VIDEO ARTICLE
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Free-Electron Radiation Nanophotonics

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Abstract

A charged particle travelling in a homogeneous medium emits photons when it travels faster than the phase velocity of light. This phenomenon is known as Cherenkov radiation, which enables many applications, such as the development of light sources at the terahertz/X-ray regimes and the invention of Cherenkov detectors for identifying particles in high-energy physics and astrophysics. In this talk, we will introduce two exotic phenomena of Cherenkov radiation from inhomogeneous nanostructures [**1-6**]. First, we propose a new paradigm for Cherenkov detectors that utilizes the broadband angular filter made from stacks of variable one-dimensional photonic crystals [**1-3**]. Owing to the Brewster effect, the angular filter is transparent only to Cherenkov photons from a precise incident angle. Particle identification is achieved by mapping each Cherenkov angle to the peak-intensity position of transmitted photons in the detection plane. Such angular filtering effect, although decreases the photon number collected in the detection plane, enables the realization of a non-dispersive pseudo refractive index over the entire visible spectrum. Moreover, the pseudo refractive index can be flexibly designed to different values close to unity. Our angular-selective Brewster paradigm offers a feasible solution to implement compact and highly sensitive Cherenkov detectors especially in beam lines with a small angular divergence using regular dielectrics. Second, we report a general approach to enhance the photon yield of Cherenkov radiation using dispersionless plasmons [**4-6**]. Broadband dispersionless plasmons can be realized by exploiting either the acoustic nature of terahertz plasmons in a graphene-based heterostructure or the nonlocal property of optical plasmons in a metallodielectric structure. When coupled to moving electrons, such dispersionless plasmons give rise to a radiation enhancement rate more than two orders of magnitude (as compared with conventional Cherenkov radiation) over an ultrabroad frequency band. Moreover, since the phase velocity of dispersionless plasmons can be made as small as the Fermi velocity, giant radiation enhancements can be readily induced by ultralow-energy free electrons (e.g. with a kinetic energy down to 3 electronvolts), without resorting to relativistic particles.

Keywords: Cherenkov radiation, metamaterials, photonic crystals, graphene plasmons.

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Biography

Education and work experience

2020.09-now	Research professor, College of Information Science & Electric engineering, Zhejiang University (ZJU), China.
2017.02-2020.09	Post-doc, Division of Physics and Applied Physics, School of Physical and Mathematical Science, Nanyang Technological University (NTU), Singapore. [Baile Zhang's group]
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Awards

First prize of Zhejiang Provincial Natural Science Award 2021
Experimental and theoretical studies of inverse Cherenkov radiation in metamaterials.

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