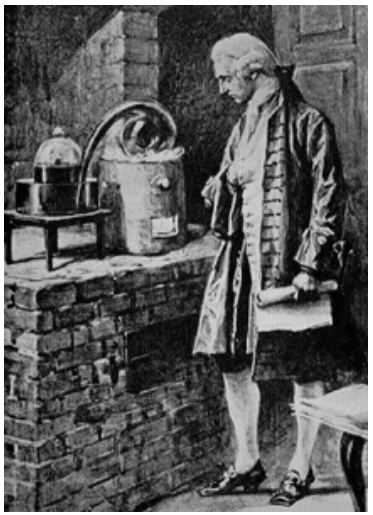
מבוא לתורת היחסות הפרטית

פרופסור צבי מזא"ה

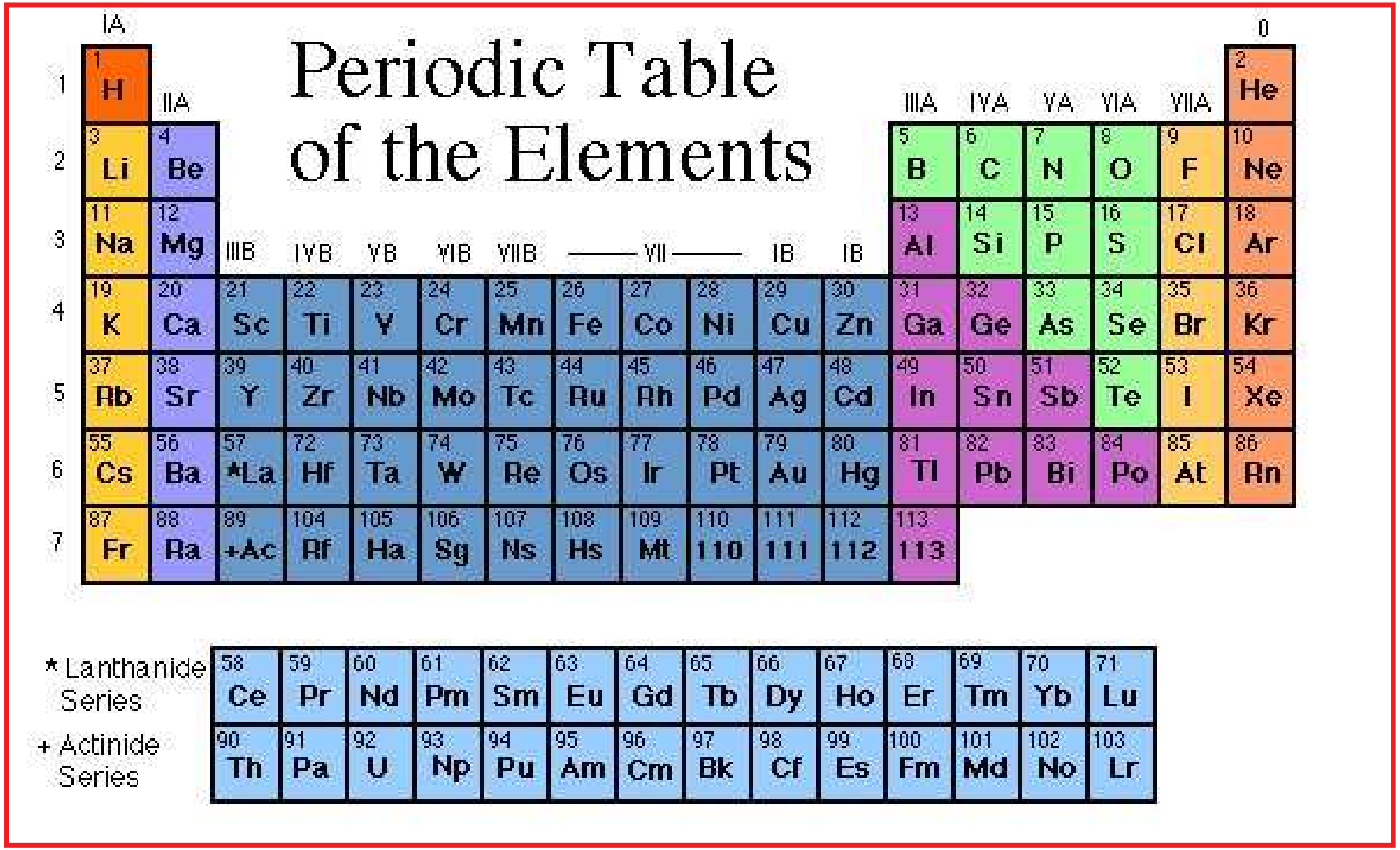
Lavoisier (1743-1794):

