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# Calculation of Luminance between delta wavelengths depending on temperature in different bands

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# حساب الانبعاثية الضوئية بين فرق من الأطوال الموجية اعتمادا على درجة الحرارة ولحزم مختلفة

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**الخلاصة**

في هذا العمل تم استخدام النظرية الكلاسيكية لإشعاع الجسم الأسود، والتحليل الإحصائي لتحديد المزايا النسبية لحزمه واحدة او حزمتين للحصول على بيانات التتبع. نقوم بحساب عدد الفوتونات وقيم الانبعاثية الضوئية لاطوال موجية مختلفة تحت درجة حرارة مختلفة . وبالتحليل الرياضي نحسب الإشعاعية باستخدام قانون بلانك لايجاد الخطأ مع درجة الحرارة والطول الموجي لزمن تتبع مختلف و خصائص هندسية مختلفة . ويمكن التعبير عن العلاقة بين الطول الموجي وكثافة الإشعاع أحادي اللون للجسم الاسود بطريقة رياضية وبرسم هذه العلاقة عند درجات حرارة مختلفة. نستنتج أنه من خلال انشاء متجهيين الأول لفرق دلتا من الطول الموجي والثاني لنفس الطول الموجي ، فان حجم هذا المتجه الجديد الذي توزيعه بين البداية والنهاية الخطية يجب ان يكون بنفس حجم متجه درجة الحرارة. وان شكل منحنيات الكثافة الأحادية اللون يشبه شكل دالة توزيع ماكسويل. يمكن استخدام هذا الطريقة لاغراض المعايرة أو العثور على أي قيمة مفقودة من هذه العوامل.

## Abstract

In this work the classical blackbody radiation theory and a statistical analysis were used to determine the relative advantages of single-band and two-band data acquisition. We calculate the Number of photon and present the difference of luminance for two (or many) wavelength under different temperature at different bands. Mathematical analysis has been implemented by calculates the irradiance using Planks law to find the error with the temperature and the wavelength for different acquisition time and many geometry. The relationship between wavelength and monochromatic intensity of blackbody radiation is expressed in mathematical way. We plot monochromatic energy density of blackbody radiation at different temperatures as function of the wavelength. The relationship between wavelength and monochromatic intensity of blackbody radiation is expressed in mathematical way and by plotting this relation at different temperatures. We conclude that by created two vectors first on the delta wavelength and the second on the same wavelength, the

size of this new vector its distribution between the beginning and end of a linear must be absolutely the same size as the temperature vector. The shape of curves of monochromatic intensity is like the shape of distribution function of Maxwell. One can use this method for calibration or find any missing value of these factors.

## 1. Introduction

In this study mathematical analysis has been performed using planks law to find the error with the temperature and the wavelength for different acquisition time and many geometry, classical blackbody radiation theory, published atmospheric transmission data, and statistical analysis were used to determine the relative advantages of single-band and two-band data acquisition by calculates the exact irradiance according to Planck's law and from the reduced curves without neglecting the fundamental point of comparison between the wavelengths and fixed delta wavelength then our choice of determining the luminance according to wavelength and temperature integral method. For this we create two vectors first on the delta wavelength and the second on the same wavelength.

## 2. Modeling studies

Planck's law describes the spectral distribution of the radiation from black body the Radiant emission of an object that absorbs all incident radiation, is a perfect radiator. The energy emitted by a blackbody is the maximum theoretically possible for a given temperature. The radiative power (or number of photon emitted) and its wavelength distribution are given by the Planck radiation law [1].

$$W_\lambda = \frac{2\pi hc^2}{\lambda^5\left[\exp\left[\frac{hc}{\lambda kT}\right]-1\right]} \quad w/(cm^2.\mu m) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$W(\lambda,T) = \frac{2\pi c}{\lambda^4\left[\exp\left[\frac{hc}{\lambda kT}\right]-1\right]} \quad Photons/(s.cm^2.\mu m) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where: $\lambda$= wavelength (μm), T = temperature (K)

h = Planck's constant=$6.62617*10^{-34}$ (j.sec), c = velocity of light

k = Boltzmann's constant=$1.38054*10^{-23}$ (W.sec/K)

