Super Light-by-Light Scattering in Vacuum Induced by Intense Vortex Lasers

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Collision of ultra-intense optical laser and X-ray free electron laser (XFEL) pulses is a promising approach to detecting nonlinear vacuum polarization (VP), a long-standing prediction of quantum electrodynamics remaining to be tested. Identifying the signals induced by polarized vacuum relies on purifying the X-ray polarization and poses significant challenges due to strongly reduced signal and low signal-to-noise ratio (SNR). Here we propose an approach that allows one to directly detect VP signals without the need for an X-ray polarizer. A new VP effect is identified in collision of an X-ray probe with an intense laser in a vortex mode, which we call the super light-by-light scattering (super-LBL), through which signal photons are kicked out of the X-ray background with large tangential momentum. Super-LBL originates from the gradient force of the vortical vacuum current in azimuthal direction and induces momentum exchange beyond the transverse momentum of laser-photon. This effect efficiently sets the scattered signal photons apart from the X-ray background, producing observable signals with both the strength and SNR more than two orders of magnitude higher than those from the known VP effects.

References

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