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Observation of All-Optical Berezinskii-Kosterlitz-Thouless Transition[1] GUOHAI SITU, JASON W. FLEISCHER, Princeton University — The Bereszinskii-Kosterlitz-Thouless (BKT) transition is a two-dimensional dynamic phase transition in which vortex creation competes with entropy production. Each factor is logarithmic in energy, with attempts at long-range order restricted by both geometry and thermal fluctuations. The BKT transition has been observed in a variety of quantum systems, including superfluid films, superconductors, and trapped atomic gases, but it is at root a classical process. Here, we demonstrate a classical BKT transition by observing the 2+1D propagation of an optical beam in a photonic lattice. In this system, there is a one-to-one mapping between the discrete nonlinear Schrödinger equation for paraxial propagation and the traditional XY model of condensed matter physics, with thermodynamic averaging replaced by ensemble averaging over initial random phases. We show experimentally that both the number of vortices produced and the universal jump in correlations agree with predictions from mean-field theory. The results give new confirmation of BKT theory, in a purely classical context, and reinforce the use of photonic systems as an experimental testbed for statistical physics.

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