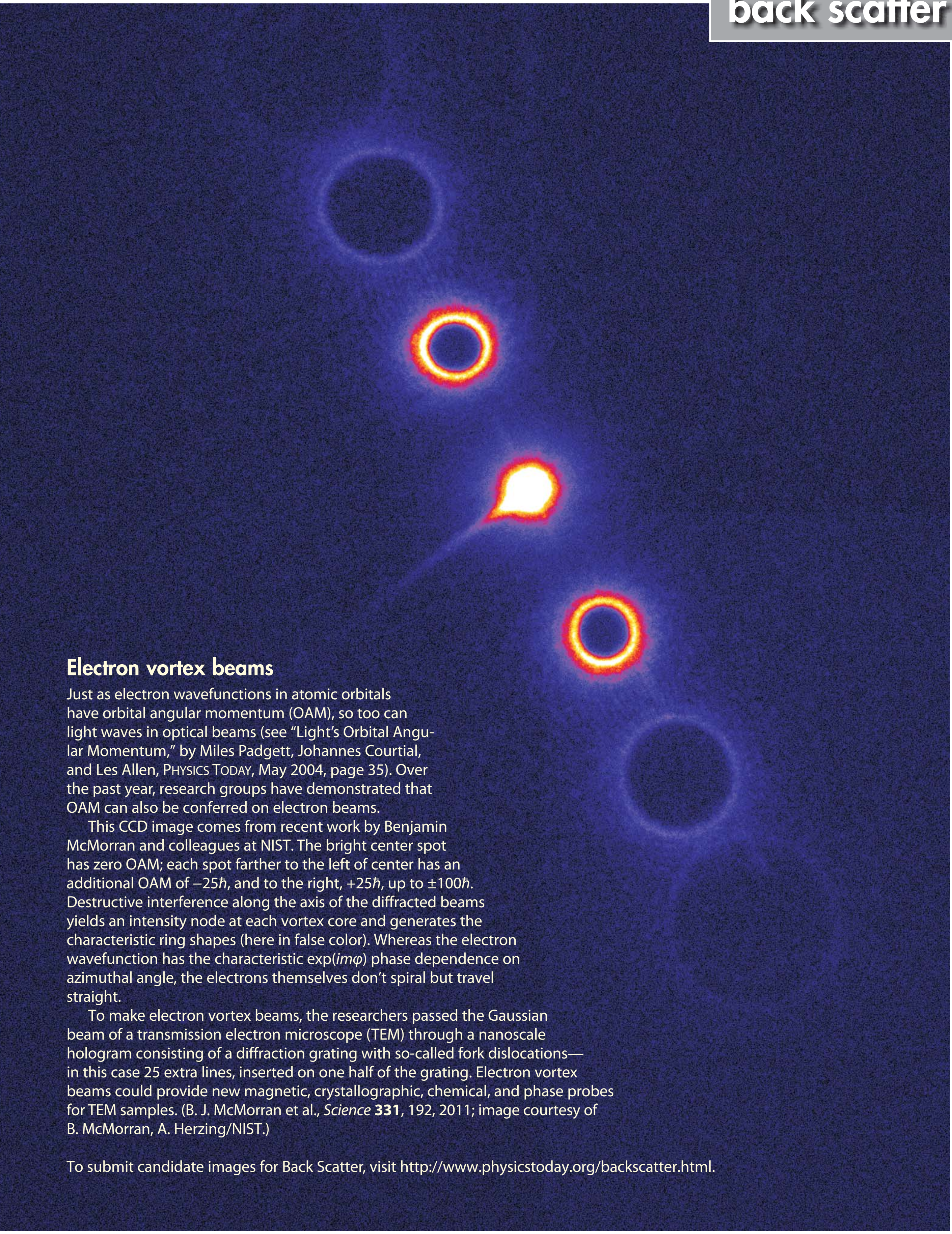

## Electron vortex beams

Just as electron wavefunctions in atomic orbitals have orbital angular momentum (OAM), so too can light waves in optical beams (see "Light's Orbital Angular Momentum," by Miles Padgett, Johannes Courtial, and Les Allen, PHYSICS TODAY, May 2004, page 35). Over the past year, research groups have demonstrated that OAM can also be conferred on electron beams.

This CCD image comes from recent work by Benjamin McMorran and colleagues at NIST. The bright center spot has zero OAM; each spot farther to the left of center has an additional OAM of $-25\hbar$, and to the right, $+25\hbar$, up to $\pm 100\hbar$. Destructive interference along the axis of the diffracted beams yields an intensity node at each vortex core and generates the characteristic ring shapes (here in false color). Whereas the electron wavefunction has the characteristic $\exp(im\varphi)$ phase dependence on azimuthal angle, the electrons themselves don't spiral but travel straight.

To make electron vortex beams, the researchers passed the Gaussian beam of a transmission electron microscope (TEM) through a nanoscale hologram consisting of a diffraction grating with so-called fork dislocations—in this case 25 extra lines, inserted on one half of the grating. Electron vortex beams could provide new magnetic, crystallographic, chemical, and phase probes for TEM samples. (B. J. McMorran et al., *Science* **331**, 192, 2011; image courtesy of B. McMorran, A. Herzing/NIST.)

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