Journal of Applied Mathematics and Physics, 2017, 5, 1537-1539
http://www.scirp.org/journal/jamp
ISSN Online: 2327-4379
ISSN Print: 2327-4352

Erratum to "The Faraday Isolator, Detailed Balance and the Second Law" [Journal of Applied Mathematics and Physics, Vol. 5, No. 4, April 2017 PP. 889-899]

George S. Levy

Entropic Power, 130 Rockview Irvine, CA 92612, USA
Email: glevy@entropicpower.com

How to cite this paper: Levy, G.S. (2017) Erratum to "The Faraday Isolator, Detailed Balance and the Second Law" [Journal of Applied Mathematics and Physics, Vol. 5, No. 4, April 2017 PP. 889-899]. *Journal of Applied Mathematics and Physics*, **5**, 1537-1539.
https://doi.org/10.4236/jamp.2017.58127

Received: July 31, 2017
Accepted: August 21, 2017
Published: August 25, 2017

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The original online version of this article (Levy, G.S. (2017) The Faraday Isolator, Detailed Balance and the Second Law. *Journal of Applied Mathematics and Physics*, **5**, 889-899. doi: https://doi.org/10.4236/jamp.2017.54078.) erroneously assumes that in a Faraday isolator, thermal radiation from a black body/polarizer combination entering the rotator is polarized and therefore can be acted upon by the rotator, resulting in the rectification of heat flow. In fact, this thermal radiation is *unpolarized rendering the rotator inoperative*. Hence a Faraday isolator cannot rectify thermal radiation. The author wishes to correct the error in this article.

A Faraday isolator comprises a Faraday rotator inserted between two polarizers oriented from each other by a polarization angle of 45 degrees. Radiation entering through the input, is polarized by the input polarizer, rotated by 45 degrees by the rotator and crosses the output polarizer. Radiation entering through the output is polarized by the output polarizer, is rotated an additional 45 degrees and is stopped by the input polarizer. Hence a Faraday operates as a light valve. Thermal radiation however, needs to be treated differently because polarizers contribute their own thermal radiations. The author erroneously assumes that this radiation is unpolarized.

The article considers a Faraday isolator inserted between two black bodies. Thermal radiation conjointly produced by a black body and a polarizer enters the rotator on each of its sides. The contribution from the black body is polarized in the plane of polarization of the polarizer. Remarkably, thermal radiation contributed by the polarizer is polarized perpendicularly to this plane in accordance with Kirchoff's law of radiation. The original version of the law states that emissivity and absorptivity are the same for all angles and wavelengths. Transmissive polarization can be viewed as selective absorption that depends on the polarization angle. Even though the law does not specifically mention polarization angle, it is believed that a polarizer's thermal radiation is polarized along the maximum absorption axis, perpendicularly to the plane of polarization. The combined blackbody/polarizer radiation is therefore unpolarized rendering the rotator ineffective. The Faraday isolator does not function and does not rectify heat flow.

The foregoing analysis shows that the radiation from a black body and polarizer is unpolarized. The polarizer is first assumed to be nicol-based, with absorbing side surfaces. The result of the analysis is also assumed to hold for a film-based polarizer. Consider the nicol-based polarizer in Figure 1.

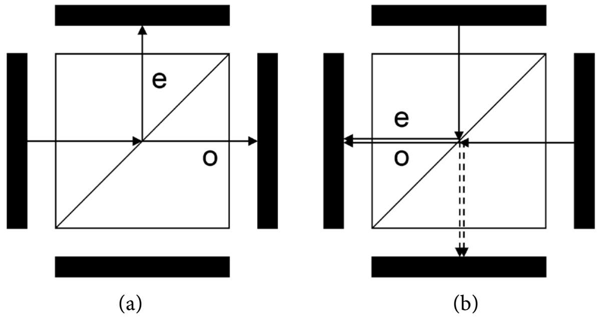

Figure 1. (a) In a nicol-based polarizer with absorbing sides, thermal emission from a black body is split into an ordinary ray and an extraordinary ray by a nicol prism; (b) in a symmetrical arrangement in thermal equilibrium, the output from the nicol is unpolarized as it includes an ordinary ray and an extraordinary ray.

As shown in (a) the ordinary rays go through the nicol but the extraordinary rays are reflected toward the absorbing side surfaces. In thermal equilibrium (b), all surfaces are at the same temperature, each surface receiving an ordinary ray from an opposite surface and an extraordinary ray from a side surface. The combination of ordinary ray and extraordinary ray is unpolarized.

The polarizer shall now be assumed to be nicol-based with reflecting side surfaces as shown in Figure 2.

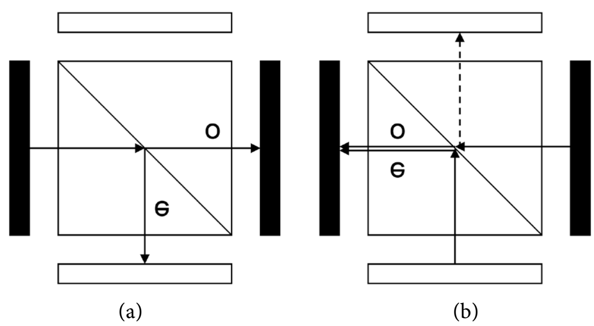

Figure 2. (a) In a nicol-based polarizer with reflecting sides, thermal emission from a black body is split into an ordinary ray and an extraordinary ray by a nicol prism; (b) the radiation received by a black body includes an ordinary ray from the opposite black body and an extraordinary ray reflected from itself. The combined radiation is unpolarized.

In thermal equilibrium, the black body on either side of the nicol receives an ordinary ray transmitted through the nicol from the opposite black body. Each black body also receives an extraordinary ray that originates from itself and is reflected by the polarizer. Therefore, the combined radiation received by each black body is unpolarized. This last point is of academic interest only as nicol-based polarizers with reflective side surfaces cannot be used to build a Faraday isolator as they fail to support unidirectionality. As already discussed in the article, the forward ray traverses the isolator in the forward direction. However, the reverse ray is reflected three times, crossing the rotator twice. Overall, the reverse ray traverses the isolator in the reverse direction thereby failing to support the unidirectionality of the isolator.

In summary, thermal radiation from a black body seen through a polarizer is unpolarized. This radiation cannot be acted upon by a rotator. A Faraday isolator in thermal equilibrium with black bodies at its input and output cannot operate on their thermal radiation.

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