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Discovery of ambiguity in the traditional definitions of angle of diffraction and glancing angle

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ABSTRACT

This paper reports on the discovery of ambiguity in the traditional definitions of the 'Angle of diffraction' in Physical/Wave optics and 'Glancing angle' in X-ray crystallography. Just like the 2005 discovery by the author regarding the ambiguity in the traditional definitions of angles of incidence, reflection and refraction, the traditional definitions of the aforesaid two angles have also been found to be ambiguous. The long-running definition of angle of diffraction in Physical/Wave optics does not have any parity with the definitions of angles of incidence, reflection, and refraction in Geometrical optics, in each of which the direction of the positive unit normal to the reflecting surface (surface of discontinuity) at the point of incidence is one of the two directions to be considered in defining the angle. Similarly the traditional definition of the Glancing/Grazing angle in X-ray crystallography is in conflict with the fundamental definition of angle in geometry. With a view to getting rid of the ambiguity present in the traditional definitions of 'Angle of diffraction' and 'Glancing/Grazing angle', as well as to enhance and sophisticate the relevant field of study, unambiguous definitions of both these two angles have been offered in this paper.

1. Introduction

An examination of the traditional definitions of angles of incidence, reflection, and refraction in Geometrical optics has been made by the author in [2]. It has been found that the traditional definitions of those three angles in Geometrical optics do not have any compliance with the fundamental definition of angle in Geometry [1] and hence they have been reported to be ambiguous in [2]. To get rid of the ambiguity present in the traditional definitions of those three angles in Geometrical optics, unambiguous definition of each of the aforesaid three angles has also been reported in [2–4].

As a subsequent follow up, this paper considers the traditional definitions of 'Angle of diffraction' in Physical/Wave optics and 'Glancing/Grazing angle' in X-ray crystallography. An examination of the long-running definition of angle of diffraction in Physical/Wave optics reveals that the traditional definition of angle of diffraction does not have any compliance with the definitions of angles of incidence, reflection and refraction in Geometrical optics [5,6]. The angle of diffraction as per traditional literature appears to be the angle of deviation due to diffraction in compliance with the definition of angle of deviation due to reflection or refraction in Geometrical optics. Thus there exists ambiguity in the traditional concept/definition of 'Angle of diffraction' in Physical/Wave optics. Furthermore it has been found that the traditional definition of 'Glancing angle' [7,8], or the 'Grazing angle' [9] in X-ray crystallography is not in conformity with the fundamental definition of angle

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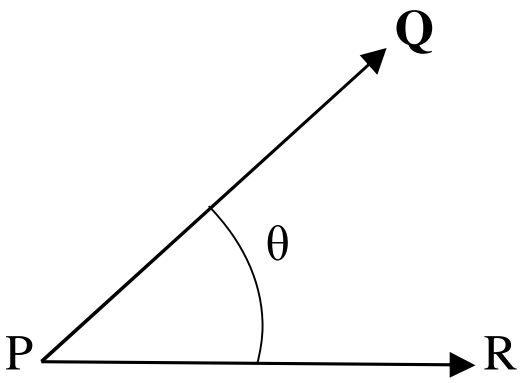

Fig. 1. Diagram showing the formation of the angle θ.

in Geometry [1]. Hence the long-used definition of the 'Glancing angle' or 'Grazing angle' is also ambiguous. In order to get rid of the ambiguity present in the long-running concept of 'Angle of diffraction' and 'Glancing/Grazing angle' in the traditional literature as well as to sophisticate the relevant field of study, unambiguous definitions of both the aforesaid two angles have been offered in this paper. Comparative study between the two forms of Bragg's relation, the first one involving the traditional glancing angle and the second one involving the unambiguous glancing angle reveals that, the two forms of the said relation though apparently different ultimately correspond to the same identical relation. The unambiguous concept of the angle of diffraction has been applied to derive the expression for the angular dispersive power of a plane diffraction grating. The two expressions for the angular dispersive power, the first one involving the ambiguous traditional angle of diffraction and the second one involving the unambiguous angle of diffraction have been found to be in conflict. Considering a typical example for a plane diffraction grating, a graphical comparison between them has been finally dealt with.

2. Definitions

2.1. Fundamental definition of angle in geometry

An angle [1] is a figure formed by two rays with the same initial point.Thus an angle can be defined only between two directions. If **PQ** and **PR** are two rays with two directions, then by angle QPR we normally mean the smaller of the angles between those two directions. Thus in Fig. 1, angle QPR = θ.

2.2. Refined unambiguous definitions of angles of incidence, reflection and refraction

In order to enhance readability of the paper, the following definitions of refined unambiguous angles of incidence, reflection and refraction existing in [3,4] are being reproduced below.

2.2.1. Refined unambiguous angle of incidence (i)

The angle of incidence (i) is the smaller of the angles between the vectors **i** and **n** subject to the condition that $\pi/2 < i \leq \pi$, so long as the case considered is a reflection (or a refraction of light as it passes from a rarer to a denser medium). If however it is a case of refraction as light passes from a denser medium to a rarer medium, the angle i must be bounded by the relation $0 \leq i < \pi/2$.

2.2.2. Refined unambiguous angle of reflection (r)

The angle of reflection (r) is the smaller of the angles between the vectors **r** and **n** subject to the condition that $0 \leq r < \pi/2$.

2.2.3. Refined unambiguous angle of refraction (R)

The angle of refraction (R) is the smaller of the angles between the vectors **n** and **R** subject to the condition that, $\pi/2 < R \leq \pi$ when the ray of light passes from a rarer medium to a denser medium, or $0 \leq R < \pi/2$ when the ray of light passes from a denser medium to a rarer medium.

2.3. The traditional angle of diffraction

As shown in Fig. 2A , the angle AOB = θ, is defined as the angle of diffraction in the traditional literature. Such a definition of the angle of diffraction is ambiguous on account of the following reasons.