Correlation Imaging through a Scattering Medium

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***abstract**: We report photon-counting imaging of entangled photon-pairs of high Schmidt number transmitted through a scattering medium. We demonstrate that spatial momentum or position quantum correlations, measured between twin images recorded on two separate detectors, exhibit in both cases speckle patterns. Moreover, the total correlation is only slightly lowered by scattering.*

Among all the experiments dealing with quantum correlation properties of Spontaneous Parametric Down Conversion (SPDC) [1], some studies adress the propagation of entangled two-photon states through random medium [2]. While in [2] two single-point detectors are scanned in the image planes, we propose in this paper to directly image, onto two separate electron-multiplying charge coupled device (EMCCD) cameras operating in photon-counting regime [3], the two-photon states transmitted through a scattering medium. Here, far-field and near-field quantum correlations are evidenced depending on the two reported imaging configurations. Finally, we performed stochastic simulations [4] to confirm the experimental results. The experimental set-up for the far-field

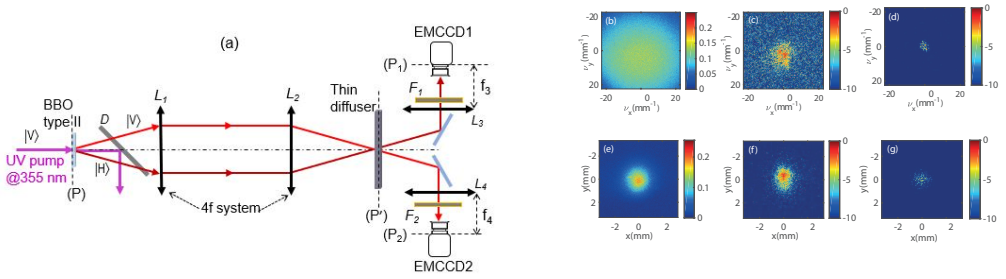

Fig. 1. (a) Experimental setup for far-field measurement. $|V\rangle$ and $|H\rangle$: vertical and horizontal polarizations. (P_1) and (P_2): the Fourier plane, and (P') the image plane. D: dichroic mirror, F_3 and F_4: interferential filters. (b) average photon number in single far-field images (signal or idler) of SPDC, (c) measured correlation function in dB between 40 000 twin images and (d) correlation function issued from 10 000 stochastic simulations. For the near-field correlations: (e) average photon number in single near-field images (signal or idler) of SPDC, (f) measured correlation function in dB between 70 000 twin images and (g) correlation function issued from 10 000 stochastic simulations.

correlations is illustrated in Fig. 1a. For the near-field correlations, we only replace the $4-f$ imaging system by a $2-f$ imaging system. In this case, the position of the diffuser lies in the far-field of the crystal and the EMCCD cameras image the near-field. Fig. 1b and Fig. 1e show respectively the far-field and near-field images of the SPDC simply conditioned by the phase matching condition and the pump beam shape, respectively. As shown in [2], the absence of a speckle pattern in the single-beam images of the SPDC results from the incoherent character of the light formed by a single beam of the entangled light. In contrast, and in agreement with [2], the cross correlation of the images exhibits speckle patterns in the far-field (Fig. 1c) as well as in the near-field (Fig. 1f). The experimental results are confirmed by stochastic simulations one as seen in Fig. 1d and Fig. 1g.

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