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Brewster's law in the light of the refined unambiguous angles of incidence, reflection, and refraction

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ABSTRACT

This paper reports on the discovery of ambiguity in the traditional definition of the Polarizing angle (also called the Brewster's angle) as well as that in the traditional Brewster's law, since both of them are based on the long-running concepts of angles of incidence, reflection, and refraction, each of which has been reported to be ambiguous in 2005 by the author. With the incorporation of the refined unambiguous angles of incidence, reflection, and refraction, reported by the author in 2015, unambiguous definition of the Polarizing angle (or the Brewster's angle) as well as the unambiguous statement of the Brewster's law have been offered along with the accomplishment of relevant proof.

1. Introduction

Consequent upon the launching of the new world of geometrical optics [1], which basically works on the refined unambiguous angles of incidence, reflection and refraction, it is essential to rethink about immediate replacements of the laws and theoretical discussions or derivations of the traditional optical physics which are based on the traditional ambiguous angles of incidence, reflection, and refraction with incorporation of the refined unambiguous angles of incidence, reflection, and refraction [1] to bring preciseness and sophistication in the relevant field of study so as to enhance the relevant literature as well. With that point in mind, the author considered first the deviation problems in ray optics in [8] to obtain novel results. Novel interesting results have also been reported in [9] in regard to the dispersive power of a prism.

This paper is concerned with the traditional definition of the Polarizing angle (or the Brewster's angle) and the traditional Brewster's law [2–6] of Physical optics. It has been observed that both of them are based on the traditional concepts of angles of incidence, reflection, and refraction, each of which has already been reported to be ambiguous in [7]. As a result, both the traditional definition of the Polarizing angle (or the Brewster's angle) and the traditional Brewster's law are ambiguous as well. To get rid of such ambiguity, both the traditional definition of the Polarizing angle (or the Brewster's angle) and the traditional Brewster's law have been modified with incorporation of the refined unambiguous angles of incidence, reflection, and refraction to give birth to the definition of unambiguous Polarizing angle (or unambiguous Brewster's angle) as well as the unambiguous statement of Brewster's law along with accomplishment of relevant theoretical proof.

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2. Definitions

In this section, the definition of the traditional Polarizing angle (or the Brewster's angle) has been offered first. Thereafter from the view point of readability, the definitions of refined unambiguous angles of incidence, reflection, and refraction have been reproduced from the earlier work [1] of the author.

2.1. Polarizing angle or Brewster's angle

The particular value (say, φ) of the angle of incidence (other than 0^0) for which the reflected ray and the refracted ray are at right angles to each other, thereby rendering the extent of polarization of light reflected from the surface of a transparent material a maximum, is known as the Polarizing angle (or the Brewster's angle) for the transparent material used.

It may be noted that the aforesaid traditional definition of the Polarizing angle (or the Brewster's angle) is based on the traditional definition of angle of incidence, which has been reported to be ambiguous in [7]. As a result, the traditional definition of the Polarizing angle (or the Brewster's angle) stands ambiguous and needs unambiguous replacement with incorporation of the refined unambiguous angle of incidence [1].

From the view point of clarity and readability of presentation, only the term 'Brewster's angle' will be used throughout in the subsequent discussion.

2.2. 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 $0 \leq i < \pi/2$.

2.3. 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 $0 \leq r < \pi/2$.

2.4. 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.

3. The traditional Brewster's law

The Scottish physicist Sir David Brewster, from a series of experiments conducted with various transparent reflectors discovered a law, known as Brewster's law [2–6] in 1811, which can be stated in any one of the two forms (i) and (ii) as follows.

(i) If a ray of light is incident on the surface of a transparent material at an angle of incidence equal to the Brewster's angle (φ), then $\mu = \tan\varphi$, where μ is the refractive index of the transparent material with respect to the surrounding medium.
(ii) If a ray of light is incident on the surface of a transparent material at an angle of incidence equal to the Brewster's angle (φ), then the reflected ray and the refracted ray are at right angles to each other.

It may be noted that derivation of each of the aforesaid forms, viz. (i) and (ii) of the traditional Brewster's law is available in standard texts like [6].

Now, it would be worth mentioning here that the traditional Brewster's law and its derivation are based on the long-running definitions of angles of incidence, reflection, and refraction, each of which has been reported to be ambiguous in [7]. As a result, the traditional Brewster's law also appears to be ambiguous and needs unambiguous replacement with incorporation of the refined unambiguous angles of incidence, reflection, and refraction [1].

4. The unambiguous statement of Brewster's law on the basis of the refined unambiguous angles of incidence, reflection, and refraction

In order to get rid of the ambiguity in the traditional statement of Brewster's law, this section considers incorporation of the refined unambiguous angles of incidence, reflection, and refraction [1]. The definition of the unambiguous Brewster's angle has been offered first. Thereafter the unambiguous statement of Brewster's law has been provided along with incorporation of proof.