

01)

2017

FRIDAY ♦ SEPTEMBER

36th Week • 244-121

AUGUST 2017							SEPTEMBER 2017							
WEEK	S	M	T	W	T	F	S	WEEK	S	M	T	W	F	S
31			1	2	3	4	5	35						
32	6	7	8	9	10	11	12	36	3	4	5	6	7	8
33	13	14	15	16	17	18	19	37	10	11	12	13	14	15
34	20	21	22	23	24	25	26	38	17	18	19	20	21	22
35	27	28	29	30	31			39	24	25	26	27	28	29

Black-body Radiation.

Wien's displacement law :-

With the increase of temp. of black body, the max. intensity of radiation shift towards the shorter wavelength region.

$$\lambda_m \cdot T = \text{constant}$$

$$\Rightarrow \lambda_m \propto \frac{1}{T}$$

$$\text{or, } \lambda_m \propto T$$

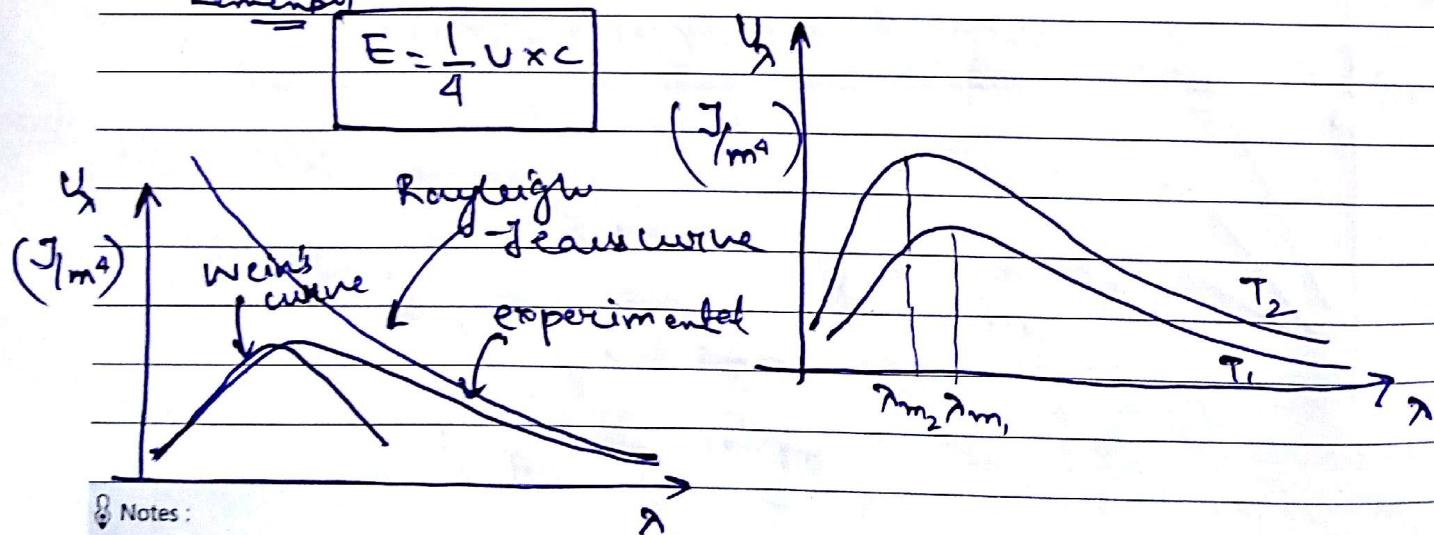
Theoretical Explanations:-

Wien's energy distribution law:-

$$U_\lambda d\lambda = \frac{a}{\lambda^5} \exp\left(-\frac{b}{\lambda T}\right) d\lambda$$

Remember

$$E = \frac{1}{4} U c$$



Notes :

OCTOBER 2017							NOVEMBER 2017								
WK	S	M	T	W	T	F	S	WK	S	M	T	W	T	F	S
40	1	2	3	4	5	6	7	44		1	2	3	4		
41	8	9	10	11	12	13	14	45	5	6	7	8	9	10	11
42	15	16	17	18	19	20	21	46	12	13	14	15	16	17	18
43	22	23	24	25	26	27	28	47	19	20	21	22	23	24	25
44	29	30	31					48	26	27	28	29	30		

