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Second-harmonic generation and the conservation of spatiotemporal orbital angular momentum of light

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Light with spatiotemporal orbital angular momentum (ST-OAM) is a recently discovered type of structured and localized electromagnetic field. This field carries characteristic space–time spiral phase structure and transverse intrinsic OAM. Here, we present the generation and characterization of the second harmonic of ST-OAM pulses. We uncover the conservation of transverse OAM in a second-harmonic generation process, where the space–time topological charge of the fundamental field is doubled along with the optical frequency. Our experiment thus suggests a general ST-OAM nonlinear scaling rule, analogous to that in conventional OAM of light. Furthermore, we observe that the topology of a second-harmonic ST-OAM pulse can be modified by complex spatiotemporal astigmatism, giving rise to multiple phase singularities separated in space and time, depending on group velocity mismatch or phase mismatch. We also analyzed the spatiotemporal momentum density and energy density flows of a fundamental ST-OAM pulse and its second-harmonic field. Our study opens a new route for nonlinear conversion and scaling of light carrying ST-OAM, with the potential for driving other secondary ST-OAM sources in electromagnetic, thermoacoustic, electron waves and beyond.