Negative Refraction : an Intrinsic Property of Uniaxial Crystals

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Negative refraction (NR) is a phenomenon where light is refracted to propagate along the same side as the incident light with respect to the normal of the interface, contrary to the normal light refractions. It can be used to realize the "superlense" with a resolution smaller than the wavelength and many other optic applications. Recently, NR has been realized in metamaterials, photonic crystals and traditional crystals. Although the wave vector k does not form a left-handed triplet with the electric field E and magnetic filed H for the light in conventional crystals, the light can be bent on the same side with the incident light. We theoretically and experimentally show that negative refraction can be realized at the surface of uniaxial crystals by orientating the crystals with their optic axes at a certain angle θ_0 to the normal of the light incoming surface. The concept of negative refraction can be extended to be an intrinsic property of all uinaxial crystals. That is, NR can be realized in all the uniaxial crystals including with the tetragonal, hexagonal and trigonal symmetries. It is revealed that the angular range for incident light to yield negative refraction attains its maximum that only depends on the difference of two indices of refraction |ne-no| when $\tan^2\theta_0$=n0/ne. The maximum refracted angle is dependent on the ratio ne/no. The careful experiments on positive uniaxial crystal YVO_4 and negative unaxial crystal calcite ($CaCO_3$)give results in good agreement with the calculated ones.

Keywords: crystal structure properties, optical crystallography, refractive index