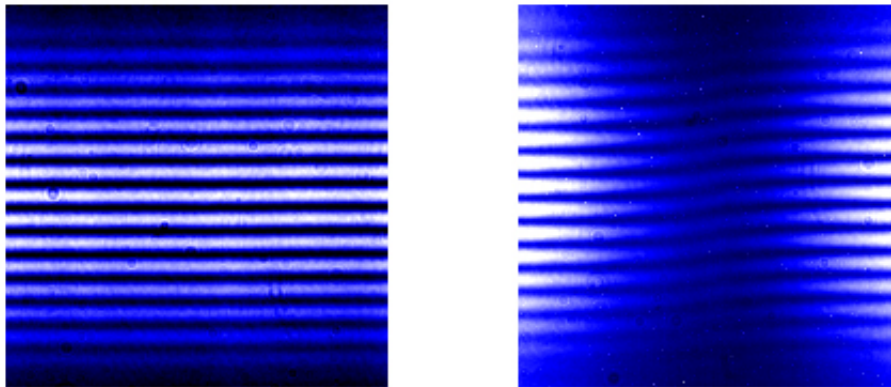


# Vortex photons from electrons in circular motion

July 21 2017

---



UV radiation from a relativistic electron beam is diffracted by a double-slit. In contrast to the normal light (left), the diffraction shows a deformation in the central part (right), indicating the existence of the phase singularity, which is a definite evidence of the vortex nature. Credit: Institute For Molecular Science

Researchers at IMS and their coworkers have shown theoretically and experimentally that a high energy electron in circular/spiral motion radiates vortex photons from the radio wavelength to gamma rays. This greatly broadens application spectra of the vortex photons in the field of physical science. Moreover, the finding indicates that vortex photons are ubiquitous in the universe. It paves the way to a completely new research field: natural vortex photon science.

Light is sometimes called an electromagnetic wave, in which electric and magnetic fields are oscillating and the oscillations propagate in space. Normally, light has a plane wave front. In contrast, an optical vortex possesses a helical wave front and carries orbital angular momentum. Existence of such peculiar photons was theoretically predicted about 25 years ago. Today, such photons can be readily produced in laboratories by using special optical devices, although the wavelengths are limited in the vicinity of visible light. Researchers are exploring their applications in nanotechnology, imaging and information/communication technologies. On the other hand, a natural elementary process capable of producing vortex photons has not been found, though there are a few theoretical proposals that normal photons may be converted to vortex photons in a strong gravitational field around a rotating black hole or as passing through inhomogeneous interstellar media.

About 10 years ago, researchers theoretically predicted that an undulator, a device widely used in modern synchrotron light sources, could be capable of producing vortex photons in the X-ray range. This was experimentally confirmed several years later at a German synchrotron. However, a majority of significant characteristics of optical vortex generation has remained unverified. Researchers at IMS and their coworkers theoretically investigated this process and have shown that an electron in circular or spiral motion radiates vortex photons. This process is the basis of various important radiation processes in astrophysics and plasma physics, such as cyclotron radiation, synchrotron radiation and Compton scattering, and has been described in many textbooks or research papers. However, there has been no discussion on the vortex nature of this radiation. The wavelength of this radiation extends from radio wave to [gamma rays](#), depending on the physical condition. This new finding indicates that [vortex](#) photons are produced in various situations in the universe, in the entire wavelength range.

Furthermore, the researchers at IMS and their coworkers succeeded in a

precise experimental observation of the undulator [radiation](#) from a [synchrotron light source](#), UVSOR-III, for the first time (Figure). They observed the UV [light](#) emitted from an electron beam in spiral motion, and indicated that a special structure called a phase singularity exists in the center of the [photon](#) beam from the undulator. Moreover, higher energy photons have been shown to carry larger angular momenta. These measurements definitely support the theoretical prediction.

Professor Masahiro Katoh (IMS) says, "Vortex photons should be ubiquitous in the universe. What kind of role do they play in nature? Our achievement opens up a totally new research field."

The research is published in *Scientific Reports*.

**More information:** "Angular Momentum of Twisted Radiation from an Electron in Spiral Motion", *Physical Review Letters*, 2017.

"Helical Phase Structure of Radiation from an Electron in Circular Motion", *Scientific Reports*, 2017.

Provided by National Institutes of Natural Sciences

Citation: Vortex photons from electrons in circular motion (2017, July 21) retrieved 10 April 2024 from <https://phys.org/news/2017-07-vortex-photons-electrons-circular-motion.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.