Research data for

All-optical dynamic focusing of light via coherent absorption in a plasmonic metasurface

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General notes:

- Green annotations indicate the corresponding figures across the main manuscript and the supplementary material.
- All theoretical and experimental intensity cross sections shown in the main manuscript and the supplementary material are extracted from the provided intensity maps in .xlsx files (theory) and .tif files (experiment)
- .tif files are the images captured by the CCD camera. In all cases the horizontal axis corresponds to the CCD pixel number along the x-axis. In all cases the vertical axis corresponds to the CCD pixel number along the y-axis. The .tif files within each data set (folder) are corrected for different exposure times used to fully exploit camera's dynamic range.
- When plotted in the manuscript the pixel count is translated to the equivalent μm-scale on the sample plane and the images are centered around the overall centre of the illuminating light pattern as well as cropped to show 20 μm along the x-axis and 20 μm along the y-axis. The CCD has 1024 x 1280 pixels of 4.65 μm x 4.65 μm each. Due to 50x magnification of the imaging system, each pixel corresponds to 93 nm x 93 nm on the metasurface beam splitter.

ResearchData.zip contains:

1. Folder Fig2-MetamaterialSample which includes:

- sample_SEM_image.tif (Fig. 2)
  Scanning electron micrograph of the metasurface beam splitter. Gray corresponds to gold and black corresponds to apertures. The picture shown in the manuscript was cropped to better depict the array details.
- SampleSpectrum.xlsx file (Fig. 2)
  Sample spectrum sheet: spectral measurements of travelling wave reflection (R), transmission (T) and absorption (A) for illumination of either front or back of the metasurface beam splitter.

2. Folder IdenticalZonePlates – Experimental Dataset (i)
(Fig. 2 intensity maps, Fig.3a-d, Fig. S2d, Fig. 5a)

The .tif images show *xy*-plane intensity cross-sections recorded by placing the camera at position xx.x mm along the optical path, where position 00.0 mm corresponds to imaging the metasurface beam splitter and 1 mm of camera movement corresponds to moving the imaged plane by 400 nm.

'FZP_A_atxxx': Illumination of the metasurface by Fresnel zone plate pattern A only.
'FZP_B_identical_atxxx': Illumination of the metasurface by Fresnel zone plate pattern B only.
'nodes_identical_atxxx': Coherent illumination of the metasurface by Fresnel zone plate patterns A and B with the phase modulator set to maximize the image intensity.
'antinodes_identical_atxxx' : Coherent illumination of the metasurface by Fresnel zone plate patterns A and B with the phase modulator set to minimize the image intensity.

3. Folder SignalWithInnerRingsZonePlates – Experimental Dataset (ii) (Fig.4a-d, Fig. S3d)

The .tif images show *xy*-plane intensity cross-sections recorded by placing the camera at position xx.x mm along the optical path, where position 00.0 mm corresponds to imaging the metasurface beam splitter and 1 mm of camera movement corresponds to moving the imaged plane by 400 nm.

'FZP_A_atxxx': Illumination of the metasurface by Fresnel zone plate pattern A only.
'FZP_B_2innerRings_atxxx': Illumination of the metasurface by Fresnel zone plate pattern B only.
'nodes_2innerRings_atxxx': Coherent illumination of the metasurface by Fresnel zone plate patterns A and B with the phase modulator set to maximize the image intensity.
'antinodes_2innerRings_atxxx' : Coherent illumination of the metasurface by Fresnel zone plate patterns A and B with the phase modulator set to minimize the image intensity.

4. Folder ComplementaryZonePlates – Experimental Dataset (iii) (Fig. 5b, Fig. S4d, Fig. S5)

The .tif images show *xy*-plane intensity cross-sections recorded by placing the camera at position xx.x mm along the optical path, where position 00.0 mm corresponds to imaging the metasurface beam splitter and 1 mm of camera movement corresponds to moving the imaged plane by 400 nm.

