Parametric Down Conversion of X-Ray Photons

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Parametric down conversion (PDC) is the energy-conserving spontaneous decay of photons into two others in a nonlinear optical medium. These two photons are correlated in a highly nonclassical way \cite{1}. PDC is well known in the visible regime and is applied in experiments such as two photon interferometry \cite{2}, shot noise suppression \cite{3} and tests of the quantum theory \cite{4, 5, 6}.

A way of detecting parametric down conversion of x-ray photons (XPDC) was first proposed by Freund and Levine \cite{7} and demonstrated by Eisenberger and McCall \cite{8} on an x-ray tube. Since then, only two groups have published results of XPDC: Yoda et al. \cite{9} and our own group \cite{10, 11}. This is certainly due to the weakness of the effect. For typical x-ray energies, the conversion cross section is about $10^{-9}$ of the Thomson scattering cross section \cite{11}. The matching of wave vectors in all of these experiments was done in the way originally proposed by Freund and Levine \cite{7}. The idea is to detune slightly by an angle $\Delta \Theta$ from a Bragg reflex to match the incident wave vector to the wave vectors of the converted photons.

Our activities of this year were efforts to obtain a quantitative determination of the conversion cross section with the wave vector matching scheme of Freund and Levine \cite{7}. Experiments were done at beamline Petra-I of HASYLAB and ID18 of the ESRF, results of which are shown below. We used Si drift chamber detectors and the time correlation electronics described in the annual report of 1998 and our publication \cite{11}. The event rate of close to 0.1/s achieved at the ESRF should be sufficient for demonstrations of applications of the pairs of correlated x-ray photons, such as sub-Poisson statistics \cite{12}.

Furthermore, we tried to observe XPDC with another wave vector matching scheme, involving dynamical scattering and to observe XPDC with resonance enhancement at the Ge K absorption edge. Both experiments were performed at the Petra-I beamline of HASYLAB but gave no conclusive results for reasons which are inherent in the effects under investigation.

![Figure 1: Plot of the time correlation of energy-discriminated photons, covering $\pm 10 \mu$s (and $\pm 1 \mu$s in the inset) from Petra-I at the detuning angle of maximum event rate. There are 158 events in 7\textfrac{1}{2} hours. Due to an intentional BNC cable delay in one of the signal chains, the coincidence peak appears at ca. 350ns time difference.](image-url)
Figure 2: Plot of time correlation spectra from ID18 of the ESRF for different detuning angles $\Delta \Theta$. A coincidence peak appears at the value of $\Delta \Theta$ for which a maximal effect is expected. The integral of the coincidence peak at the maximum gives 145 events in 1/2 hour.

References