How to Understand the Planck´s Oscillators? Wien Peaks, Planck Distribution Function and Its Decomposition, the Bohm Sheath Criterion, Plasma Coupling Constant, the Barrier of Determinacy, Hubble Cooling Constant. (24.04.2020)

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Abstract

In our approach we have combined knowledge of Old Masters (working in this field before the year 1905), New Masters (working in this field after the year 1905) and Dissidents under the guidance of Louis de Broglie and David Bohm. Based on the great works of Wilhelm Wien and Max Planck we have presented a new look on the "Wien Peaks" and the Planck Distribution Function and proposed the "core-shell" model of the photon. There are known many "Wien Peaks" defined for different contexts. We have introduced a thermodynamic approach to define the Wien Photopic Peak at the wavelength $\lambda = 555$ nm and the Wien Scotopic Peak at the wavelength $\lambda = 501$ nm to document why Nature excellently optimized the human vision at those wavelengths. There could be discovered many more the so-called Wien Thermodynamic Peaks for other physical and chemical processes. We have attempted to describe the so-called Planck oscillators as coupled oscillations of geons and dyons. We have decomposed the Planck distribution function in two parts. Inspired by the Bohm Diffusion and the Bohm Sheath Criterion we have defined the plasma coupling constant that couple oscillations of geons and photons. The difference of the Planck least action of photons and the least action of geons might define the Barrier of Determinacy that create a limit for the resolution in the Microworld. We have newly formulated the Hubble cooling constant and inserted it into the Newton-Zwicky Cooling Law of photons for the description of the cooling of old photons. This proposed view on Planck´s Oscillators might open a new way for the description of "Heat" and "Light" processes.

Keywords: Planck´s Oscillators, Wien Peaks, Planck Distribution Function and Its Decomposition, Wien Photopic and Scotopic Peaks, Coupled Oscillations of Geons and Dyons, Plasma Coupling Constant, the Barrier of Determinacy, Hubble Cooling Constant, "Heat Wave" and "Light Wave", "Nature Loves to Hide"

1. Introduction

"Heat" and "Light" are concepts in the center of the research of all generations. Can we bring a new reasonable concept into this Field of research or is this Field already closed? In order to achieve our target, we have to combine knowledge of Old Masters (working in this field before the year 1905), New Masters (working in this field after the year 1905), and Dissidents working on the double helix model of the photon for many years. The key breakthrough was found in the empirical formulae of David Bohm-the Bohm diffusion and the Bohm sheath criterion. These Formulae might guide us into the hidden World of Photons, Geons, and Dyons. There was another important source for our research-how many Wien peaks can be used for the description of the Planck distribution function? Which of those Wien Peaks is the best one for the description in a given situation?

2. Inspirations from Old Masters and New Masters-How to Understand the Planck´s Oscillators?

We were inspired by many Great Researchers working in this field for generations. In Table 1 we summarized some of those steps in our understanding of those topics.

Table 1. "Heat" and "Light". How to understand the Planck´s Oscillators?

"Heat" and "Light". How to understand the Planck´s Oscillators?
1830 - 1850 - The Wave Theory of Heat: A Forgotten Stage in the Transition from the Caloric Theory to Thermodynamics (see Stephen G. Brush in 1970)
1800 - Herschel - radiant heat discovered
1800 - 1850 - Old Masters observed heat waves and their reflection, refraction, diffraction, polarization, interference, etc.
1860 - Kirchhoff: the definition of the black body, Kirchhoff´s cavity
After 1860 - Stefan - Boltzmann constant, Boltzmann constant
1894 - Wien - Wien distribution function, Wien displacement law
1900 - Rayleigh - Jeans - equation for low frequencies
1900 - Lummer, Pringsheim, Kurlbaum, Rubens - experimental data
1900 - Planck - Planck distribution function, Planck constant, Planck´s oscillators
1905 - Einstein - quantum of light, photoelectric effect
1924 - de Broglie - particle - wave formula
1925 - Bohr, Heisenberg, Schrödinger et al. modern quantum mechanics
After that many New Masters have been working on the quantum mechanics
1950 - Bohm: empirical formula of the Bohm diffusion, the Bohm sheath criterion
Many Great New Masters continue to work on these topics
Wheeler: Thermal geons
J.J. Mareš. P. Hubík, V. Špička: What is Heat? How to describe the Planck´s oscillators?
J. Šesták: How to describe the cooling of old photons?

