X-ray Photon Echo by Doppler Frequency Comb

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A technique to generate controllable X-ray photon echoes, called Doppler frequency comb (DFC), has been proposed [1]. It uses a set of resonantly absorbing nuclear targets that move with different velocities (as illustrated in Fig. 1), which forms a frequency comb in the nuclear absorption spectrum. This results in a periodic reproduction of an incident photon wave packet under the condition that the bandwidth of the comb exceeds that of the incident field and the total optical thickness is high enough. The theory and experimental demonstration of the Doppler frequency comb using synchrotron radiation and a set of ^{57}Fe Mössbauer absorbers will be discussed. This is the first quantum storage scheme realized at ~ 10 keV photon energy.

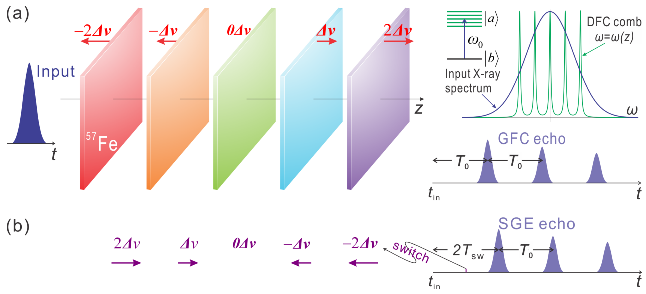

Figure 1: Illustration of X-ray photon echo. The input X-ray wave packet is absorbed by the Doppler frequency comb, formed by M Mössbauer targets, moving with velocities $v_m = m\Delta v$, $m = 1, 2, 3, \cdots, M$. (a) In the gradient frequency comb (GFC) regime, the velocity of each target is kept constant. The periodic beating between spectral components of the polarization in different targets forms the echo with periodicity T_0. (b) In the stepwise gradient echo (SGE) regime, the velocity directions of all targets are switched to the opposite at the moment $t_{\rm in} + T_{\rm sw}$ before the appearance of the first GFC echo (at $t_{\rm in} + T_0$). The phases of the targets' polarizations spread before the switching and rewind thereafter so that an echo emerges at a controllable moment, *i.e.*, twice the switching time after the input: $t_{\rm in} + 2T_{\rm sw}$

References

[1] X Zhang, W-T Liao, A Kalachev, R Shakhmuratov, M Scully and O Kocharovskaya, Phys Rev Lett **123**, 250504 (2019)