2017
SEPTEMBER ♦ SATURDAY

36th Week • 245 - 120

(02)

Rayleigh - Jeans

$$U_{\nu} d\nu = \frac{8\pi kT}{c^3} d\nu$$

Classical explanation according to Rayleigh-Jeans

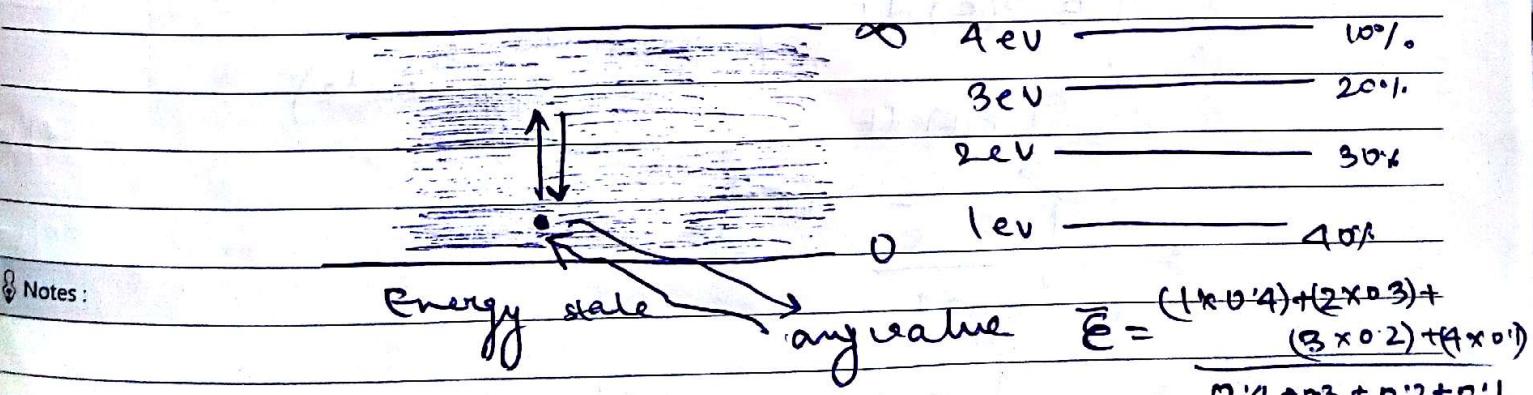
The atom of the black body, at a given temp, behaves like a simple harmonic oscillator, each having characteristic frequency of oscillation. The no. of oscillator per unit volume within the frequency range $\nu \rightarrow \nu + d\nu$ is:-

$$N(\nu) d\nu = \frac{8\pi \nu^2}{c^3} d\nu$$

$$U_{\nu} d\nu = N(\nu) d\nu \times \bar{E}$$

According to classical concept, the energy scales are continuous i.e. each oscillator can absorb or emit any value of energy.

SUNDAY 03



Let $P(E)$ be the probability of finding the particle in E energy state.

According to Boltzmann distribution $P(E) \propto e^{-E/kT}$

$$\therefore P(E) = c e^{-E/kT}$$

$$\Rightarrow \int_0^\infty P(E) dE = \int_0^\infty c e^{-E/kT} dE$$

$$\Rightarrow 1 = c(kT) \int_0^\infty e^{-z} dz$$

$$\Rightarrow 1 = c(kT) \Gamma(1)$$

$$\Rightarrow c = \frac{1}{kT}$$

$$\int_0^\infty e^{-x} x^{n-1} dx = \Gamma(n)$$

$$\Gamma(1) \approx 1$$

$$\Gamma(\frac{1}{2}) = \sqrt{\pi}$$

The avg. energy of the oscillator, within the ~~freq.~~ range ω to $\omega + d\omega$ is

$$\Gamma(n+1) = n\Gamma(n)$$

$$\bar{E} = \frac{E_1 P(E_1) + E_2 P(E_2) + \dots}{P(E_1) + P(E_2) + \dots}$$

$$= \frac{\int_0^\infty E P(E) dE}{\int_0^\infty P(E) dE} \quad (\text{continuous energy state})$$

$$= \int_0^\infty \frac{E e^{-E/kT}}{kT} dE$$

Notes:

$$\therefore \bar{E} = \frac{1}{kT} \int_0^\infty E e^{-z} dz \quad (kT)^2 = 1 (kT) = kT$$

