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Continuous time quantum random walks in free space TONI EICHELKRAUT, CHRISTIAN VETTER, ARMANDO PEREZ-LEIJA, Institute of Applied Physics, Friedrich-Schiller-Universität Jena, DEMETRIOS CHRISTODOULIDES, CREOL, University of Central Florida, ALEXANDER SZAMEIT, Institute of Applied Physics, Friedrich-Schiller-Universität Jena — We show theoretically and experimentally that two-dimensional continuous time coherent random walks are possible in free space, that is, in the absence of any external potential, by properly tailoring the associated initial wave function. These effects are experimentally demonstrated using classical paraxial light. Evidently, the usage of classical beams to explore the dynamics of point-like quantum particles is possible since both phenomena are mathematically equivalent. This in turn makes our approach suitable for the realization of random walks using different quantum particles, including electrons and photons. To study the spatial evolution of a wavefunction theoretically, we consider the one-dimensional paraxial wave equation $(i\partial_z + \frac{1}{2k}\partial_x^2)\Psi = 0$. Starting with the initially localized wavefunction $\Psi(x,0) = exp[-x^2/2\sigma^2]J_0(\alpha x)$, one can show that the evolution of such Gaussian-apodized Bessel envelopes within a region of validity resembles the probability pattern of a quantum walker traversing a uniform lattice. In order to generate the desired input-field in our experimental setting we shape the amplitude and phase of a collimated light beam originating from a classical HeNe-Laser (633 nm) utilizing a spatial light modulator.

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