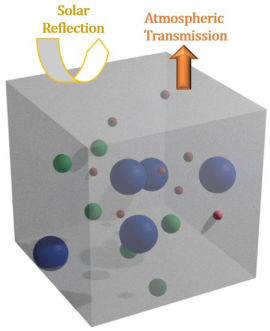
TUNING NANOPARTICLES FOR RADIATIVE COOLING

To achieve efficient passive radiative cooling, reflecting solar light effectively is crucial. Nanoparticles have been handy for boosting solar reflectance by scattering light. However, what often gets overlooked is the impact of material dispersion – how materials respond to light at different frequencies. Our study addresses this gap and uncovers a key insight: nanoparticles with similar responses in the visible behave differently in the infrared spectrum due to material dispersion.

This discovery is highly significant because another ingredient for efficient radiative cooling is the ability to selectively emit radiation within the transparent infrared atmospheric window. In this window, the atmosphere is transparent and therefore all the heat radiated by the structures is released to the cold outer space leading to an overall cooling effect.



Draft of a radiative cooling composite material: a combination of resonant nanoparticles engineered to reflect solar light with precision, simultaneously facilitating efficient heat radiation through the atmospheric window.

Our study demonstrates that dispersive nanoparticles have suppressed-scattering windows. These windows enable selective thermal emission within a highly reflective sample and are solely influenced by material dispersion. Importantly, they persist even in complex materials like random composites and periodic metasurfaces, staying fixed to the same wavelength.

To illustrate the performance, we take a closer look at calcium-silicate-hydrate (CSH), a primary phase in concrete, as a dispersive host. Our case study shows that fine-tuning suppressed-scattering windows is possible by co-designing nanoparticles and host materials.

The conclusion of our research is that by adjusting nanoporosities, concrete could become capable of passive radiative cooling during daylight – a promising path for practical applications.

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(J. M. Pérez-Escudero et al., “Suppressed-scattering spectral windows for radiative cooling applications,” Opt. Express, vol. 31, no. 4, p. 6314, Feb. 2023, doi: 10.1364/OE.477368.).

MIRACLE Photonic Concrete

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