2-D spatial mesurement of the Einstein-Podolsky-Rosen in cameras images.

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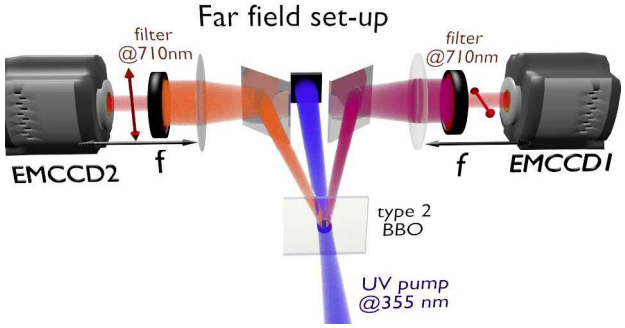
In 1935, Einstein, Podolsky and Rosen (EPR) proposed a "gedanke experiment" in which two entangled particles were considered. They shown that even if the particles are well separated in a way that they cannot exchange information, they can exhibit both perfect position and momentum correlations. Spontaneous Parametric Down Conversion (SPDC) generate entangled photons whose behavior is close to the original state described by EPR.
We demonstrate here EPR entanglement using images provided by two different cameras. The quantum state involved in the demonstration is generated by SPDC in a BBO crystal using a type II phase matching configuration. Full field images are obtained from EMCCD cameras (Electron-Multiplying CCD) in a photon counting regime. Data are used without any post-selection, and the near and far field standard deviations involved in the Heisenberg inequality test are obtained directly by computing the images provided by the synchronized cameras. In contrast with previous demonstrations, we ensure the consistency of the demonstration by using the whole intensity of the SPDC in both near and far fields. We obtained former results using a single camera ; in that case however the spatial separation of the images wasn't total and the violation of the Heisenberg uncertainty principle was only of a factor 4. We report here a violation by a factor 601 on one of the transverse spatial dimension and 33 in the other.



$$\Delta^2 x \Delta^2 p_x = \frac{1}{601}\frac{\hbar^2}{4} < \frac{\hbar^2}{4}$$

$$\Delta^2 y \Delta^2 p_y = \frac{1}{33}\frac{\hbar^2}{4} < \frac{\hbar^2}{4}$$

To our knowledge, our results correspond to the highest violation of the Heisenberg inequalities ever obtained with an EPR state, whatever the variables considered.

[1] A. Einstein, B. Podolsky, and N. Rosen, "Can quantum-mechanical description of physical reality be considered complete ?" Phys. Rev., **47**, 777-780 (1935).
[2] P.-A. Moreau, J. Mougin-Sisini, F. Devaux, and E. Lantz, "Realization of the purely spatial Einstein-Podolsky- Rosen paradox in full-field images of spontaneous parametric down-conversion." Phys. Rev. A, **86**, 010101 (2012).

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