3. "Wien Peaks" and the Planck Distribution Functions

Max Planck in 1900 derived his Great distribution functions that started a new development of physics:

$$B_\nu = \frac{2h\,\nu^3}{c^2}\frac{1}{\exp\left[h\nu\,/\,\left(kT\right)\right]-1} \tag{1}$$

$$B_\lambda = \frac{2h\,c^2}{\lambda^5}\frac{1}{\exp\left[hc\,/\,\left(\lambda kT\right)\right]-1} \tag{2}$$

where B_ν is the emitted power per unit area per steradian per frequency interval, B_λ is the emitted power per unit area per steradian per wavelength interval, h and k are the Planck and Boltzmann constants and c is the speed of light.

There are several very inspirative papers on the Wien Peak positions: e.g., J.M. Overduin (2003), M.A. Heald (2003), Z.M. Zhang and X.J. Wang (2010), J.M. Marr and F.P. Francis (2012), S.M. Stewart (2012), A. Delgado-Bonal (2017), S. M. Stewart and R.B. Johnson (2017), and website "Calculation of Blackbody Radiance".

Based on the Wien displacement law several "Wien Peaks" were derived, some of them are given in the Table 2.

Table 2. "Wien Peaks" in the Planck distribution function

Wien Peak for the spectral photon radiance in units frequency	
$2(1- e^{-x}) = x$ where $x = h\nu/kT$	$x = a_2 = 1.59362426004$
Wien Peak for the spectral radiance in units frequency	
$3(1- e^{-x}) = x$ where $x = h\nu/kT$	$x = a_3 = 2.82143937212$
Wien Peak for the spectral photon radiance in units wavelength	
$4(1- e^{-x}) = x$ where $x = h\nu/kT$	$x = a_4 = 3.92069039487$
Wien Peak for the spectral radiance in units wavelength	
$5(1- e^{-x}) = x$ where $x = h\nu/kT$	$x = a_5 = 4.96511423174$

Several researchers developed another "Wien Peaks" in order to describe different contexts of the application of the Planck distribution function. Which of those "Wien Peaks" have been used by real detectors in the Nature?

4. "Wien Photopic Peak", "Wien Scotopic Peak", "Wien Thermodynamic Peaks"

The existence of several Wien Peaks leads to a question-which of those Wien Peaks should be used for a given situation? E.g., there is a paradox for the human vision (see e.g. B. H. Soffer & D. Lynch in 1999, A. Delgado-Bonal and J. Martin-Torres in 2016). The Wien Peak for the spectral radiance in units of frequency lays in the infrared region. Why is not the maximum efficiency of human photopic vision in infrared range but at the wavelength 555 nm (= 5.4 * 10^{14} Hz, see the definition of the SI unit CANDELA)? Why Nature tuned the maximum of the photopic vision to the wavelength 555 nm? The answer is very surprising and documents the Great Art of our Nature-we can modify the Planck distribution function if we insert to that function the frequency ν divided by the value a_2 = 1.5936…By this modification we find the maximum of the Solar spectrum both for the number of photons and their energy at the Solar temperature T = 5800 K at λ_{max} = 555 nm:

$$B_\nu = \frac{2h}{c^2}\left(\frac{\nu}{a_2}\right)^3 \frac{1}{\exp\left[h\nu / \left(a_2\, kT\right)\right] - 1}$$

(3)

The discovery of this Wien Photopic Peak stimulated us to search for more Wien Peaks based thermodynamic arguments and we have found one formula for the value a_5 = 4.9651… leading to the maximum λ_{max} = 555 nm:

$$E = \left(a_5 - \frac{1}{2}\right)kT + \frac{1}{2}kT$$

(4)

We can conclude that the human eye is the great thermodynamic detector. For the photopic vision under well-lit conditions part of the photon energy change to "heat quantum" and the rest of the photon energy creates the "light" in the human eye. In the case of the scotopic vision under low-light level all photon energy is transformed into the "light". This maximum at 501 nm we can call the "Wien Scotopic Peak". This effect of the scotopic vision is called the Purkinje effect after the Great Old Master Jan Evangelista Purkyně.

We might similarly define other "Wien Thermodynamic Peaks" that could be found in some other physical, chemical or biochemical processes-Table 3.

