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A subradiant optical mirror formed by a single structured atomic layer JUN RUI, DAVID WEI, ANTONIO RUBIO-ABADAL, SIMON HOLLERITH, CHRISTIAN GROSS, IMMANUEL BLOCH, Max-Planck-Institute of Quantum Optics, JOHANNES ZEIHER, DAN STAMPER-KURN, Department of Physics, University of California, Berkeley — Efficient and versatile interfaces for the interaction of light with matter are an essential cornerstone for quantum science. A fundamentally new avenue of controlling light-matter interactions has been recently proposed based on the rich interplay of photon-mediated dipole-dipole interactions in structured subwavelength arrays of quantum emitters. Here we report on the direct observation of the cooperative subradiant response of a two-dimensional (2d) square array of atoms in an optical lattice. We observe a spectral narrowing of the collective atomic response well below the quantum-limited decay of individual atoms into free space. Through spatially resolved spectroscopic measurements, we show that the array acts as an efficient mirror formed by only a single monolayer of a few hundred atoms. By tuning the atom density in the array and by changing the ordering of the particles, we are able to control the cooperative response of the array and elucidate the interplay of spatial order and dipolar interactions for the collective properties of the ensemble. Bloch oscillations of the atoms out of the array enable us to dynamically control the reflectivity of the atomic mirror. Our work demonstrates efficient optical metamaterial engineering based on structured ensembles of atoms.

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