

## Twisted Photons radiated from Free Electons

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### Abstract

Twisted photons (vortex photons) have helical phase front and carry orbital angular momentum in adding to spin angular momentum. In these days, they are readily produced in laboratories by using lasers and optical components, and are used to explore their applications to information, communication, nano- or imaging technologies. On the other hand, it was theoretically predicted that helical undulators widely used in synchrotron light sources can produce vortex photons and it was experimentally demonstrated later. We investigated the underlying physics of this phenomenon and have found that radiation from an electron in circular motion is twisted, having helical phase front and carrying orbital angular momentum. This mechanism is the basis of the various radiation processes by free electrons, such as cyclotron/synchrotron radiation, Thomson/Compton scattering. The most interesting aspect of this finding is that vortex photons can be produced naturally in various situations in laboratories and in nature, such as in nuclear fusion plasma, in particle accelerators, in stellar magnetospheres and so on. Moreover, it implies that laboratorial vortex photon sources can be realized in the entire wavelength range, from radio-waves to gamma-rays based on these processes. As an example, we show that vortex gamma-rays, which carry orbital angular momentum, can be produced by non-linear inverse Compton scattering of intense circularly polarized laser by relativistic electrons.