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Advances in Quantum X-ray Imaging

Thursday 29 August 2024 12:00 (15 minutes)

Abstract
In this study, we explore the generation of entangled photon pairs through the process of nonlinear Bragg diffraction in the X-ray spectrum to perform X-ray spontaneous parametric down conversion (SPDC). SPDC is traditionally achieved using birefringent nonlinear materials in the visible and near-infrared regime[1]. By orienting the medium (single crystal diamond) and the X-ray pump to initiate Bragg diffraction and then slightly deviating from the ideal Bragg angle, we satisify phase matching condition as per the law of nonlinear diffraction[2].

Our breakthrough at the NSLS-II's CHX (11-ID) beamline involves the successful detection of X-ray SPDC photon pairs at an unprecedented rate of approximately 6,100 pairs per hour, significantly surpassing the previously known highest rate of 317 pairs per hour[3]. Not only do we showcase the strong energy anti-correlation of these pairs[4], but we also introduce the first images of their spatial structure captured using a pixelated area detector. Our research includes quantum correlation images of both binary and biological subjects using this X-ray source, a discussion on the effect of crystal quality on the photon pairs, and an exploration of potential applications, backed by simulations.

This advancement in the production and identification of correlated X-ray states heralds a range of promising applications. The relatively high efficiency of this source paves the way for quantum X-rays applications using quantum/ghost imaging techniques. These include reducing radiation dosage while retaining image quality, achieving lensless magnification and super-resolution imaging, and delving into fundamental quantum physics within a previously lesser-explored part of the electromagnetic spectrum.
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Figure Captions
1. Experimental setup.
2. SPDC X-ray detection rate progress over time.
3. SPDC X-ray selection observables and spatial properties.
4. Experimental X-ray SPDC ring, imaging mask, and energy non-degeneracy mappings.
5. Classical and quantum correlations images of E. cardamomum seed.

References
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I plan to submit also conference proceedings

No

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