Table 3. "Wien Thermodynamic Peaks"

Wien Thermodynamic Peaks for the spectral radiance in units frequency for T = 5800 K	Effect
$E_\nu = a_3\, kT$	Maximal "heat" from photons, Herschel Peak at 879 nm
$E_\nu = (a_3 - 1/2)\, kT + 1/2\, kT$	1069 nm ?
$E_\nu = (a_3 - 3/2)\, kT + 3/2\, kT$	1877 nm ?
$E_\nu = (a_3 - 5/2)\, kT + 5/2\, kT$	7717 nm gravitation effect
Wien Thermodynamic Peaks for the spectral radiance in units wavelength for T = 5800 K	
$E_\lambda = a_5\, kT$	499 nm scotopic vision
$E_\lambda = (a_5 - 1/2)\, kT + 1/2\, kT$	555 nm photopic vision
$E_\lambda = (a_5 - 3/2)\, kT + 3/2\, kT$	716 nm ?
$E_\lambda = (a_5 - 5/2)\, kT + 5/2\, kT$	1006 nm ?
$E_\lambda = (a_5 - 7/2)\, kT + 7/2\, kT$	1693 nm ?
$E_\lambda = (a_5 - 9/2)\, kT + 9/2\, kT$	5333 nm ?

We can conclude that a given detector is able split the same photon energy packet into frequency or wavelength packets. There is an analogy - we can withdraw our money in the "USD" energy packets or "Euro" energy packets in banknotes with different values. There might be a rule in the Nature - sometimes it is better to pay using the "USD" energy packet, in other circumstances we should pay using the "Euro" energy packet.

We want to pass this scenario into the hands of Readers of this Journal better educated in Thermodynamics, processes in physics, chemistry and biology to estimate this model in other situations.

5. Decomposition of the Planck Distribution Function

We would like to extract some more information about the internal structure of the Planck Distribution Function. Therefore, we propose to decompose this Function in two parts as:

$$B_\nu = \frac{2h\nu^3}{c^2}\left[\frac{1}{\exp\left[h\nu/\left(kT\right)\right]-1}\right] = \frac{2h\nu^3}{c^2}\left[\exp\left[-h\nu/\left(kT\right)\right] + \frac{\exp\left[-h\nu/\left(kT\right)\right]}{\exp\left[h\nu/\left(kT\right)\right]-1}\right] \tag{5}$$

This operation splitted the Planck Distribution Function into the Wien Distribution Function plus one new distribution function. We estimate that the Wien Distribution Function could describe geons and the second part might describe dyons. The Wien "approximation" for photons might be precise distribution function for geons. We estimate that the particle called "photon" might create simultaneously two coupled waves - one "heat wave" and one "light wave".

At low frequencies - in the domain of the Rayleigh-Jeans Law - dyon oscillations dominate in the blackbody radiation. Based on this Rayleigh-Jeans Law at higher frequencies we approach to the "ultraviolet catastrophe".

At very high frequencies - in the area of the Wien Law - geon oscillations play the dominate role.

In the middle range of frequencies - the territory of the Planck Law - both dyon and geon oscillators create together the **"**quantum effect" through their synergic co-oscillation.

We want to pass this model into the hands of Readers of this Journal better educated in the mathematics to describe this synergic effect of dyons and geons. This joint synergic oscillation might explain the observed "quanta" of energy.

In order to get more information from the Microworld we will employ the Bohm Diffusion and the Bohm sheath criterion.

6. The Bohm Sheath Criterion, the Bohm Diffusion, Beta of Plasma and Geon Properties

David Bohm in 1947 - 1954 conjectured several important formulae for plasma that might be useful for the description of geons - the Bohm Sheath Criterion and the Bohm Diffusion (e.g., K.U. Riemann in 1991 and N. Sternberg and V. Godyak in 2007). This concept was recently applied by Jiří Stávek (2020). In this model the geon and dyon form together the photon - a coupled oscillator of the "heat wave" and the "light" wave:

$$m\, 2\, c\, V_{St} = k\, T \tag{6}$$

where m is the geon mass (identical to the photon mass), c is the light speed, V_{St} is the Bohm speed describing the perpendicular vibration speed ("heat content"), k is the Boltzmann constant and T is temperature.

David Bohm in 1949 conjectured the Bohm diffusion scaling for the diffusion of plasma across a magnetic field with the magnetic field strength B:

$$D_B = \frac{k_B T}{16Be} \tag{7}$$

The meaning of this empirical Bohm diffusion is actively discussed in the literature. The number 16 is only empirical constant and might be changed by a future modification.

