Identification of Gamma-Ray Vorticies with Compton Scattering and Their Emissions in Strong Magnetic Field

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Photon vortices caring orbital angular momentum (OAM) [1] with a wave function of Laguerre Gaussian (LG) wave and Bessel wave are one of most interesting topics in various fields of physics. It is expected to create in astronomical systems such as black holes [2] and neutron-stars. Gamma-ray bursts (GRBs) are one of the most energetic explosive phenomena in the universe. One of remarkable features for observed GBR γ rays is a fact that high linear (circular) polarization was observed for some γ rays in the energy region of several hundred keV. One of its possible generation mechanisms is synchrotron radiations from relativistic electrons under strong magnetic fields.

We have suggested a possibility that Hermite Gaussian (HG) wave photons are generated by the high-harmonic radiations in GRBs [3]. The HG wave function is one of higher-order Gaussian modes of the electromagnetic field. The HG (LG) wave can be presented by a combination of LG (HG) wave. However, there is a critical question, how to identify these gamma-rays in astronomical observation and laboratory experiments.

We have proposed a new method to identify the wave function of these non-plane wave photons using Compton scattering [3,4]. The differential cross section of the scattered photon measured simultaneously with the scattered electron for the incident photon with wave function of LG is calculated in the framework of relativistic quantum mechanics [4].

In Fig. 1 we show the contour plots of the differential cross sections as functions of θ_y and ΔE when the energy of the initial photon is 0.5 MeV, its z-component of the OAM for is $1\hbar$. The result shows that this method is powerful tools to investigate the angular momentum of the wave function of incident gamma-ray vortices.

We also discuss the gamma-ray vortex emission from electrons with synchrotron motions in strong magnetic fields, which imply that the vortex photon can be emitted from astronomical systems with strong magnetic field such as neutron-stars and magnetars.

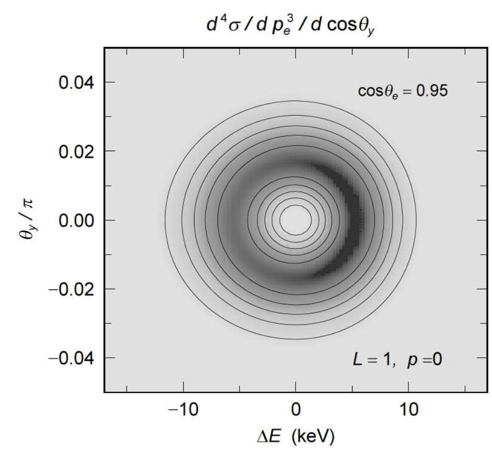

Fig.1 : The contour plots of the differential cross-section of Compton scattering. The polar angle θ_e for the scattered photon is given by $\cos\theta_e = 0.95$. The horizontal axis shows the energy difference ΔE from that in standard Compton scattering, and the vertical axis shows the polar angle between *zx*-plane and the scattered photon angle.

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