Weak Measurements of Light Chirality with a Plasmonic Slit

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Supplementary Material

1. Determination of the momentum and coordinate shifts.

The illuminating beam is prepared in a way that a focal spot is located behind the metal surface. Accordingly, the beam focusing is visible in the plasmonic beam at a certain distance from the slit. The distance could be varied in the setup, but was chosen so that the slit length would be larger than the incident spot size, to avoid beam cutting and edge diffraction.

In the real (x, y) space of the LRM setup, a vertical y-shift of the focal spot is visible for the incident tilted linear polarization (real ε), Fig. S1(c). In the case of an elliptical input polarization (imaginary ε), a momentum shift of the SPP beams is manifested in the real space by an angular deviation of the beam centroid, Fig. S1(b). It is convenient to analyze the momentum shift in the Fourier space (k_x, k_y), where the captured field intensity is distributed along a circle (arcs) corresponding to the SP wavevector: $k = k_p$, Figs. S1(d)-(f). The angular width of the arcs corresponds to the effective NA of the experimental setup. When an elliptical input polarization is used, the intensity distribution peak is shifted upwards or downwards along the k_y-axis, Fig. S1(e).

Thus, to measure the coordinate and momentum shifts of the SPP beam we analyze, respectively, its transverse intensity distribution in the focal plane in the real space, $I(y)$, and the intensity distribution along the SPP circle in the Fourier plane, $\tilde{I}(k_y)$. Correspondingly, the coordinate and momentum centroids of the beam are determined via standard center-of-mass formulas: $\langle y \rangle = \int yI(y)dy \big/ \int I(y)dy$ and $\langle k_y \rangle = \int k_y \tilde{I}(k_y)dk_y \big/ \int \tilde{I}(k_y)dk_y$.

In Figure S1(a) and (d) we included the SPP field distribution for perfect y-linear polarization of the incident light ($\varepsilon = 0$). Obviously, the system is mirror-symmetric with respect to the y-axis in this case, and no transverse shifts occur in the SPP beams. Note that the weak-measurement approximation breaks down in this case (the weak value (5) diverges) because the transverse beam distribution is not Gaussian anymore. Instead, $I(y)$ has a double-hump profile similar to the Hermite-Gaussian mode of the first order, Fig. S1(a), i.e., $\Phi_{out} \propto y\exp\left[-y^2/w_0^2\right]$, cf. Eq. (6). Our equations (15) for the beam centroids accurately describe this regime as well, yielding $\langle y \rangle = \langle k_y \rangle = 0$ for $\varepsilon = 0$.

2. Plasmon field distributions from the theory and FDTD simulations.

For the sake of completeness, we also show here the SPP field distributions for different input polarizations obtained from the theoretical Eqs. (8)-(12) and by FDTD numerical simulations. Figure S2 shows these distributions for the parameters and polarizations used in the experimental

Fig. S1. Since all the patterns are central-symmetric with respect to the $(x, y) \to (-x, -y)$ transformation, we plot FDTD distributions at the $x < 0$ half-planes and theoretical distributions at the $x > 0$ half-planes.

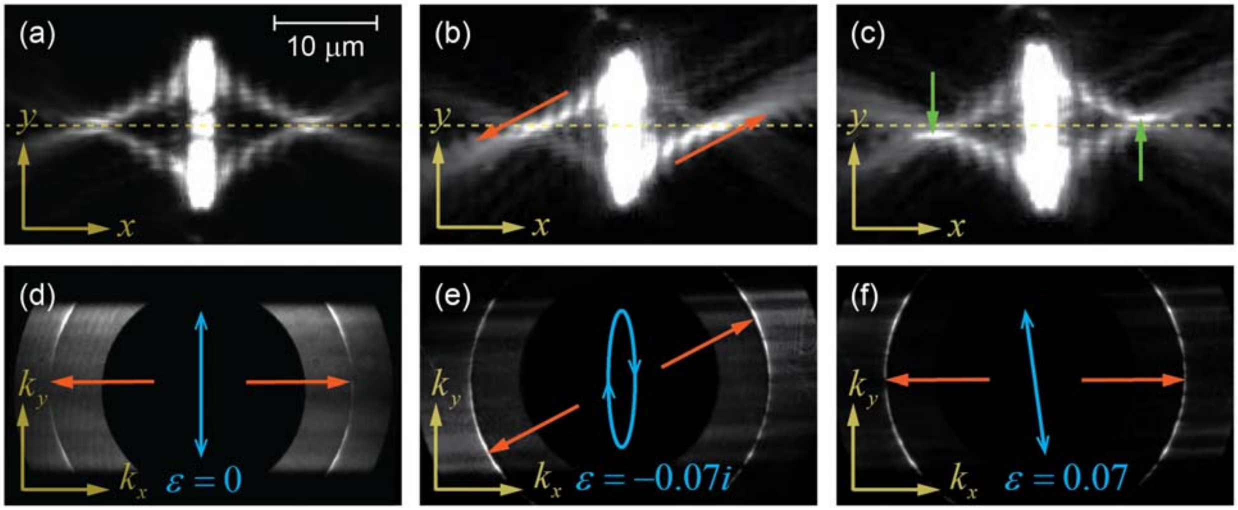

Fig. S1. The SPP field distributions in the real (upper row) and Fourier (lower row) spaces at slightly different polarizations of the incident light. Namely, the cases of y-linear ($\varepsilon = 0$), slightly elliptical (small imaginary ε) and tilted linear (small real ε) polarization are presented. Directions of the propagation of the beam (momenta) are indicated by orange arrows, whereas coordinate y-shifts of the focal spots are shown by green arrows.

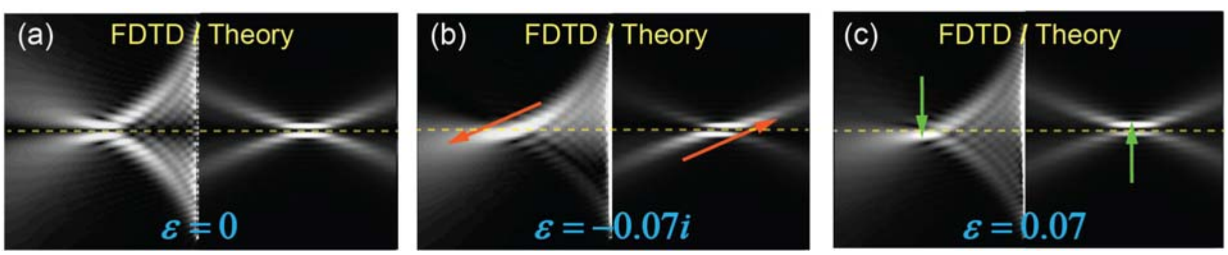

Fig. S2. FDTD simulated (left parts) and theoretically calculated from Eqs. (8)-(12) (right parts) distributions of the SPP field for the parameters and input polarizations corresponding to the real space experimental images in Fig. S1.