OCTOBER					2017		NOVEMBER 2017						
WEEK	S	M	T	W	F	S	WEEK	S	M	T	W	F	S
40	1	2	3	4	5	6	44		1	2	3	4	
41	8	9	10	11	12	13	45	5	6	7	8	9	10
42	15	16	17	18	19	20	46	12	13	14	15	16	17
43	22	23	24	25	26	27	47	19	20	21	22	23	24
44	29	30	31				48	26	27	28	29	30	

2017
SEPTEMBER ♦ TUESDAY



37th Week • 248 - 117

(05)

$$1. \quad \bar{E} = kT$$

Now the energy density of the black body radiation at a given temp. T within the frequency range ν to $\nu + d\nu$ is $U_\nu d\nu$

$$\begin{aligned} U_\nu d\nu &= N(\nu) d\nu \times \bar{E} \\ &= \frac{8\pi\nu^2}{c^3} d\nu \times kT \end{aligned}$$

$$U_\nu d\nu = \frac{8\pi kT \nu^2}{c^3} d\nu$$

In terms of wavelength;

$$U_\lambda d\lambda = -U_\nu d\nu \quad [d\nu \uparrow d\lambda \downarrow]$$

$$= -\frac{8\pi kT \nu^2}{c^3} d\nu$$

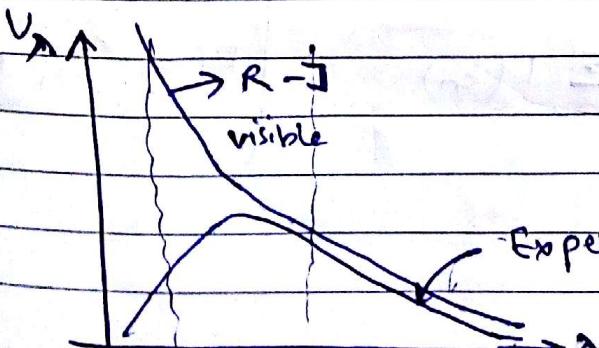
$$\nu = \frac{c}{\lambda}$$

$$\Rightarrow d\nu = -\frac{c}{\lambda^2} d\lambda$$

$$= \frac{8\pi kT}{c^3} \times \frac{c^2}{\lambda^2} \times \frac{c}{\lambda} d\lambda$$

$$U_\lambda d\lambda = \frac{8\pi kT}{\lambda^4} d\lambda$$

as $\lambda \rightarrow 0$ $U_\lambda \rightarrow \infty$ } This
but experimentally $U_\lambda \rightarrow 0$ } discrepancy
between theoretical
and experimental values.



Experimental region is known as ultraviolet catastrophe.

06)

2017

WEDNESDAY ♦ SEPTEMBER

37th Week • 249-116

AUGUST 2017							SEPTEMBER 2017						
WK	S	M	T	W	T	F	S	WK	S	M	T	W	F
31			1	2	3	4	5	35			1	2	
32	6	7	8	9	10	11	12	36	3	4	5	6	7
33	13	14	15	16	17	18	19	37	10	11	12	13	14
34	20	21	22	23	24	25	26	38	17	18	19	20	21
35	27	28	29	30	31			39	24	25	26	27	28

Planck's Black body Radiation law

He assumed that :-

- (i) The oscillator can have energies which are discrete ie. an integral multiple of finite quanta of energy.

$$E_n = n h \nu$$

where $n = 0, 1, 2, 3, \dots$

$$h = 6.634 \times 10^{-34} \text{ J/Hz}$$

$$\begin{matrix} E_3 \\ E_2 \\ E_1 \\ 0 \end{matrix}$$

- (ii) The change of energy of the oscillator due to emission and absorption of radiant energy can also take place by a discrete value $h\nu$.

