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Bending the laws of diffraction with hyperbolic metamaterials

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Diffraction strongly affects our everyday life as well as our future progress. It provides the resolution limit for microscopy, photography, and other imaging techniques; it determines the scattering and emission properties of small objects; it affects the propagation of telecom signals in bent fibers. The diffraction can be understood as the ability of the relatively small, wavelength-scale, structures to change the direction of the beam of light propagating in the surrounding medium. The resulting change in the propagation of the beam is determined by the complex interplay between the shape and size of the structures and of the beam, and, to the large degree, by the properties of the material surrounding the obstacles. Here we show that a subclass of metamaterials, nanostructured composites with strong anisotropy of their optical response, known as hyperbolic media, are capable of providing unique modifications to the well-known diffraction laws. In particular, hyperbolic media open the door for negative refraction, sub-wavelength focusing, super-resolution imaging, and introduce new mechanisms for nonlinear interaction of optical beams. In the talk we will discuss theoretical foundations of optics of hyperbolic metamaterials and will also present the results of recent experimental studies of these unique systems.