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TO FIND OUT THE SOLUTION OF ULTRAVIOLET CATASTROPHE

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ABSTRACT: My research topic is to find out the solution of ultraviolet catastrophe or we can say origin of Quantum Mechanics.IN this topic we start from interaction of radiation with matter and how the problem arise in this interaction and this arising problem is known as ultraviolet catastrophe. To resolve this catastrophe many physicists trying to solve this ultraviolet catastrophe .

Literature Review:

- WIEN

Wien tried to explain the observed blackbody spectrum by using classical ideas and assumptions. He considered the blackbody radiation is made up of numerous linear harmonic oscillator (called resonators) of molecular dimensions. Wien able to explained the black body radiation at lower wavelength but could not explain on higher wavelength

- RAYLEIGH-JEANS
- Rayleigh -jeans radiation (1900) is also considered the black body and he assumed that blackbody is composed of a collection of linear harmonic oscillator and tried to explain by classical ideas. Rayleigh jeans able o explain black body radiation at higher wavelength but could not explain on lower wavelength.

- PLANCK
- Planck realized that physics of the microworld was different and needed an approach which was not classical. By assuming this planck succeeded to explain the ultraviolet catastrophe.

PARTICLE ASPECT OF RADIATION

According to classical physics, a particle is characterized by an energy E and a momentum p whereas a wave is characterized by an amplitude and a wave vector k ($k=2\pi/\lambda$) that specifies the direction of propagation of the wave ;particles and waves exhibit entirely different behaviour.

For instance, the "particle" and "wave" properties are mutually exclusive; waves can exchange any(continues) amount of energy with particles.

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In this topic we are going to see rigid concepts of classical physics led to its failure in explaining a number of microscopic phenomena such as blackbody radiation,the photoelectric effect and the Compton effect.

BLACK BODY RADIATION

First of all we define what is blackbody ?
Blackbody is defined as

- It can absorb radiation of all wavelengths falling on its. So its absorption coefficient is unity at all wavelength.
- It cannot reflect radiation falling on it. So it's reflection coeffiecient is zero.
- It cannot transmit radiation falling on it. So its transmission coefficient is zero.

As the body can neither reflect nor transmit radiation of all wavelength falling on it. That's why its called black body.

When heated, a solid object glows and emit thermal radiation. As the temperature increases, the object becomes red, then yellow and then white..The thermal radiation emitted by glowing solid objects consists of continuous distribution of frequencies ranging from infrared to ultraviolet. The continuous pattern of the distribution spectrum is in sharp contrast to the radiation emitted by heated gases; the radiation emitted by gases has discrete distribution spectrum:few sharp lines.

Understanding the continuous character of the radiation emitted by a glowing solid object constitute one of the major unsolved problems during the second half of thenineteeth century.All attempts to explain this phenomenon by means of the available theories of classical physics

Ended up in miserable failure.

This problem consisted in essence of specifying the proper theory of thermodynamics that describes how energy gets exchanged between radiation and matter.

When an object is heated it radiates electromagnetic energy as a result of the thermal agitation of the electrons in its surface.The intensity of this radiation depends on its frequency and on the temperature;the light it emits range over the entire spectrum.An object in thermal equilibrium with its surroundings radiates as much energy as it absorbs. It thus follows that a blackbody is perfect absorber as well as a perfect emitter of radiation..

A practical blackbody can be constructed by taking a hollow cavity whose internal walls perfectly reflect electromagnetic radiation (e.g metallic walls) and which was a very samall hall on its surface .Radiation that enters through the hole will be trapped inside the cavity and gets completely absorbed after successive reflections on the inner surfaces of the cavity. The hole thus absorbs radiation like a blackbody.when cavity is heated at temp t' radiation that exit from hole is known as blackbody radiation and hole behave as a perfect emitter ;when the temp is increases,the hole will starts to glow.for understanding the radiation inside the cavity we need to analyze the spectral distribution of the radiation coming out of the hole.

