Manipulating the Diffraction Limit with Optical Anisotropy

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We demonstrate that material anisotropy can be effectively used to achieve the light propagation in highly-confined spatial areas. We propose a meta-material design of a strongly anisotropic optical media, and present a novel class of waveguides with such a metamaterials cores, called *photonic funnels*.

In contrast to conventional telecom fibers that support radiation transfer only when their size is larger than a wavelength, the anisotropy-based photonic funnels presented in this work support propagating modes confined to the spatial areas of the order of 1/30-th of the free-space wavelength. In contrast to plasmonic structures that operate on surface waves and were previously proposed to beat the diffraction limit, the mode structure in photonic funnel is identical to the one in telecom fibers. Furthermore, depending on the material configuration, the modes propagating in photonic funnels may have either positive or negative phase velocity, potentially leading to a superior phase manipulation in nanoscale areas.

In this talk we focus on real-life perspectives of photonic funnels. We start by presenting anisotropic meta-materials for near, mid- and far-IR frequencies. We demonstrate, that these composites allow the construction of waveguides where the effective refractive index self-adjusts to the waveguide radius: as the radius is reduced, the refraction index grows, virtually eliminating the diffraction limit in the system. We further present a detailed study of the effects of material absorption, spatial dispersion, and waveguide cladding composition on the photonic funnel performance.

We conclude by demonstrating efficient light propagation at nano-scale, as well as efficient energy transfer between micro- and nano- domains for several frequency ranges.