The latter is given by the Wien's displacement law which gives the peak of the spectural emittance curve by the following equation:

$$\boldsymbol{\lambda_m} = \frac{a}{T} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$\lambda_{mw}T$=2898 μm.K for maximum watts, $\lambda_{mp}T$=3670 μm.K for maximum photons, The changes of $W_\lambda$ with differential changes in T can be expressed as [2]:

$$\frac{\partial W}{\partial T} = \frac{C_1 C_2 . e^{C_2/\lambda T}}{\lambda^6 T^2 \left(e^{C_2/\lambda T - 1}\right)^2} \quad , \quad \frac{\partial W}{\partial T} = W_\lambda \frac{C_2 . e^{C_2/\lambda T}}{\lambda T^2 \left(e^{C_2/\lambda T - 1}\right)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

The well- known Stephan- Boltzmann law

$$W = \int_0^\infty W_\lambda d\lambda = \sigma . T^4 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Where (σ) is the Stephan- Boltzmann constant=5.67*$10^{-12}$ ($w/cm^{-2}.K^{-4}$)
The maximum value of spectral radiance emittance can be calculated by:

$W_{\lambda m} = BT^5 \ldots\ldots\ldots(6)$ Where B=12862*$10^{-15}$ ($W . cm^{-2}\ \mu^{-1}\ K^{-5}$)

We must define the Irradiance, when an object absorbs radiation; it warms up then, radiation "carries" energy. The amount of energy carried by the radiation is called the irradiance. It also represents the rate at which the energy is "delivered" by the wave and how "concentrated" the energy is. We need a term that is independent of time and area. That is why we are using the irradiance, which is the rate that energy passes through a certain cross-sectional area. Consequently, irradiance will have units of Joules per second per square meter; irradiance will have units of Watts per square meter (W/m2). The solar irradiance (the irradiance from the sun) is about 1367.6 W/m2 just outside the atmosphere. This value is known as the solar constant [3]. Emissivity (ε), the radiation from real sources is always less than that from a blackbody. It is a measure of how a real source compares with a blackbody. It is defined as the ratio of the radiant power emitted per area to the radiant power emitted by a blackbody per area. The directional spectral emissivity ε (θ,φ,λ,T) it is a wavelength and temperature dependent. If the emissivity does not vary with wavelength then the source is a “graybody” [4].

## 3. Results and discussion

As the self- emitted radiation is a function of the object's temperature, it is useful to inquire how $W_\lambda$ changes with differential changes in T. By calculate the exact irradiance according to Planck's law and from the reduced curves without neglecting the fundamental point of comparison between the wavelengths and fixed delta wavelength. For this we created two vectors first on the delta wavelength and the second on the same wavelength.

We choose two bands in the IR region. These bands are 3-5 µm and 8-12 µm we choose: - Tmin = 300 k, Tmax = 673 k, the increment of temperature Delta T = 20, Choice of center wavelength in microns Lambda = 0.5, Choice of value of increment of wavelength Delta Lambda = 0.01, the maxima of transmission on the center wavelength is 1 [5]. Figures (1, 4) show the relation between transmission and the vector of the wavelength is the same size as T. Figures (2,5) show the relation between luminance and wavelength and temperature. Figures (3,6) show the relation between luminance and the vector of wavelength and temperature.

