Realizing the EPR gedanken experiment with transverse momentum entangled photons

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Abstract

We report on the realization of the EPR gedanken experiment using transverse momentum entangled photons. As EPR showed, when one chooses to measure the momentum p of one of the particles of a momentum correlated pair, the other particle is projected into a correlated momentum eigenstate. However, if one wishes to measure the position x of one particle the other particle is projected into a correlated position eigenstate. This leads to the rather interesting result that a relative uncertainty product of position and momentum of the two particles can be exactly zero. The result can be much smaller than $\hbar$, which is predicted by classical wave theory. We realized this EPR experiment by using spontaneous parametric downconversion from a type-II BBO crystal following many aspects of a proposal by Lugiato's group. By projecting the down conversion source into the near field (position-like) and far field (momentum-like) of the detectors, we were able to measure a relative uncertainty product of $0.3\hbar$.