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Single-shot simulations of prolonged quantum dynamics with structured light

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Standard photonic simulations of lattice quantum dynamics rely on our ability to shape optical modes and their relative couplings. In these platforms, reproducing temporally-long evolutions is challenging, as required setups are complex and lossy. Here we report the realization of long-time photonic quantum walks, based on light propagation through a limited number of birefringent optical elements. The walk is engineered in the particles quasi-momentum space, encoded into a spatial coordinate transverse to the optical axis. Considering optical polarization as the internal degree of freedom, the evolution operator is built in terms of a spatially-varying polarization transformation, realized through liquid-crystal metasurfaces. We report up to 320 timesteps of quantum-walk evolutions, even affected by disorder, far beyond state-of-the-art simulations of such dynamics.

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