'FZP_A_atxxx': Illumination of the metasurface by Fresnel zone plate pattern A only.
'FZP_B_complementary_atxxx': Illumination of the metasurface by Fresnel zone plate pattern B only.
'nodes_complementary_atxxx': Coherent illumination of the metasurface by Fresnel zone plate patterns A and B with the phase modulator set to minimize the focal intensity.
'antinodes_complementary_atxxx' : Coherent illumination of the metasurface by Fresnel zone plate patterns A and B with the phase modulator set to maximize the focal intensity.

5. Folder Theory

Inludes .xlsx files with simulation results for each case as calculated based on the angular spectrum method:

Fresnel_Zone_plate_A.xlsx (Fig.3c-d top 2 rows, Fig.4c-d top row, Fig.6a-b top row, Fig. 6 data normalization factors, Fig. S2a-c top 2 rows, Fig. S3a-c top row, Fig. S4a-c top row, Fig. S5c-d top row)

Fresnel_Zone_plate_B_2InnerRings.xlsx (Fig.4c-d 2nd row, Fig.6b top row, Fig. S3a-c 2nd row)

Fresnel_Zone_plate_B_ComplementaryRing.xlsx (Fig. S4a-d 2nd row, Fig. S5c-d 2nd row)

Fresnel_Zone_plate_B_FocalLengthTuning.xlsx: (Fig. S6 a-d 2nd row)

IdenticalZonePlate_Nodes.xlsx (Fig.3c-d 3rd row, Fig.6a intensity map insets, Fig. S2a-c 3rd row)

IdenticalZonePlate_Antinodes.xlsx (Fig.3c-d 4th row, Fig.5a(Theory), Fig.6a intensity map insets, Fig. S2a-c 4th row)

Inner2Rings_nodes.xlsx (Fig.4c-d 3rd row, Fig.6b intensity map insets, Fig. S3a-c 3rd row)

Inner2Rings_antinodes.xlsx (Fig.4c-d 4th row, Fig.6b intensity map insets, Fig. S3a-c 4th row)

ComplementaryFZPs_Nodes.xlsx (Fig. 5b (Theory), Fig. S4a-c 3rd row, Fig.S5c-d 3rd row)

ComplementaryFZPs_Antinodes.xlsx: (Fig. S4a-c 4th row, Fig.S5c-d 4th row)

FocalLengthTuning_Nodes.xlsx: (Fig. S6 a-d 3rd row)

FocalLengthTuning_Antinodes.xlsx: (Fig. S6 a-d 4th row)

In each one of the above .xlsx file there are 6 sheets providing all necessary data for:

- x and y axes in meters (sheet 1) and simulated intensity values on the sample plane (sheet 2)
- r (radial position) and z axis (propagation axis) in meters (sheet 3) and simulated intensity values (sheet 4)
- x and y axes in meters (sheet 5) and simulated intensity values at the focal plane (sheet 6)

Fig6 – FWHM_under_RelativeBeamPhaseScan.xlsx: (Fig. 6)

Includes simulation results presented as theory curves in Fig. 6

- Phase phi, full width half maximum intensity focal diameter and focal depth for identical Fresnel zone plates (sheet 1 – Fig.6a)
- Phase phi, full width half maximum intensity focal diameter and focal depth for combination of Fresnel zone plate A with the Fresnel zone plate B that consists of only the 2 inner rings (sheet 2 – Fig.6b)

Clarification on intensity scaling and normalization of theoretical data shown in the manuscript:

To aid comparison between experimental and theoretical light distributions in Fig. 3-5 and Fig. S2-S5, the presented theoretical data of each data set has been scaled by the same factor such that the theoretical and experimental peak focal intensities of zone plate A match. Different experimental exposure times used for different experimental data sets in order to make optimal use of the camera's dynamic range result in different scaling factors for the data sets studying (i) identical zone plates, (ii) zone plates with different numbers of rings and (iii) complementary zone plates.

Theory curves and intensity maps in Fig. 6 are normalized to the maximum intensity along the z-axis for Fresnel zone plate A.