Section of Public Relations	Dongsun Cho Section Chief 062-715-2061	Nayeong Lee Senior Administrator 062-715-2062
Contact Person for this Article	Senior Researcher Chul-Sik Kee Advanced Photonics Research Institute 062-715-3426	
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Senior Researcher Chul-Sik Kee's team develops a material that can hide objects from light like an invisibility cloak

- GIST (Gwangju Institute of Science and Technology) Advanced Photonics Research Institute Senior Researcher Chul-Sik Kee's team has developed a Photonic Dirac dispersion material* that hides an object from light like an invisibility cloak or completely removes the phase information of the incident light and cannot be restored.

  * Photonic Dirac dispersion materials: A Dirac cone or Dirac dispersion material is a material with an hourglass structure in which the relationship between the energy and wavelength of an electron is made up of two cones, and a representative material is graphene. Similarly, in a structure in which the refractive index changes periodically, two modes in which the relationship between the frequency and wavelength of light are in a straight line meet. This point is called a Dirac point. The effective refractive index of the Direct point mode is almost zero, so it shows the propagation of light, which is impossible in nature, such as the invisibility cloak of light.

  - The research team understood the relationship between the Fourier-harmonic components* of a photonic crystal** and the radiation loss of the photonic crystal modes, and presented a theoretical method to implement a photonic crystal with optical Directive dispersion characteristics by manipulating specific Fourier-harmonic components.

* Fourier-harmonic components: multiples of frequency corresponding to cycles of periodic structure

** photonic crystal: a structure whose refractive index changes periodically and strongly reflects light in a specific frequency range

□ The research on Direc dispersion characteristics using the existing photonic crystal was mainly conducted in the low frequency region with a longer wavelength than the photonic crystal cycle, and there was no report in the high frequency region with a wavelength similar to that of the photonic crystal. This is because the mutual interference between the higher-order Fourier-harmonic components of the photonic crystal induces radiation loss, which impedes the implementation of Direc scattering characteristics in the high-frequency region.

◦ The research team has theoretically studied the relationship between the Fourier-harmonic components of the photonic crystal and the radiation loss of the photonic crystal modes. Through this study, the interaction between the higher-order Fourier-harmonic components is not only the Direc dispersion property but is also closely related to the bound state in the continuum* and Fano resonance**. Based on this result, by manipulating specific Fourier-harmonic components, Direc's dispersion characteristics, continuous level constraint state, and Fano resonance were also implemented in the high-frequency region.

* bound state in the continuum, BIC: electrons with continuous level energy greater than the constraint energy are spatially bound in a quantum mechanical state and recently discovered as a state in which light (photons) are permanently confined in photonic crystals

** Fano resonance: characterized by an asymmetric transmission spectrum in a very narrow frequency range due to the resonance caused by the mutual interference of the radiation mode and the constrained mode

□ Post-doctoral researcher Sun-Goo Lee and Senior Researcher Chul-Sik Kee said, "This study is meaningful in understanding the relationship between Fourier-harmonic components and radiation loss of photonic crystal modes and presenting a method for implementing Direc-dispersion characteristics, continuous-level constraint state, and Fano resonance in the high-frequency region, which has not been reported so far. It is expected to be used in stealth technology, electromagnetic wave shielding technology, high-efficiency nonlinear devices, and high-sensitivity optical sensors in the future."

- This research was led by GIST Advanced Photonics Research Institute Senior Researcher Chul-Sik Kee and conducted by Dr. Sun-Goo Lee and Dr. Seong-Han Kim with support from the Ministry of Science and ICT, the Ministry of Education, and the GIST Research Institute and was published online on May 27, 2021 in Photonics Research.

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