A new law for metamaterials

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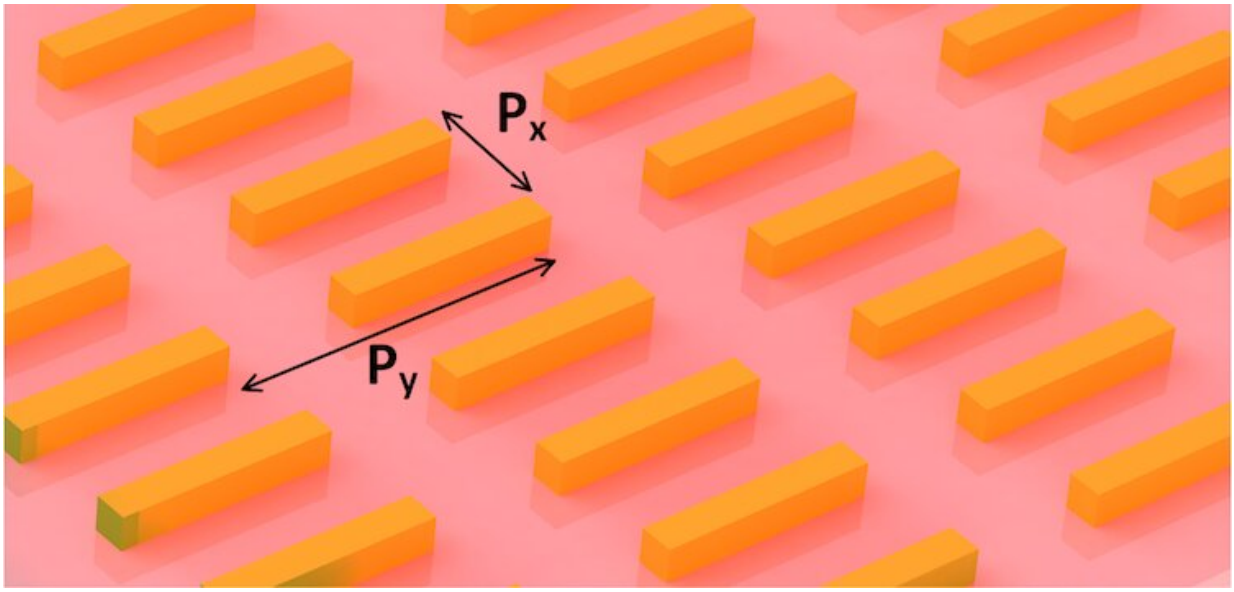

A new scale law uncovers the physics behind the collective thermal emission behavior of metamaterials. Credit: College of Engineering, Carnegie Mellon University

Metamaterials, which are engineered to have properties not found in nature, have long been developed and studied because of their unique features and exciting applications. However, the physics behind their thermal emission properties have remained unclear to researchers—until now.

In a paper published in *Physical Review Letters*, Sheng Shen, an associate

professor in Carnegie Mellon's department of mechanical engineering, and his student Jiayu Li, a Ph.D. candidate, have created a new scale law to describe the thermal emission from metasurfaces and metamaterials.

"With this new scale law uncovering the underlying physics behind the collective thermal emission behavior of metamaterials, researchers could easily utilize existing design and optimization tools to achieve desired thermal emission properties from metamaterials, instead of blindly searching for the best solution through mapping the entire design space," Li said.

Thermal emission refers to the type of light a material emits. For example, humans emit infrared light, while glowing hot metal emits visible light. In general, thermal emission depends on an object's temperature and composition. Metasurfaces, however, diverge from our classical understanding of thermal emission because of their unique sub-wavelength scale structure.

The impact of Shen and Li's new scale law will be seen in many fields, including electrical engineering, optoelectronics, materials science, and thermal engineering. Applications of metamaterials include solar energy harvesting, optical filters, and thermal camouflage.

"At CMU, we are applying this new scale law to design novel metamaterial-based thermal infrared devices for a variety of applications including infrared signature control, infrared sensing, thermal management, and thermal energy conversion," Shen said.

The paper, titled "Scale Law of Far-Field Thermal Radiation from Plasmonic Metasurfaces," was published in *Physical Review Letters* in March 2020. Ph.D. candidate Bowen Yu was an additional author.

More information: Jiayu Li et al. Scale Law of Far-Field Thermal

Radiation from Plasmonic Metasurfaces, *Physical Review Letters* (2020).
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