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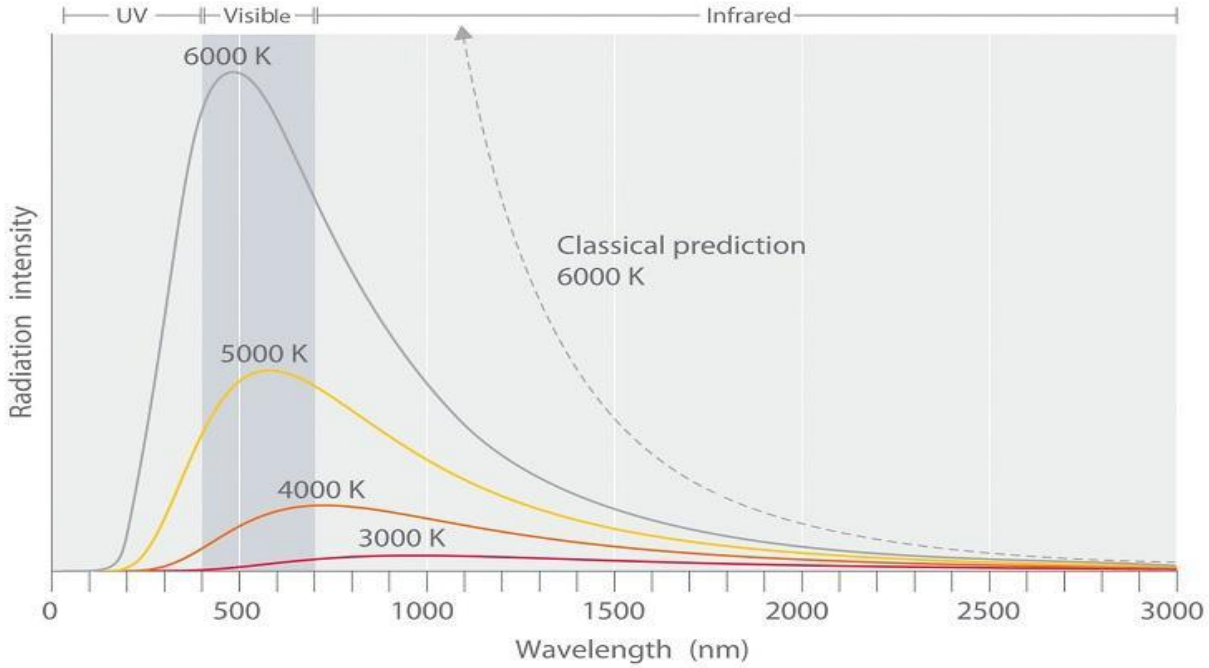
By the mid-1800s,alarge collection of experimental data about black body radiation was obtained for various objects.

All these data show that, at equilibrium the radiation emitted has a well defined,continuous energy distribution:to each frequency there corresponds energy denity which depends not on the chemical composition o the object nor on its shape but only on the temp. of the cavity 's walls.



From the internet source

The peak of the radiation spectrum is proportional to the temp.This is the reason behind the change in color of a heated object as its temp increases from red to yellow to white.It turned out that the explanation of the blackbody spectrum was not so easy.

A number of attempts aimed at explaning the origin of the continuous character of this radiation were carried out.

By the use of classical ideas wien able to explain the blackbody radiation to some extent.

ATTEMPT TO EXPLAIN BLACKBODY SPECTRUM BY WIEN:

Wien tried to explain the observed black body spectrum by using classical ideas and assumptions which were follows:

1. The radiating system is considered to be built out of numerous linear harmonic oscillator of molecular dimensions.
2. The frequency of wave emitted by a resonator is proportional to kinetic energy of resonator i.e v is directly proportional to product of half of mass and square of velocity.
3. The energy density of radiation at a wavelength is proportional to the no. of resonator oscillating with wavelength between λ and $\lambda + d\lambda$.

Wien formula is

$E d\lambda = 8\pi hc \exp(-hc/\lambda kt) d\lambda / \lambda^5 dd$

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DRAWBACK OF WIEN'S FORMULA

WIEN'S RADIATION FORMULA was found to agree with the experimentally obtained blackbody spectrum only for low λ .The high spectrum could not be explained by wien's radiation formula.so wiens law fails to expainblackbody radiation spectrum at high frequencies.

ATTEMPT TO EXPLAIN BLACKBODY SPECTRUM BY RAYLEIGH JEANS:

1. The radiating system is composed of acollection of linear harmonic oscillators.These atomic oscillators in the walls of enclosure,continuously exchange energy in any amount with electromagnetic radiation with λ varying from λ=0 to ∞ .
2. Electromagnetic radiation are reflected from the walls of enclosure.the incident and reflected waves interfere to form stationary waves.
3. Classical law of equipartition of energy was employed to find energy of each independent vibration.

