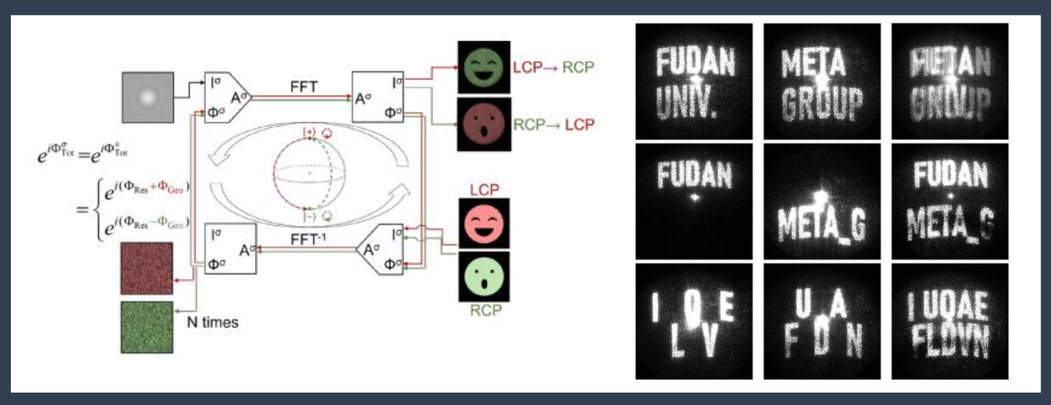

Fig. 5 Delinked Bi-Channel Holograms Based on Metasurfaces

- **Key process**

For two pre-designed patterns A^{σ}, The total phase Φ^{σ}_{Tot} is obtained after N-times cycle

- **Meta-surface design**

1. $e^{i\Phi^{\sigma}_{Tot}} = e^{i(\Phi_{Res}+\sigma\Phi_{Geo})}$
2. $\Delta\Phi = \pm\pi$: LCP→RCP, RCP→LCP

VI. Multi-channel Vectorial Hologram

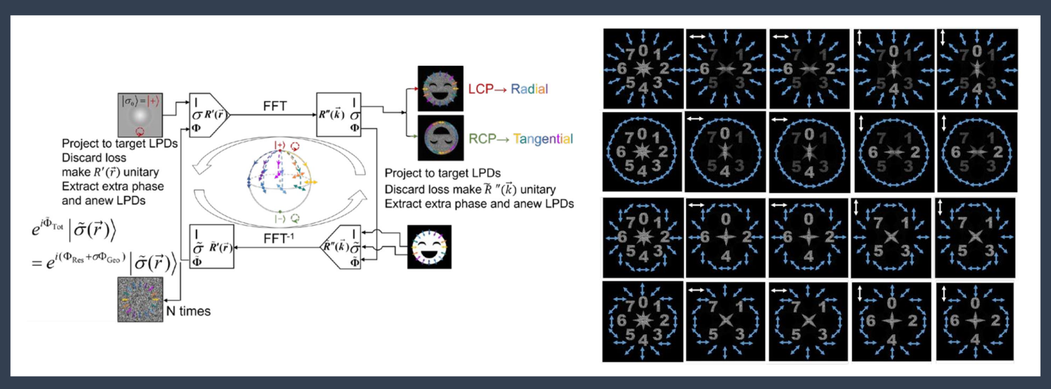

Fig. 6 Multi-Channel Vectorial Holograms with cylindrical polarization

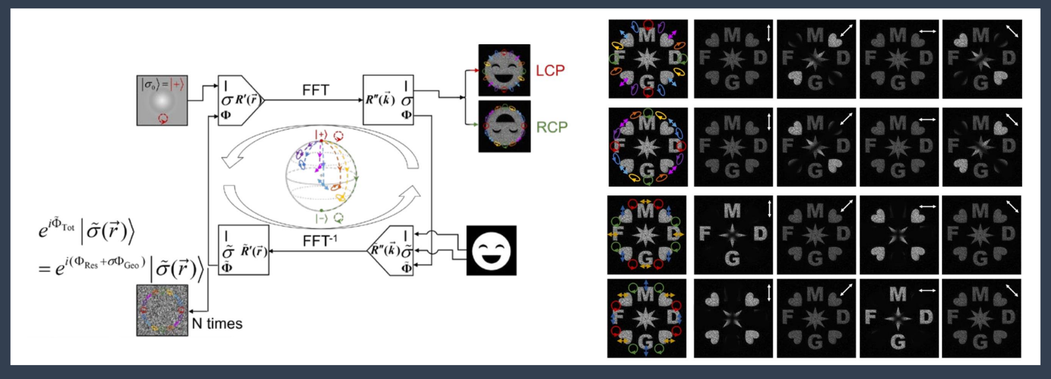

Fig. 7 Multi-Channel Vectorial Holograms with varied local elliptical polarization

- **Key process**

For a pre-designed pattern A with complex local polarization distributions(LPDs) , the total phase Φ_{Tot} and $|\tilde{\sigma}\rangle$ are obtained after N-times cycle

- **Meta-surface design**

$$e^{i\tilde{\Phi}_{Tot}(\vec{r})}|\tilde{\sigma}(\vec{r})\rangle = \tilde{\boldsymbol{R}}'(\vec{r})|\sigma_0\rangle = F^{-1}\tilde{\boldsymbol{R}}''(\vec{k})|\sigma_0\rangle$$

$$\Delta\Phi = \pi/2$$

$$\Delta\Phi = \begin{cases} -2\varphi + \pi, & 0 \le \varphi < \frac{\pi}{2} \\ 2\varphi - \pi, & \frac{\pi}{2} \le \varphi < \pi \\ -2\varphi + 3\pi, & \pi \le \varphi < \frac{3\pi}{2} \\ +2\varphi - 3\pi, & \frac{3\pi}{2} \le \varphi < 2\pi \end{cases}$$

LCP → Radial, RCP → Tangential　　LCP(RCP) →LPDs with varied ellipticity

VII. Conclusions & Perspectives

1. A generic platform is proposed for the high-efficient realization of arbitrary holograms.
2. Both single-channel hologram and delinked bi-channel holographic meta-devices are designed and characterized to demonstrate this platform.
3. Multi-channel vectorial holograms with meta-surfaces are also designed and characterized, each possessing different multi-channel LPDs.
4. More holographic physics to be revealed and new generation of photonic holographic devices to be explored...

References

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[3] Guoxing Zheng, et. al. Nat Naono. 10,1038(2015).
[4] Yao-Wei Huang, et.al.Nano Lett.2015,15,3122-3127