Calculation: The no. of oscillator per unit volume within the frequency range ν to $\nu + d\nu$ is

$$N(\nu) d\nu = \frac{8\pi \nu^2}{c^3} d\nu$$

The average energy of the oscillator having frequency ν ,

$$\bar{E} = \frac{\varepsilon_0 P(\varepsilon_0) + \varepsilon_1 P(\varepsilon_1) + \varepsilon_2 P(\varepsilon_2) + \dots}{P(\varepsilon_0) + P(\varepsilon_1) + P(\varepsilon_2) + \dots}$$

$$= \frac{\sum_{n=0}^{\infty} \varepsilon_n P(\varepsilon_n)}{\sum_{n=0}^{\infty} P(\varepsilon_n)}$$

$$P(\varepsilon_n) \propto e^{-\frac{E_n}{kT}}$$

$$P(\varepsilon_n) = C e^{-\frac{E_n}{kT}}$$

Notes :

OCTOBER						
WK	S	M	T	W	T	F
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

2017
SEPTEMBER ♦ THURSDAY

37th Week • 250-115

(07)

$$\sum P(E_n) = c_1 \sum e^{-E_n/kT}$$

$$\Rightarrow 1 = c_1 \sum e^{-E_n/kT}$$

$$f_{C_1} = \frac{1}{\sum e^{-E_n/kT}}$$

$$P(E_n) = \frac{e^{-E_n/kT}}{\sum e^{-E_n/kT}}$$

$$\bar{E} = \frac{\sum_{n=0}^{\infty} E_n \cdot e^{-E_n/kT}}{\sum_{n=0}^{\infty} e^{-E_n/kT}}$$

$$= \frac{\sum_{n=0}^{\infty} nh\nu \cdot e^{-nh\nu/kT}}{\sum_{n=0}^{\infty} e^{-nh\nu/kT}}$$

$$\bar{E} = \frac{0 + h\nu e^{-h\nu/kT} + 2h\nu e^{-2h\nu/kT} + 3h\nu e^{-3h\nu/kT} + \dots}{1 + e^{-h\nu/kT} + e^{-2h\nu/kT} + e^{-3h\nu/kT} + \dots}$$

$$= h\nu e^{-h\nu/kT} \left[\frac{1 + 2e^{-h\nu/kT} + 3e^{-2h\nu/kT} + \dots}{1 + e^{-h\nu/kT} + e^{-2h\nu/kT} + \dots} \right]$$

$$\left[e^{-h\nu/kT} = x \right] = \frac{h\nu x \left[1 + 2x + 3x^2 + \dots \right]}{1 + x + x^2 + \dots}$$

08)

2017

FRIDAY ♦ SEPTEMBER

37th Week • 201-114

AUGUST 2017							SEPTEMBER 2017							
WK	S	M	T	W	T	F	S	WK	S	M	T	W	T	F
31		1	2	3	4	5	35							
32	6	7	8	9	10	11	12	36	3	4	5	6	7	8
33	13	14	15	16	17	18	19	37	10	11	12	13	14	15
34	20	21	22	23	24	25	26	38	17	18	19	20	21	22
35	27	28	29	30	31			39	24	25	26	27	28	29

$$= \frac{h\nu \cdot x}{(1-x)} \frac{(1-x)^{-2}}{(1-x)^{-1}}$$

$$= h\nu \cdot x \cdot (1-x)^{-1}$$

$$= \frac{h\nu \cdot x}{1-x}$$

$$= \frac{h\nu}{\frac{1}{x} - 1}$$

$$\bar{\epsilon} = \frac{h\nu}{e^{\frac{h\nu}{kT}} - 1}$$

*

*

*

*

For shorter frequency range

$$e^{\frac{h\nu}{kT}} - 1 \approx \frac{h\nu}{kT}$$

$$\therefore \bar{\epsilon} = kT$$

The energy density within the frequency range ν to $\nu + d\nu$ is given by $V_\nu d\nu = N(\nu) d\nu \times \bar{\epsilon}$

$$= \frac{8\pi\nu^2}{c^3} d\nu \times \frac{h\nu}{e^{\frac{h\nu}{kT}} - 1}$$

Notes:

(*) $V_\nu d\nu = \frac{8\pi h\nu^3}{c^3 [e^{\frac{h\nu}{kT}} - 1]} d\nu$

OCTOBER 2017			NOVEMBER 2017			
WEEK	S	M	T	W	F	
40	1	2	3	4	5	6
41	8	9	10	11	12	13
42	15	16	17	18	19	20
43	22	23	24	25	26	27
44	29	30	31			
	44	1	2	3	4	
	45	5	6	7	8	9
	46	12	13	14	15	16
	47	19	20	21	22	23
	48	26	27	28	29	30