Based on these assumptions RAYLEIGH JEANS OBTAIMED THE FORMULA

Ed λ =8πKTd λ/ λ^4

DRAWBACK OF RAYLEIGH JEANS RADIATION FORMULAE

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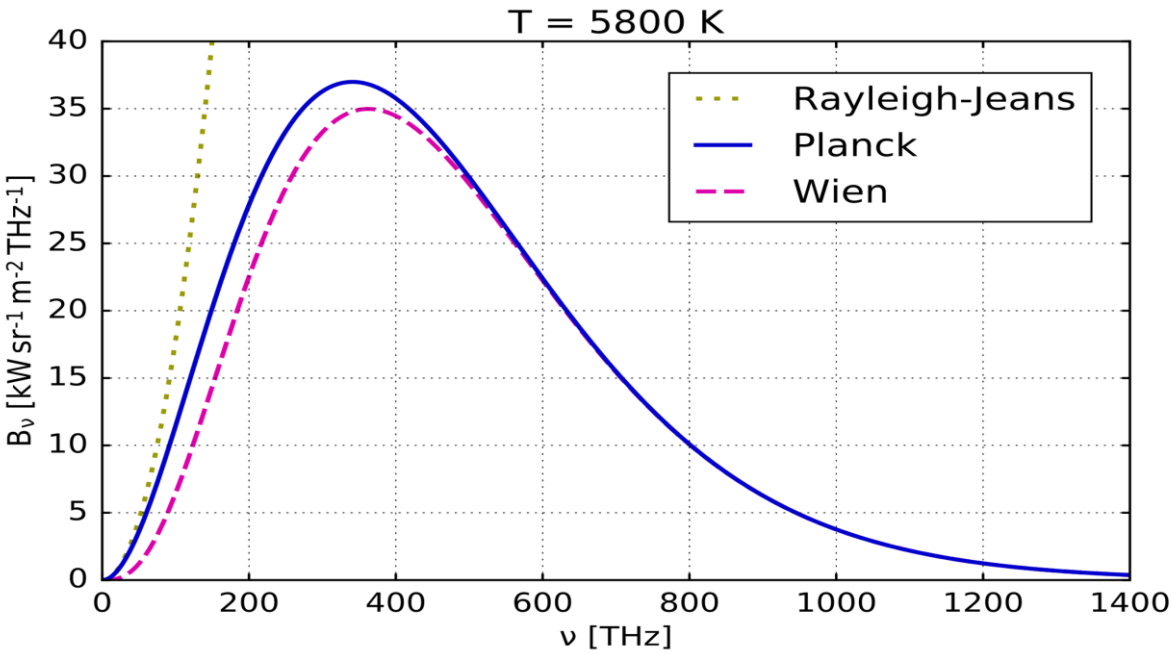

FROM INTERNET SOURCE

RAYLEIGH JEANS EXPLAINED BLACKBODY ONLY FOR HIGH WAVELENGTH AND NOT EXPLAINED ON LOWER WAVELENGTH.

RAYLEIGH JEANSdistribution formulae could not explained blackbody spectrum on low wavelength.

EXPLANATION OF BLACKBODY RADIATION OF PLANCK(1900)

REASON OF FAILURE OFCLASICAL THEORIES OF WIEN AND RAYLEIGH JEANS

The entire part of blackbody radiation spectrum could not explained by the classical theories of wien and Rayleigh jeans.This is due to following assumptions which are based on classical ideas

1. The atomic oscillators can have any arbitrary amount of energy between E=0 to E=∞ .
2. The atomic oscillators can emit or absorb energy of radiation continuously and in any arbitrary amount.

PLANCK'S ASSUMPTIONS

Planck realized that physics of microworld was different and needed approachwhich was not classical.

Planck made the following assumptions:

1.The radiating system is considered to be built out of numerous electric dipoles which are linear(1-D) harmonic oscillators of microscopic dimensions.Radiation inside enclosure is due to oscillation of these dipole oscillators.

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2.The oscillators due to their oscillation,emit electromagmetic radiation into blackbody chamber and absorb them as well.At a particular temp. the oscillators maintain equilibrium with radiation within blackbody chamber.

3.Oscillators energy is quantized i.e zero or integral multiple of hv namely 0,hv,2hv,3hv…….

$$E=nhv \;;n=0,1,2\ldots..$$

Where v =linear frequency of oscillation, h =planck's constant ;n is called quantum number

4Energy exchange occurs in quantized manner in units of hv .Exchange of energy occurs between oscillators and radiation discontinuously and not in a continuous manner.Also any amount of energy is not exchanged.Only discrete amounts of energy in units of hvare exchanged.This assumption is non classical in nature and explains emission and absorption of radiation.