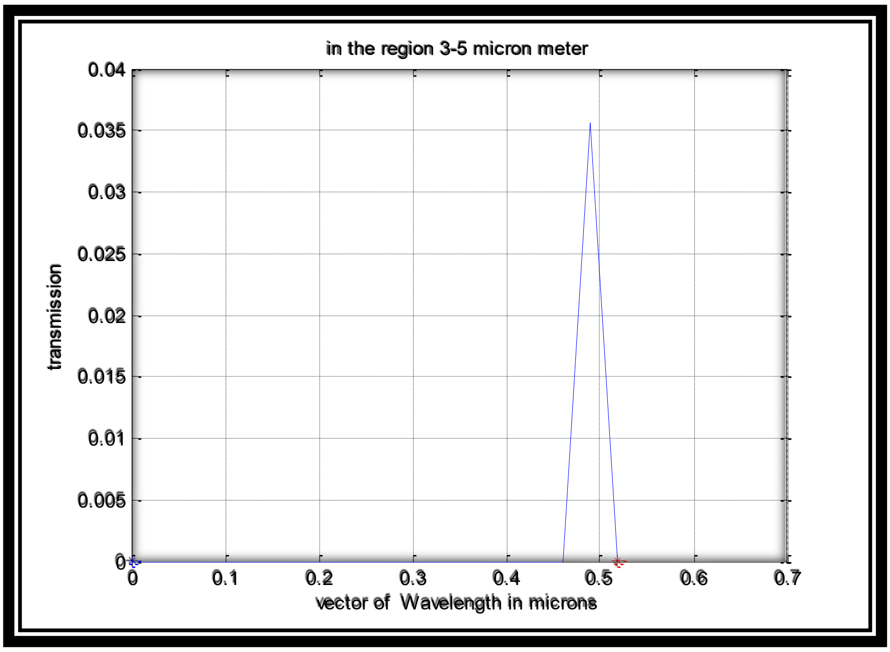


Figure (1):- the relation between transmission and the vector of the wavelength

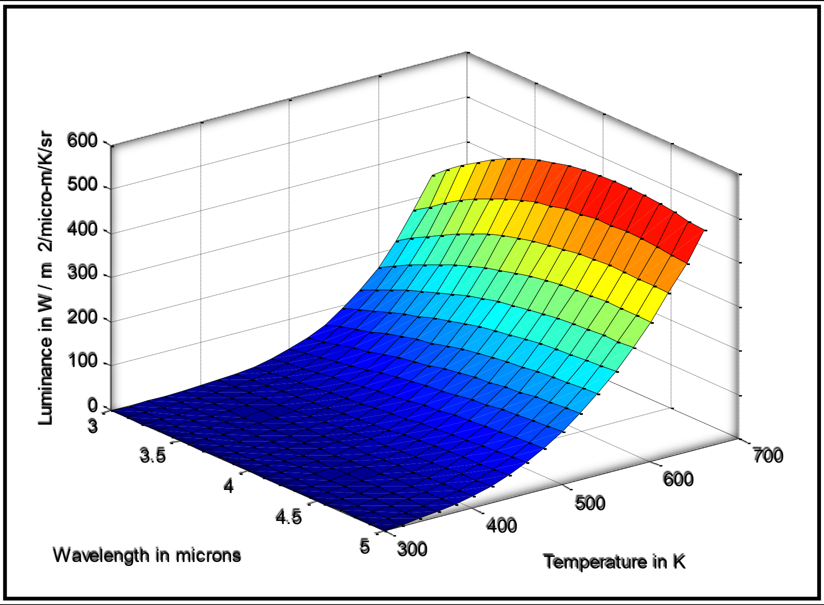


Figure (2):- the relation between luminance and wavelength and temperature.

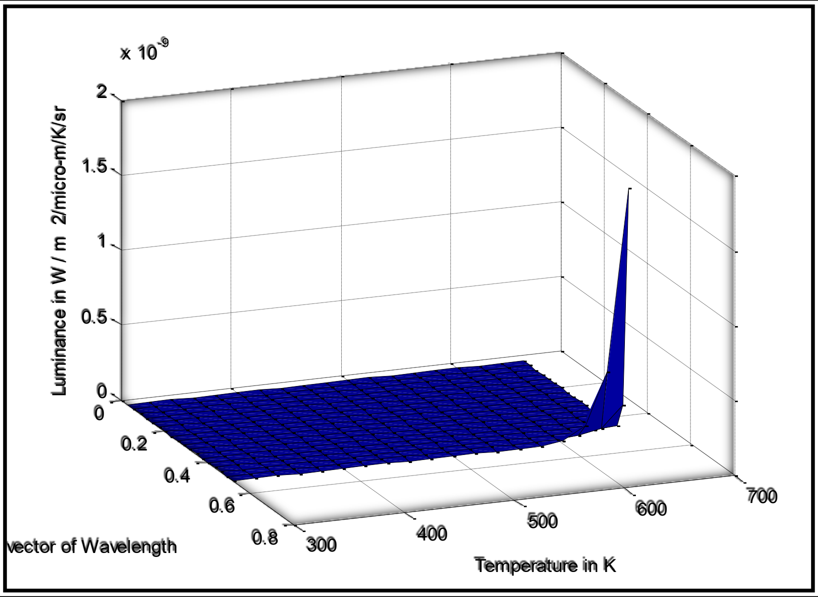


Figure (3):- the relation between luminance and the vector of wavelength and temperature.

