varied with direction. They were 372±9 zeptonewton (zN = 10^{-21} N), 347±14 zN and 808±42 zN, corresponding to a factor of 24×, 87× and 21× beyond the quantum limit in the *x*, *y* and *z* directions, respectively. More importantly, this force measurement based on super-resolution imaging does not have a fundamental lower frequency limit to detection. It can be applied for sensing d.c. or low-frequency forces external to the trap or internally from a co-trapped biomolecule or nanoparticle.

The next ICO congress will be held in Dresden, Germany in 2020. ❐

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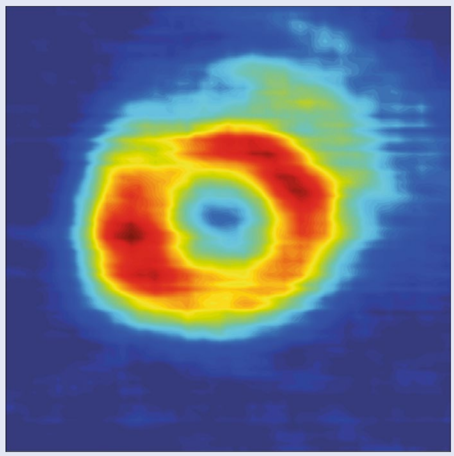
FREE-ELECTRON LASERS

Ultraviolet twist

Optical vortices, light beams that carry orbital angular momentum (OAM) thanks to a twisted phase front and exhibit a characteristic doughnut-shaped intensity profile, have been a cause of considerable scientific interest in recent years. Visible and infrared vortex beams, for example, have a myriad of potential applications in optical communications, super-resolution imaging and particle manipulation.

However, to date, the generation of vortices in the extreme-ultraviolet (XUV) or X-ray spectral regions has proved to be difficult. Now, a team of scientists from Italy and Switzerland has proposed and demonstrated two simple schemes that suit implementation at free-electron lasers (FELs) and thus allow generation of intense XUV vortices (P. R. Ribič et al., *Phys. Rev. X* 7, 031036; 2017).

Such XUV vortices are expected to provide opportunities for studying new phenomena in light–matter interactions including the violation of dipolar selection rules during photoionization, the production of skyrmionic defects in magnetic materials and the development of new materials characterization techniques based on OAM dichroism.



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In the first scheme, nonlinear harmonic generation is used to produce a vortex beam (pictured) in the second harmonic (15.6 nm wavelength) in an FEL with a helical undulator. The approach relies on interactions between an ultraviolet Gaussian seed beam and the electron beam within the FEL's six undulators, dispersive section and a chain of radiators. The advantage of the approach is that it does not require any additional optical elements to be placed into the FEL beam path, apart from a zirconium filter at the output to block the fundamental FEL beam.

In the second approach, a spiral zone plate (340-nm-thick silicon membrane etched with a spiral pattern) is introduced into the FEL beam path to imprint a helical phase onto the FEL beam, thus generating a focused XUV vortex. Vortices with different amounts of topological charge (a quantized amount of twist) can be generated by using spiral zone plates with different patterns. The approach allows the generation of intense XUV vortices with a peak intensity approaching 10^{14} W cm^{-2}.

The team says that in principle both schemes could also be applied to generate vortex beams in the soft and hard X-ray spectral regions.

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