We will extract from this equation amplitude A, wavelength λ and volume of geons V_G as:

$$A = \frac{\lambda}{2\pi} = \frac{1}{2\pi}\frac{k_B T}{2}\frac{1}{Bec} \tag{8}$$

$$\lambda = \frac{k_B T}{2}\frac{1}{Bec} \tag{9}$$

$$V_G = \lambda\frac{k_B^2 T^2}{16\pi B^2 e^2 c^2} = \frac{2\mu_0}{B^2}\frac{k_B T}{2} \tag{10}$$

Because the geon is in the equilibrium with the magnetic field strength B in the surroundings, we can express Beta of plasma as:

$$\beta = 1 = \frac{pressure\ of\ geon}{magnetic\ pressure} = \frac{\dfrac{energy\ of\ geon}{volume\ of\ geon}}{magnetic\ pressure} = \frac{\dfrac{k_B T}{2}\dfrac{1}{V_G}}{\dfrac{B^2}{2\mu_0}} \tag{11}$$

After some re-arrangement we will get an expression for the geon wavelength λ for the geon the helical path with the Weber speed $c_W = \sqrt{2}\,c$ and its energy $E = kT$ as:

$$\lambda = 8\pi\,\mu_0 e^2 c\,\frac{c}{k\,T} = \frac{h_G c}{k\,T} = \frac{0.005277515...\left[m\ K\right]}{T} \tag{12}$$

This is the displacement law for geons as a part of photons - an analogy with the Wien´s displacement law for photons.

The quantum of geon action can be evaluated as:

$$h_G = 8\pi\,\mu_0 e^2 c = 2.43048...\,{}^{*}10^{-34} J\ s \tag{13}$$

One relation connecting the Planck least action h of photons, the geon least action h_G and the fine structure constant α was found by Jiří Stávek (2020) as:

$$\alpha = \frac{h_G}{16\pi h} \tag{14}$$

7. The Plasma Coupling Γ for Geons

The plasma coupling Γ is defined as a ratio of the Coulomb energy to the thermal one. For geons we can write:

$$\Gamma = \frac{E_C}{kT} = \frac{\dfrac{1}{4\pi\,\varepsilon_0}\dfrac{e^2 2\pi}{\lambda_G}}{kT} = \frac{e^2}{2\,\varepsilon_0\lambda_G kT} = \frac{e^2}{2\,\varepsilon_0 h_G c} = \frac{e^2\mu_0 c^2}{2\,h_G c} = \frac{1}{16\pi} \tag{15}$$

The plasma coupling for geons Γ plays a very important role in the Microworld because it couples the "heat wave" and the "light wave" of the photon as:

$$E = h_G \nu_G = 16\pi\alpha h\,{}^{*}\,\frac{\nu}{16\pi\alpha} \tag{16}$$

In this "core - shell" model of the photon the "core" is the "heat wave" surrounded by the "shell" creating the "light wave".

8. The Barrier of the Determinacy

In quantum mechanics, the uncertainty principle (also known as Heisenberg´s uncertainty principle) represents a fundamental limit to the precision with which the experimental values for certain pairs can be experimentally achieved. Earle Hesse Kennard in 1927 derived the formal inequality relating the standard deviation of position σ_x and the standard deviation of momentum σ_p as:

$$\sigma_x \sigma_p \geq \frac{\hbar}{2} \geq 5.27286...\,{}^{*}10^{-35}\ Js \tag{17}$$

For the case of the "core - shell" model of the photon we can approach the barrier B of the experimental determinacy limited by the amplitude difference of the super-elastic double-helix photon $\lambda/2\pi$ and the super-elastic double-helix geon $\lambda_G/2\pi$. For the difference of the actions of photon h and the action of geon h_G we can write:

$$B = \left(\frac{h}{2\pi} - \frac{h_G}{2\pi} \right) = \frac{h}{2\pi} \left(1 - 16\pi\alpha \right) = \frac{h}{2\pi} \left(1 - \frac{\alpha}{\Gamma} \right) = 6.67749... \ast 10^{-35} \ Js \tag{18}$$

It might be interesting to estimate which barrier of the determinacy will be experimentally determined as the true limit used by Nature.

9. Newton - Zwicky´s Law of Cooling of Old Photons, Hubble Cooling Constant

The "core-shell" model of photon with the geon creating a "heat wave" and the coupled "light wave" enables to analyze the cooling of that "old" photon using the Newton law of cooling. Newton´s law of cooling states that the rate of heat loss of a body is directly proportional to the difference in the temperatures between the body and its surroundings.