In the region8-12 μm the figures: -

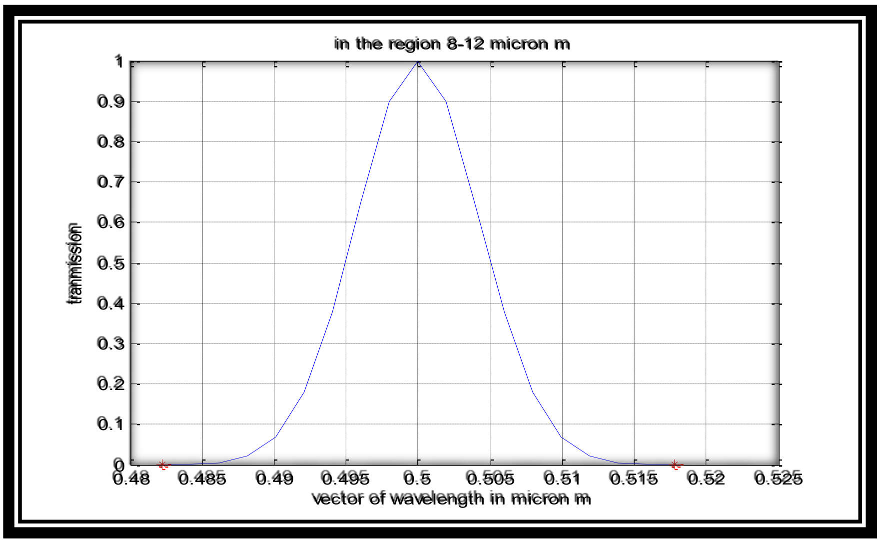


Figure (4):- the relation between transmission and the vector of the wavelength

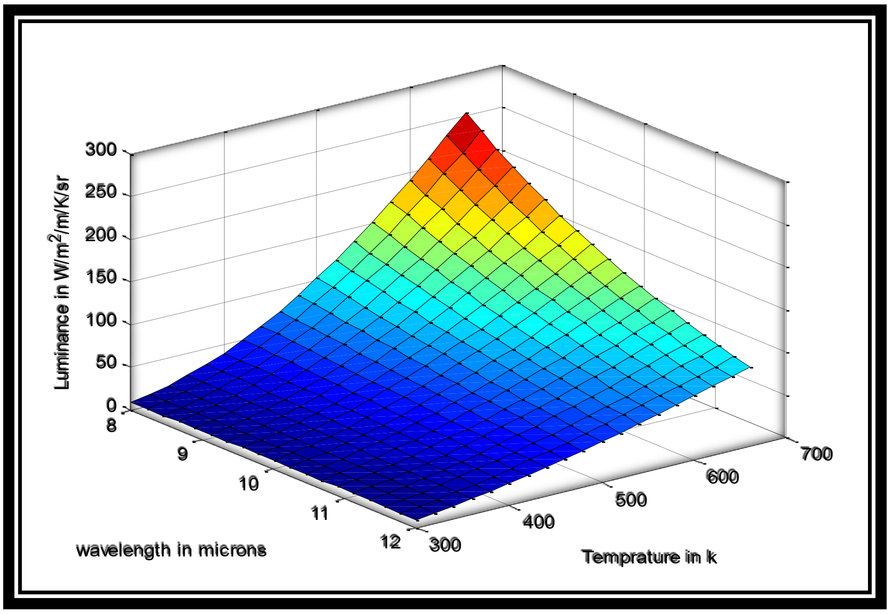


Figure (5):- the relation between luminance and wavelength and temperature.

