Efficient Interaction of X-Ray Heralded Photons with a Beam Splitter

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Beam splitters are the essential components in almost any experiment aiming at the study of fundamental quantum optics and serve as the building blocks for optical quantum technology. The extension of quantum optics into the X-ray regime would have a tremendous impact. Concepts of quantum optics can lead to a significant reduction of the radiation dose used for imaging and to the enhancement of sensitivity. A potential source for the generation of quantum forms of radiation in the X-ray regime is spontaneous parametric down-conversion (SPDC), which can be used to generate entangled photon pairs and heralded photons [1,2]. However, the spectral and angular widths of the photon pairs are in the multi-keV and several degrees ranges, respectively [1], thus it is very challenging to find optical components that can accommodate these broad widths and therefore beam splitters have never been realized for X-ray quantum optics.

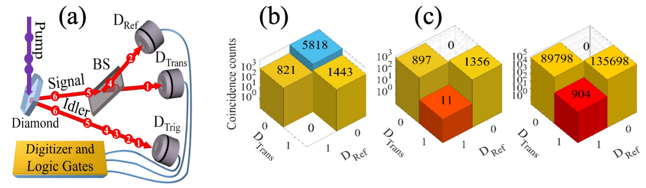

Figure 1: (a) Experimental setup. The photon pairs – which we denote as signal and idler – are generated in the diamond crystal by SPDC. (b)-(d) Coincidence count histograms of the outputs of the beam splitter where (a) only post selected heralded photons, (b) and (c) single photons and stray radiation without post-selection. The horizontal axes are the number of counts at each detector in one detection event

In this work, we show how to implement a beam splitter for X-ray quantum optics by using a mosaic crystal and demonstrate efficient interaction with the broadband X-ray heralded photons. Our setup is based on the standard scheme for generating and detecting heralded photons, as shown in Fig. 1 [1,2]. Since the SPDC generated photons are always generated in pairs, once we measure a photon at DTrig, we know with certainty that the other photon exists. These heralded photons exhibit all the properties of single photons – they cannot split when they hit upon a beam splitter; thus, the correlation between its two output ports is null. We show in Fig. 1(a) that the coincidence rate between the two output ports of the splitter is zero when only heralded photons are detected. For the comparison, we show that when we allow stray light detection as for the results shown in Figs. 1(b) and 1(c), the coincidence count rates are higher due to accidental coincidences.

References

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