The first model describing redshifts of old photons formulated Fritz Zwicky in 1929 in the same year as Edwin Hubble published his redshift data for old photons.

For the cooling of an old photon we can write:

$$\frac{T(t) - T_{CMB}}{T(0) - T_{CMB}} = e^{-H_0 t} \tag{19}$$

where $T(0)$ and $T(t)$ are photon temperatures based on the Wien displacement law at time 0 and time t of that photon age. T_{CMB} is the temperature of cosmic background given as $T = 2.725$ K (e.g., Erich Regener predicted this temperature as $T = 2.8$ K in 1933, the precise value of the CMB was later determined by many Great Experimental Physicists). The constant H_0 is the famous Hubble constant describing in this situation the cooling rate of those old photons.

Jaroslav Šesták (2020) recommended us to formulate the cooling constant in the Newton cooling law using the Biot and Fourier numbers in units W J^{-1} (watt per joule) as:

$$H_0 = \frac{2 \, c^2}{k} \frac{\partial}{\partial t} \left(\frac{m}{T} \right) = 2.331... \ast 10^{-18} \ W \ J^{-1} \tag{20}$$

This Hubble cooling constant might be used for the analysis of redshift data of old photons during their cooling process using photon frequencies as:

$$\frac{\nu(t) - \nu_{CMB}}{\nu(0) - \nu_{CMB}} = e^{-H_0 t} \tag{21}$$

This Hubble cooling constant might be used for the analysis of redshift data of old photons during their cooling process using photon wavelengths as:

$$\frac{\dfrac{c}{\lambda(t)} - \dfrac{c}{\lambda(CMB)}}{\dfrac{c}{\lambda(0)} - \dfrac{c}{\lambda(CMB)}} = e^{-H_0 t} \tag{22}$$

We want to pass this model into the hands of Readers of this Journal with a deeper knowledge of redshift data of old photons.

10. Tolman Surface Brightness Test, Density of Geons

The Tolman surface brightness test is one of cosmological tests that was first proposed in 1930 by Richard C. Tolman as a test of whether Universe is expanding or static. The surface brightness in a simple expanding Universe should decrease with the fourth power of $(z + 1)$. The traditional "tired light" scenario proposed the decrease with the first power of $(z + 1)$.

We can write the density $\rho(t)$ of the old cooling super-elastic double- helix geon as:

$$\rho\left(t\right)=\frac{m\left(t\right)}{V\left(t\right)}=\frac{m\left(t\right)}{\pi\left[\frac{\lambda\left(t\right)}{2\pi}\right]^2\lambda\left(t\right)}=\frac{m_0\left(z+1\right)^{-1}}{\frac{\lambda_0^3\left(z+1\right)^3}{4\pi}}=\frac{\rho\left(0\right)}{\left(z+1\right)^4}$$

(23)

In this scenario the density of the cooling geon decreases with the fourth power of $(z + 1)$, so as the observed brightness decreases with the fourth power of $(z+1)$.

A. Sandage and L.M. Lubin made their great experimental observation with the Hubble telescope in 2001 and confirmed the fourth power of $(z + 1)$ dependence. Their data were interpreted in favor of the expanding Universe.

(Great Old Masters including Isaac Newton proposed to evaluate the density of "aether" and tried qualitatively to insert this effect into their models).

11. Conclusions

1. We have combined knowledge of Old Masters, New Masters, and Dissidents in order to newly formulate events observed with "heat waves" and "light waves".

2. We have introduced "Wien photopic peak" and "Wien scotopic peak" based on thermodynamic arguments.

3. We have decomposed the Planck distribution function in two parts.

4. Photon was modelled as two coupled oscillators - the "heat wave" and the "light wave".

5. The value for the geon action was found from the Beta Plasma.

6. The coupling constant was derived from the plasma coupling Γ.

7. The barrier B for the determinacy was formulated.

8. Hubble cooling constant describing cooling of old photons was inserted into the Newton - Zwicky law of cooling.

9. The density of old photons was formulated and checked with the Tolman surface brightness test prediction.

10. We need more experimental data for the events with "heat waves" and "light waves".

11. Nature might hide Her Beauty in plain sight protected by the mathematical camouflage.

12. We want to pass this model into hands of Readers of this Journal better educated in Mathematics, Physics and Thermodynamics.

Conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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