Team creates a curved waveguide able to significantly bend X-ray beams

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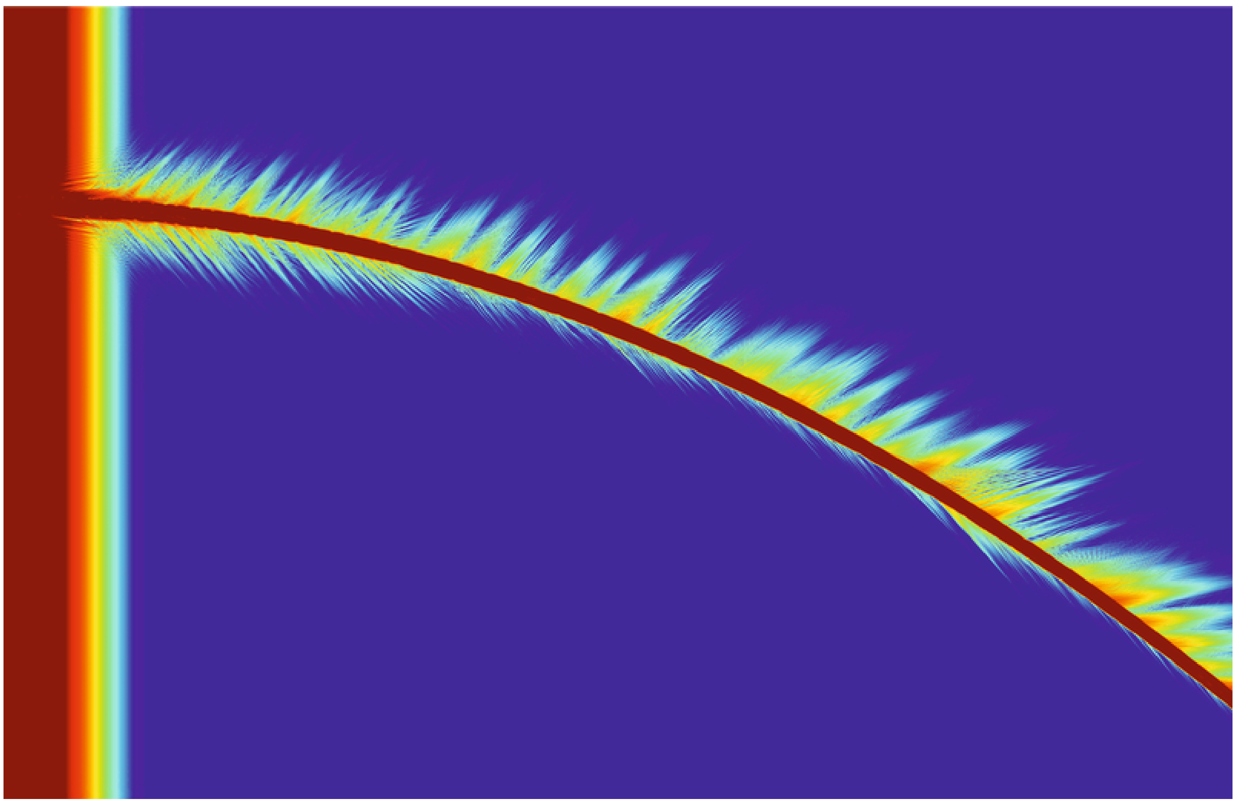

Curvy x-ray vision. In the new waveguide, most of the x-ray radiation follows the curved path (dark red), but a small amount leaks into the surrounding material, as shown in this computer simulation. Credit: *Physics* / T. Salditt et al., *Phys. Rev. Lett.* (2015)

(Phys.org)—A team of researchers working in Germany and France has demonstrated a way to bend X-ray beams using curved wave guides. In their paper published in *Physical Review Letters*, the team describes how they created the wave guides, the parameters they used in creating them and the results of their testing.

Light can be used to send signals through a fiber cable because the indices of refraction of air and glass are so different—light inside a fiber cable is reflected back into the hollow tunnel as turns are encountered. This is not the case for X-rays, however, because the index of refraction for it in solid materials is just a little bit less than for that of air. Subsequently, X-ray devices are typically extremely straight-lined. Now, the researchers with this new effort report that they have found a way to bend X-ray beams, possibly paving the way for their use in a wide variety of applications.

The key to bending X-ray beams, the team reports, is in sending them through a sufficiently narrow channel—narrow enough to limit the beam's maximum angle of deflection. Also, the device used to create the beam must be extremely precise.

To test their ideas, they created wave guides by etching 100nm wide curved channels onto 5x5mm squares of tantalum, which they then fired X-rays through. Their first runs involved radii curvatures of 10 to 80 mm with beams sent at Hamburg's DESY laboratory. In so doing, they found they were able to bend X-rays at up to 18 degrees. Emboldened, they etched more waveguides with channel radii curvatures of 1–30 mm and then tested them by firing X-rays through them at the European Synchrotron Radiation Facility in France. This time they were able to bend the beams to 30 degrees. Not all of the X-rays in the beam that are sent make it through the channel, of course, some are absorbed or tunnel their way through the metal—but, the team reports, enough makes it through for the waveguides to be useful in devices such as interferometers or other high-resolution applications.

The team plans to continue their work with the waveguides, confident that they can lessen leakage by using different materials, and possibly covering the channel. They suggest it might be possible to bend X-rays to even higher angles, from 90 to perhaps 180 degrees.

More information: X-Ray Optics on a Chip: Guiding X Rays in Curved Channels, *Phys. Rev. Lett.* 115, 203902 – Published 9 November 2015. dx.doi.org/10.1103/PhysRevLett.115.203902

ABSTRACT
We study the propagation of hard x rays in single curved x-ray waveguide channels and observe waveguide effects down to surprisingly small radii of curvature R≃10 mm and a large contour length s≃5 mm, deflecting beams up to 30°. At these high angles, about 2 orders of magnitude above the critical angle of total reflection θc, most radiation modes are lost by "leaking" into the cladding, while certain "survivor" modes persist. This may open up a new form of integrated x-ray optics "on a chip," requiring curvatures mostly well below the extreme values studied here, e.g., to split and to delay x-ray pulses.