Enhanced translation of x-rays by a Berry-phase effect

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In x-ray optics, it is useful to consider geometrical optics to describe a beam trajectory. Usually bending of an x-ray trajectory is due to refraction that a propagating direction perpendicular to its wave front, as shown in Fig. 1(a). Here we reveal an anomalous behavior of x-rays, distinct from the refraction phenomenon, as an enhanced beam translation \cite{1, 2}, as represented in Fig. 1(b). We demonstrate experimentally an x-ray beam translation over millimeter distances in a deformed silicon crystal \cite{2}. This enhanced translation is a consequence of the Berry-phase effect in generalized geometrical optics, which enables interplay between the gap in the dispersion in momentum space and the atomic displacements in real space \cite{1}. Such interplay in phase space enhances the beam translation by some 5 orders of magnitude, leading to the macroscopic effect.

Figure 1. Schematic pictures of two kinds of beam bending, (a) refraction and (b) translation. At the sample edge, a difference between them is most evident in an exiting direction of the wavepacket. The face orientation, normal to the wavefront of the wavepacket, is represented for intuitive understanding.

References