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Sharper X-ray vision through aberration-corrected optics

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The high brilliance of modern synchrotron radiation and X-ray free-electron laser sources allows studying the structure and dynamics of matter on relevant lengths and time scales. Creating small and intense X-ray beams is crucial to confine the beam and concentrate the radiation onto the sample. Ideally, this would require diffraction-limited X-ray optics with high numerical aperture (NA) that are also stable in the intense X-ray beam of current and future facilities. While the short X-ray wavelength allows creating foci down to a few nanometers and below in theory, it is this short wavelength that puts stringent requirements on X-ray optics and their metrology. Both are limited by today's technology.
To overcome this barrier a corrective phase plate can be employed that rectifies any aberrations if wavefront errors are known in detail. Here, I'll show the at wavelength measurement of aberrations in beryllium compound refractive lenses using ptychography and present their elimination by tailor-made corrective phase plates based on these data. The optical system composed of the original lens and the phase plate achieves diffraction-limited performance with high NA. The approach is not only limited to refractive optics, but can correct diffractive and reflective optics beyond current manufacturing limitations as well. In addition, also existing optical systems can be upgraded due to the compact size and easy implementation of the phase plate.

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