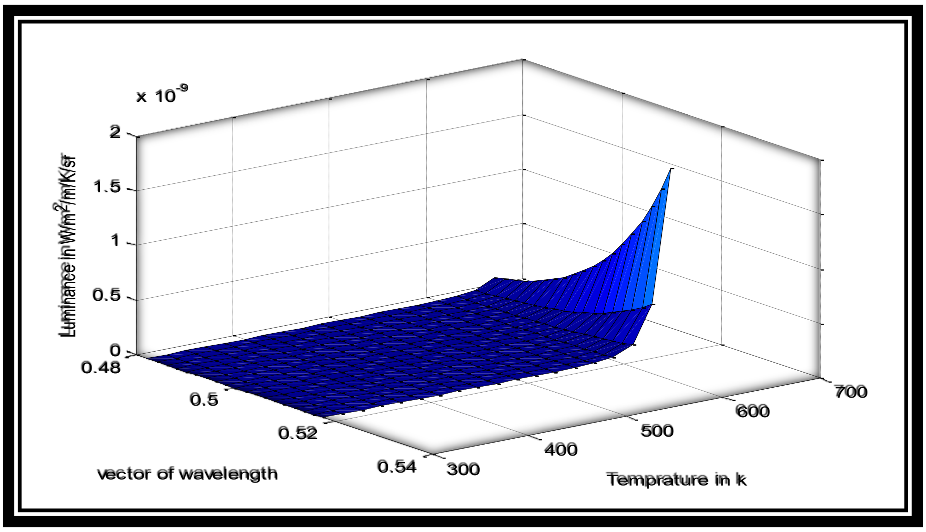


Figure (6):- the relation between luminance and the vector of wavelength and temperature.

We take any arbitrary region of wavelength for any value of temperature and plot the relation between luminance and wavelength and temperature. Let we have Tmin=773, Tmax=1673, the region of wavelength (1-20) μm.

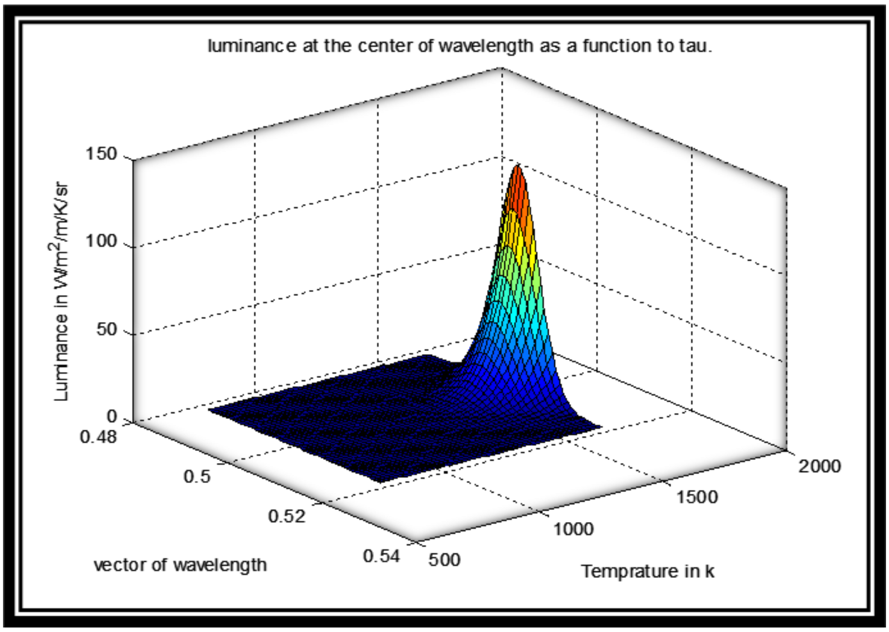


Figure (6):- the luminance at the center of wavelength a function to vector of wavelength and temperature.

Now to calculate the monochromatic energy density function [6]: - for any arbitrary value of temperature we plot the energy density function as function to wavelength as in figure (7). We can compare this figure with figure (8).

