

# Optimized quantum differential ghost imaging

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## Abstract

Differential ghost imaging is one of the more interesting protocols of ghost imaging because of its advantage in the image reconstruction of small or weakly absorbing objects. We develop a model for differential ghost imaging taking into account channel losses and noise. A new optimized protocol, able to partially compensate for them, is proposed and compared with the previous protocols, both theoretically and experimentally. Moreover, we extend the differential ghost imaging protocol to the quantum case, exploiting experimental quantum twin beams to validate our model and to test our optimized protocol.

Ghost imaging is an imaging technique theoretically proposed in 1994 [1], and experimentally demonstrated in the following year [2]. Many different variations of the original ghost imaging protocol as been proposed and experimentally demonstrated [3, 4, 5, 6, 7, 8, 9, 10, 11, 12]. The so called differential ghost imaging, proposed and demonstrated in 2010 [13], is particularly interesting because it offers a relevant advantage respect to the conventional technique in the cases of small or weakly absorbing objects. Differential ghost imaging has been experimentally realized using bright thermal light. Here we extend the differential ghost imaging protocol to the quantum case, where quantum twin beams are exploited. We develop a model for differential ghost imaging in terms of the main experimental quantities. The model takes into account channels inefficiencies and electronic noise of the detector. A new optimized protocol, able to partially compensate for them, is proposed and compared with the others, both theoretically and experimentally. The role of losses is deeply discussed since in the quantum regime appears to be extremely relevant. It is possible to note that the mean number of photons per spatio-temporal mode has a fundamental role in determining the performances of differential ghost imaging. Finally, we perform the experiment exploiting spontaneous parametric down conversion light with low number of photons per mode. In order to validate the theoretical model we perform a set of measurement on calibrated absorbing samples. Then, as an example of possible real application, we reconstruct a complex biological object. It is important to note that, for the first time to our knowledge, in a ghost imaging experiment, the quantum advantage is demonstrated exploiting intensity correlations instead of time coincidences.

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