2017
SEPTEMBER ♦ SATURDAY

09
37th Week • 252-113

in terms of wave length

$$U_\lambda d\lambda = - U_\nu d\nu$$

$$\frac{8\pi hc^3}{c^3 \cdot \lambda^3 \left[e^{\frac{hc}{\lambda kT}} - 1 \right]} \cdot \frac{c}{\lambda^2} d\lambda$$

$$U_\lambda d\lambda = \frac{8\pi hc}{\lambda^5 \left[e^{\frac{hc}{\lambda kT}} - 1 \right]} d\lambda$$

Planck's → Wein's distribution law.

$$U_\lambda d\lambda = \frac{8\pi hc}{\lambda^5 \left[e^{\frac{hc}{\lambda kT}} - 1 \right]} d\lambda$$

For shorter wavelength region,

$$\left[e^{\frac{hc}{\lambda kT}} - 1 \right] \approx e^{\frac{hc}{\lambda kT}}$$

$$U_\lambda d\lambda = \frac{8\pi hc}{\lambda^5 e^{\frac{hc}{\lambda kT}}} d\lambda = \frac{a}{\lambda^5} \exp(-\frac{b}{\lambda T}) d\lambda$$

$$a = 8\pi hc; b = \frac{hc}{k}$$

SUNDAY 10

2017

MONDAY ♦ SEPTEMBER

AUGUST 2017						SEPTEMBER 2017									
WEEK	S	M	T	W	F	S	WEEK	S	M	T	W	F			
31		1	2	3	4	5	35		1	2					
32	6	7	8	9	10	11	36	3	4	5	6	7	8	9	
33	13	14	15	16	17	18	19	37	10	11	12	13	14	15	16
34	20	21	22	23	24	25	26	38	17	18	19	20	21	22	23
35	27	28	29	30	31			39	24	25	26	27	28	29	30

Planck's → R-J law

$$U_\lambda d\lambda = \frac{8\pi hc}{\lambda^5} \left[\frac{hc}{e^{\frac{hc}{\lambda KT}} - 1} \right] d\lambda$$

for longer wavelengths

$$e^{\frac{hc}{\lambda KT}} - 1 \approx \frac{hc}{\lambda KT}$$

$$\therefore U_\lambda d\lambda = \frac{8\pi hc}{\lambda^5} \left(\frac{hc}{\lambda KT} \right) d\lambda$$

$$= \frac{8\pi KT}{\lambda^4} d\lambda \rightarrow \text{R-J's law}$$

Q] $K \cdot E = 1 \text{ MeV}$ of an electron. Calculate momentum.

$$KE = E - mc^2$$

$$\Rightarrow (1 + 0.59) \text{ MeV} = E$$

$$\therefore E^2 = p^2 c^2 + (0.59)^2$$

$$\Rightarrow p = 1.47 \text{ MeV}/c$$

Notes :

NOVEMBER 2017		
S	T	F
1	2	3
4	5	6
7	8	9
10	11	12
13	14	15
16	17	18
19	20	21
22	23	24
25	26	27
28	29	30
29	30	31

2017

SEPTEMBER ♦ TUESDAY

38th Week • 255-110

(12)

Planck's \rightarrow Wein's displacement law.

$$U_\lambda d\lambda = \frac{8\pi n c}{\lambda^5} \left[e^{\frac{hc}{\lambda kT}} - 1 \right] d\lambda$$

at $\lambda = \lambda_m$; U_λ is max.

so the denominator will be min.

$$\text{Let } y = \lambda^5 \left(e^{\frac{hc}{\lambda kT}} - 1 \right).$$

$$\left. \frac{dy}{d\lambda} \right|_{\lambda=\lambda_m} = 0$$

$$\Rightarrow 5\lambda_m^4 \left(e^{\frac{hc}{\lambda_m kT}} - 1 \right) + \lambda^5 \frac{5}{e^{\frac{hc}{\lambda kT}}} \left(-\frac{hc}{\lambda^2 kT} \right) = 0$$

$$\Rightarrow 5\lambda_m^4 \left(e^{\frac{hc}{\lambda_m kT}} - 1 \right) + \lambda^5 \frac{5}{e^{\frac{hc}{\lambda_m kT}}} \cdot \frac{hc}{kT} = 0$$

$$\Rightarrow 5 \left(\frac{hc}{e^{\frac{hc}{\lambda_m kT}}} - 1 \right) = \frac{hc}{\lambda_m kT} e^{\frac{hc}{\lambda_m kT}}$$

