

Driving the superconducting Higgs mode with twisted light

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The study of light-matter interaction using a vortex beam – an optical beam carrying orbital angular momentum (OAM) [1] – has gained considerable interest over the last decades. In particular, it is an intriguing subject to imprint the OAM of light to quantum condensates from the viewpoint of optical manipulation of macroscopic quantum state of matter. Here, we investigate the OAM transfer of vortex beam to an s-wave superconductor NbN. By coherently driving the Higgs mode with a terahertz (THz) vortex beam utilizing the nonlinear light-Higgs coupling [2], we succeeded in imprinting the OAM of the THz beam onto the superconducting condensate. Specifically, by using spatially resolved THz pump–THz probe spectroscopy technique, we have demonstrated the excitation of a rotating Higgs mode, where the Higgs mode oscillations reflect the spatial phase structure of the vortex beam. Time-dependent Ginzburg–Landau analysis indicates that the observed rotating Higgs mode manifests itself the finite gauge-invariant OAM of superconducting condensate inherited from the THz vortex beam. The demonstrated scheme provides a promising route toward the light-control of superconducting order-parameter in an ultrafast time scale.

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- [2] R. Matsunaga, N. Tsuji, H. Fujita, A. Sugioka, K. Makise, Y. Uzawa, H. Teraï, Z. Wang, H. Aoki, and R. Shimano, *Light-induced collective pseudospin precession resonating with Higgs mode in a superconductor*, Science **345**, 1145 (2014).