Metamaterial Coherent Perfect Absorber: The Anti-Lasing-Spaser

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Abstract: We experimentally demonstrate a new coherent absorption phenomenon - a time-reversed analogue of ‘Lasing Spaser’ action, through which a planar photonic metamaterial may resonantly absorb 100% of incident light.

It is shown for the first time that a planar photonic metamaterial (a single layer of nanostructured metal less than one tenth of a wavelength thick) can resonantly absorb all of the light incident on it via a coherent interaction.

This absorption phenomenon is a metamaterial analogue of the recently reported optical cavity ‘coherent perfect absorption’ effect, which constitutes a time-reversed counterpart to conventional lasing. It is a narrowband phenomenon achieved by controlling the balance between interference and absorption for counter-propagating beams in a dissipative medium and was recently demonstrated experimentally in a bulk silicon optical resonator [1].

Our study shows that an equivalent effect may be observed by exploiting resonant absorption in a single sub-wavelength plasmonic metamaterial film (Fig. 1). We experimentally demonstrate coherent absorption in a gold metamaterial at visible wavelengths and show that the level of absorption can be continuously tuned via the mutual phase of the incident beams.

The ‘lasing spaser’ is a coherent source of optical radiation fuelled by plasmonic oscillations [2], and the metamaterial coherent perfect absorber reported here is its time-reversed counterpart. Metamaterial coherent absorption may be implemented across a broad visible to near-infrared range by varying the structural design and may serve applications in optical modulators, transducers, switches or sensors.

Fig. 1: Metamaterial coherent perfect absorber: Up to 100% of total incident energy in two counter-propagating beams may be absorbed in a nanostructured metallic film of sub-wavelength thickness.
