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Challenging previous findings on x-ray parametric down conversion

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We present both theoretical and experimental insights on parametric down-conversion of x-ray photons into (pairs of) x-ray and optical photons. This three-wave mixing process promises to combine the high-resolution capabilities of x-ray diffraction with features of optical-domain spectroscopy. In particular, it offers the prospect of valence-selective probing for solid-state systems.
The detection of x-ray parametric down-conversion is challenging, however, as the nonlinear signal is weak and occurs in close proximity to strong elastic background. In order to clearly distinguish these contributions and thus obtain conclusive evidence of down-conversion, we emphasize the necessity to detect the effect's characteristic phase-matching signature.
Investigating the scattering signal beyond qualitative considerations, we introduce a theoretical description of parametric x-ray optical wave mixing processes, which we apply to the case of down-conversion.
Our simulations confirm the characteristic signature, but conclude very low conversion efficiencies at the same time.
Addressing this challenge, we present the development of an experimental setup that offers a broad acceptance for collecting the down-converted signal while suppressing the elastic background through multiple crystal reflections. Applying our setup ultimately, we do not find measurable evidence of the nonlinear effect, which corroborates the low conversion efficiencies predicted by our theory. On the other hand, our findings challenge previous claims on the effect's observation, which notably abstained from showing the characteristic signature.
For future resolution of the search for parametric down-conversion, we give an outlook to the development of alternative detection schemes.
In addition, we consider the prospect of stimulating the effect, which would amount to x-ray optical difference frequency generation.

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