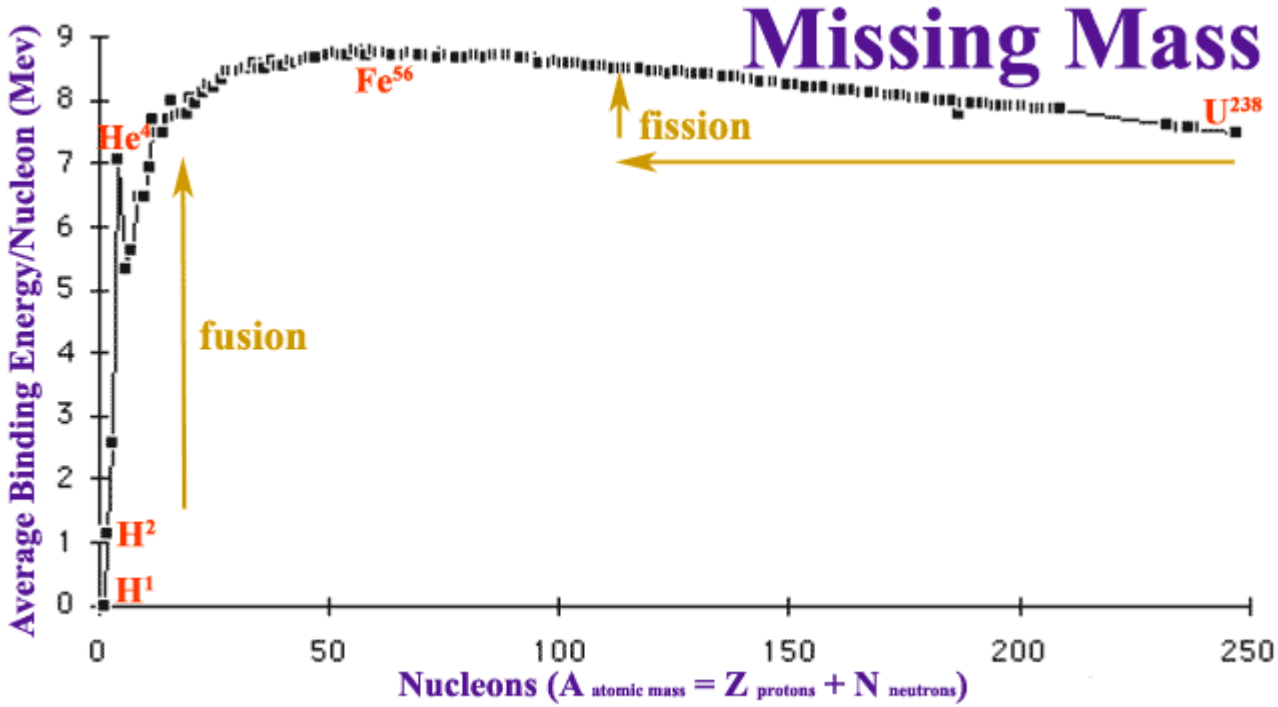


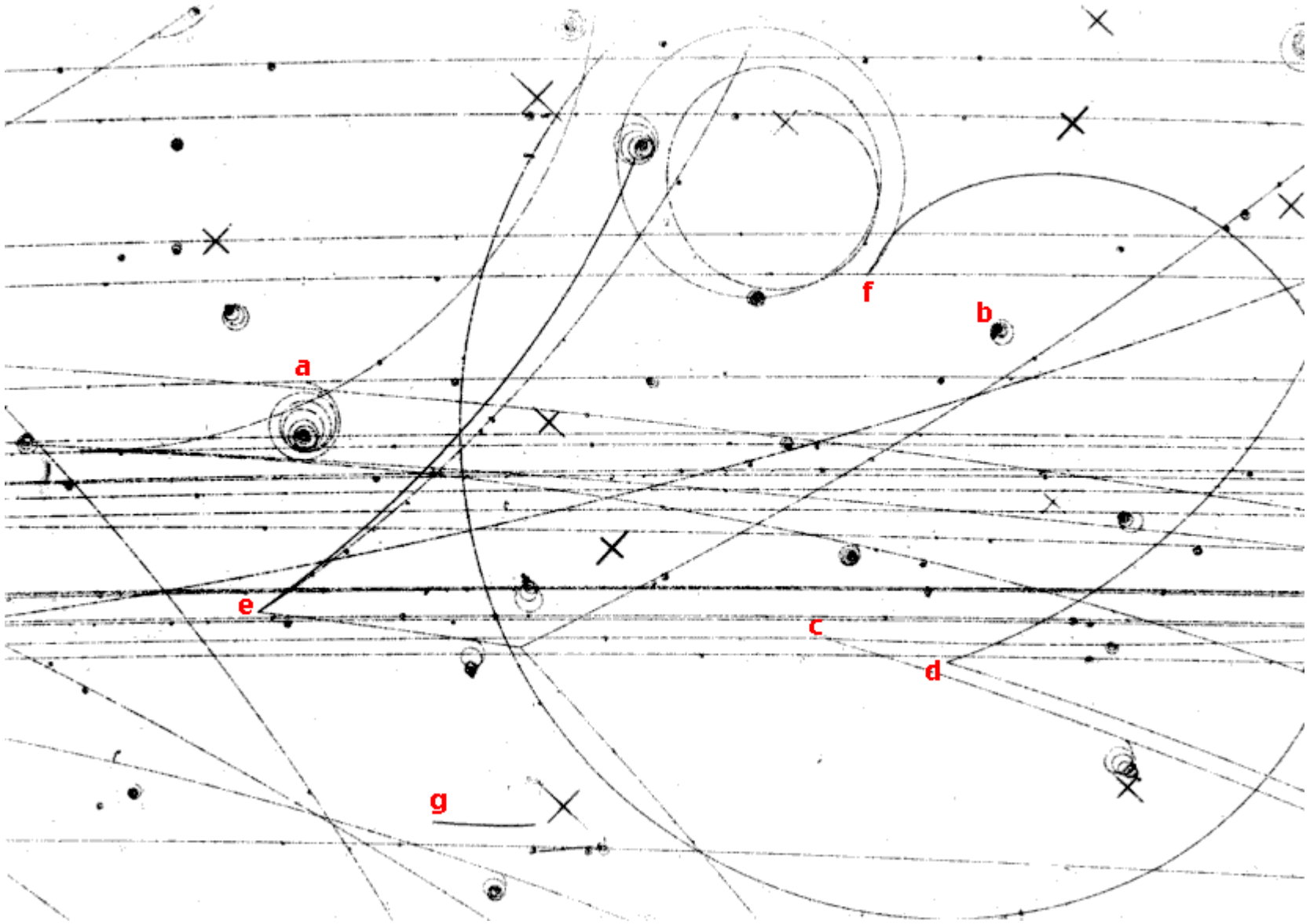
Joseph-Louis Lagrange, remarked of this event,
"It took them only an instant to cut off that head,
and a hundred years may not produce another
like it."