4. The no. of oscillators in energy state E = nhv, n 0,1,2,3….. is determined by maxwell Boltzmann distribution law.

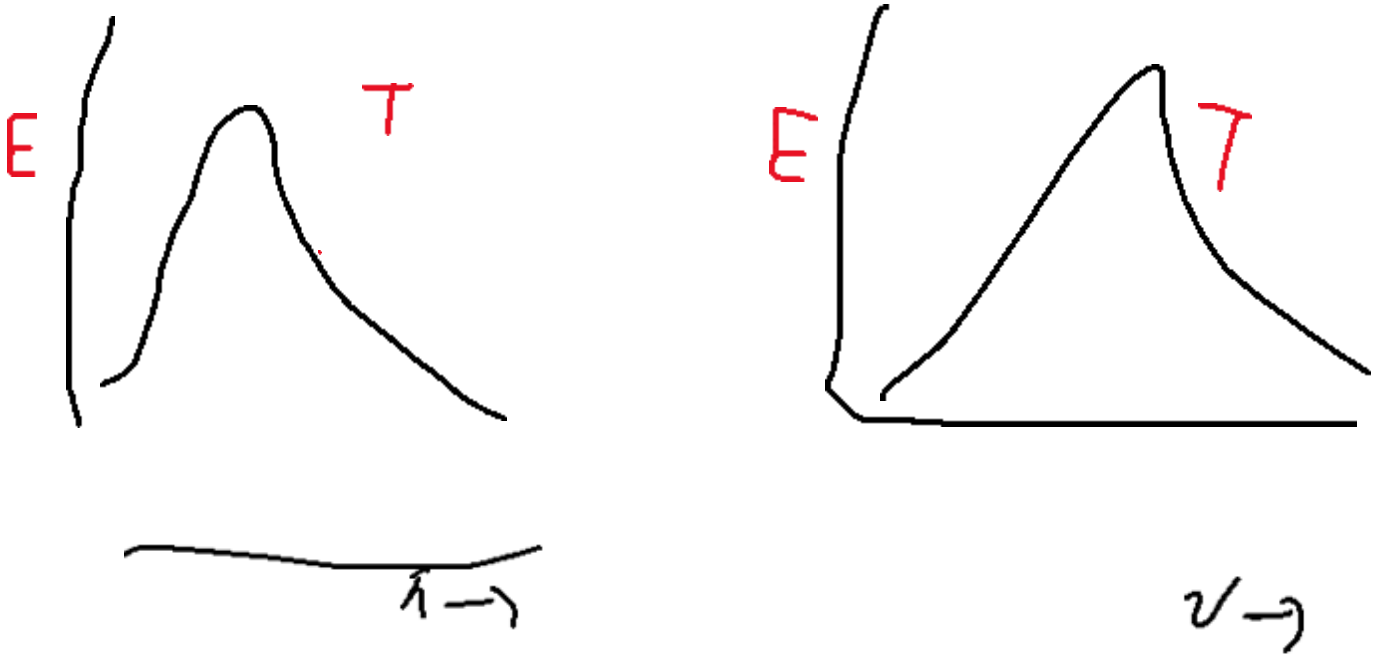
$N=N'\exp(-E/KT)=N\exp(-nhv/kt)$

Where N is no. of oscillators in the nth energy state;k Boltzmann constt;T absolute temp. of black body.

Based on this assumptions the planck derived formulae and the formulae is

$Ed\lambda = 8\pi hc\, d\lambda /\exp(-hc/\lambda kt-1)\,\lambda^{5}$

This is planck's radiation formulae in terms of wavelength



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Planck's law explain experimentally obtained blackbody spectrum

AT LOW λ:Plancks law reduces to wien's law AT LOW v:plancks law reduces to Rayleigh jean

AT HIGHλ :Plancks law reduces to Rayleigh jeans law AT HIGH v:Plancks law reduces to wien's law

DISCUSSIONS AND CONCLUSIONS

- BLACKBODY RADIATION could not be explained by WIEN AND RAYLEIGH JEANS ,BOTH OF WHICH TREATED THE PROBLEM ON CLASSICAL LAWS.But PLANCKS his non classical assumptions derive the plancks radiation formulae and explained successufully the entire part of blackbody spectrum
- This law of physics of the microlevel is radically different from the law of physics at macrolevel.The law of physics of the microworld were now known asQUANTUM MECANICS.
- The spectrum of the blackblody radiation tells the quantization of radiation and most important the particle behaviourt of electromagnetic waves.
- Introduction of constant h had indeed the end of classical physics and dawn of anew era:physics of the microphysical world.
- By the success of planck's quantization of radiation ,othert physicists like EINSTEIN,COMPTON,DE-BROGLIE AND BOHR skillfully adapted it to explain a host of other outstanding problems that had been unanswered for answer for decades.
  REFERENCES: ZETLI BOOK,INTERNET SOURCE