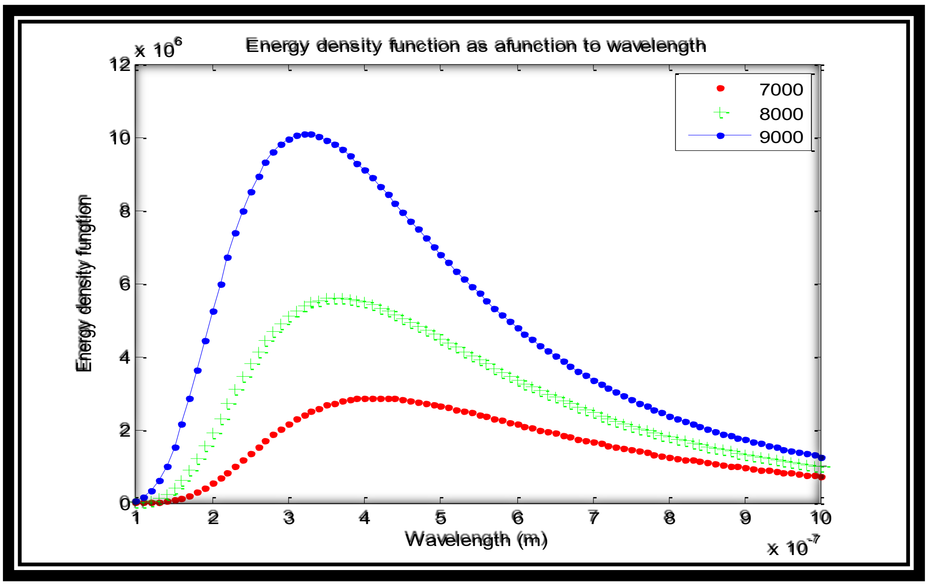


Figure (7):- the energy density function as function to wavelength

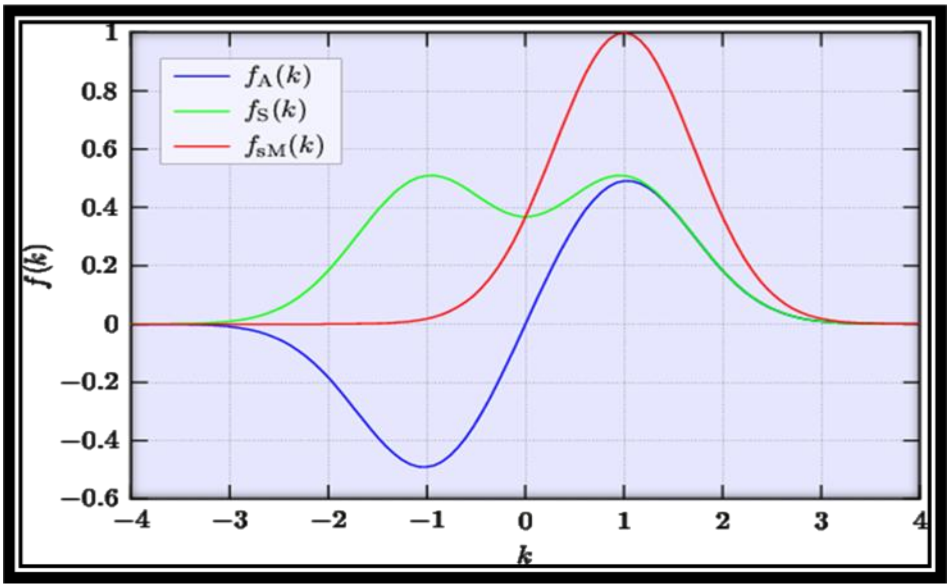


Figure (8):- Shape of a Maxwell distribution function and its symmetric and anti-symmetric parts [7].

## 4. Conclusion: -

From the presented figures by calculating the number of photon the difference of luminance for two (or many) wavelength under different temperature at different bands, we conclude that by creating two vectors first on the delta wavelength and the second on the same wavelength, the size of this new vector its distribution between the beginning and end of a linear must be absolutely the same size as the temperature vector and the values of luminance are differs from band to band according to change of vector distribution and temperature difference, while in a wide range of wavelength the luminance have a large peak at the center of wavelength as a function to vector of wavelength and temperature. In the case of energy density concluding that if shape of each curve of monochromatic intensity is in comparison with the shape of distribution function of Maxwell, the form of monochromatic intensity curve is in the form of distribution function likely

## 5. References: -

1- T.P. Merittt, and F.F. Hall ''Black Body Radiation''. "1959". Proceedings of the IRE, 1435-1437.

2- Houghton ''The Physics of Atmospheres''. "2001". 2nd ed, Cambridge University.

3- Robert A. Cohen Readings to Accompany '' The Physics of the Atmosphere''. "2011". East Stroudsburg University; January, Version 5.4, 18.

4- K.N. Liou, '' An Introduction to Atmospheric Radiation''. "2002". Second edition, Academic Press, Elsevier, Amsterdam, ISBN 0124514510.

5- W. L. Wolfe '' the Infrared Handbook ''. "1993". Environmental Research Institute of Michigan, Ann Arbor.

6- K. N. Liou, "An Introduction to atmospheric Radiation". "2002". Academic Press, Amsterdam/Boston/London/New York/Oxford/Paris/San Diego/San Francisco / Singapore / Sydney/ Tokyo.

7- Internet notes http://www.iue.tuwien.ac.at/phd/gritsch/node29.

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