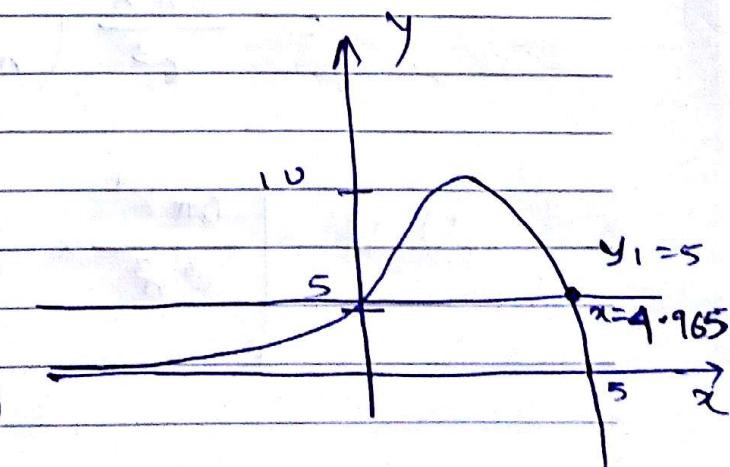
$$\text{Let } \frac{hc}{\lambda_m kT} = x.$$

$$\therefore 5(e^x - 1) = x \cdot e^x$$

$$\therefore e^x(5-x) = 5$$

$$\text{Let } y_1 = 5$$

$$y_2 = e^x(5-x)$$



13)

2017

WEDNESDAY ♦ SEPTEMBER

38th Week • 256-109

AUGUST 2017							SEPTEMBER 2017							
WK	S	M	T	W	T	F	S	WK	S	M	T	W	T	F
31			1	2	3	4	5	35						1
32	6	7	8	9	10	11	12	36	3	4	5	6	7	8
33	13	14	15	16	17	18	19	37	10	11	12	13	14	15
34	20	21	22	23	24	25	26	38	17	18	19	20	21	22
35	27	28	29	30	31			39	24	25	26	27	28	29

$$\lambda = 4.965 = \frac{hc}{\lambda_m kT}$$

$$\Rightarrow \lambda_m kT = \frac{hc}{4.965 \times k} = 2.9 \times 10^{-3} \text{ mK}$$

(4) Planck's - Stefan's law

From Planck's law,

$$U_V d\nu = \frac{8\pi h \nu^3}{c^3 [e^{h\nu/kT} - 1]} d\nu$$

$$U = \int_0^\infty U_V d\nu$$

$$= \int_0^\infty \frac{8\pi h \nu^3}{c^3 [e^{h\nu/kT} - 1]} d\nu$$

$$= \frac{8\pi h}{c^3} \int_0^\infty \frac{\nu^3 d\nu}{e^{h\nu/kT} - 1}$$

$$= \frac{8\pi h^3}{c^3} \left(\frac{kT}{h} \right)^3 \times \frac{kT}{h} \int_0^\infty \frac{x^3 dx}{e^x - 1}$$

$$\frac{h}{kT} = x$$

$$\frac{\pi^4}{15}$$

Notes: $\Rightarrow U = \left[\frac{8\pi k^4}{c^3 h^3} \times \frac{\pi^4}{15} \right] T^4$

OCTOBER		NOVEMBER 2017				
WEEK	S	M	T	W	T	F
1	1	2	3	4	5	6
2	7	8	9	10	11	12
3	13	14	15	16	17	18
4	19	20	21	22	23	24
5	25	26	27	28	29	30
6	31					

2017

SEPTEMBER ♦ THURSDAY

(14)

38th Week • 257-108

$$E = \frac{C}{4} \times U$$

$$= \left[\frac{2\pi^5 k^4}{15 c^2 h^3} \right] T^4$$

$$\Rightarrow E = (5.6 \times 10^{-8}) T^4$$

$$E = 5 T^4$$

$$\sigma = \text{Watt} / m^2 \cdot K^4$$

Photo-electric effect (Experimental curve)