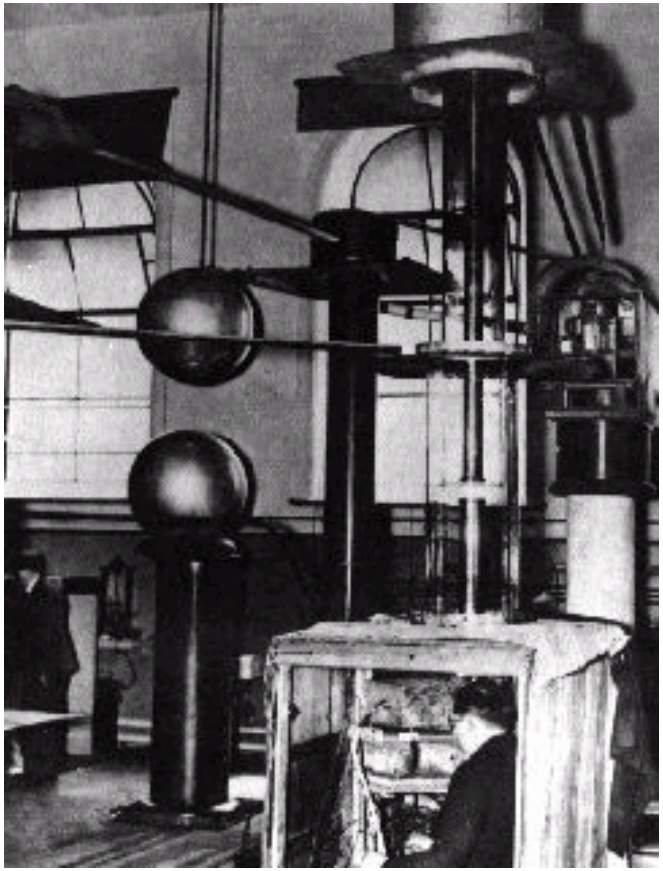
James Prescott Joule (1818 – 1889) :

חוק שימור האנרגיה


Periodic Table of the Elements
IA
IIA
IIIB
IVB
VB
VIB
VIIB
VII
IB
IB
IIIA
IVA
VA
VIA
VIIA
0
1 H
2 He
3 Li
4 Be
5 B
6 C
7 N
8 O
9 F
10 Ne
11 Na
12 Mg
13 Al
14 Si
15 P
16 S
17 Cl
18 Ar
19 K
20 Ca
21 Sc
22 Ti
23 V
24 Cr
25 Mn
26 Fe
27 Co
28 Ni
29 Cu
30 Zn
31 Ga
32 Ge
33 As
34 Se
35 Br
36 Kr
37 Rb
38 Sr
39 Y
40 Zr
41 Nb
42 Mo
43 Tc
44 Ru
45 Rh
46 Pd
47 Ag
48 Cd
49 In
50 Sn
51 Sb
52 Te
53 I
54 Xe
55 Cs
56 Ba
57 *La
72 Hf
73 Ta
74 W
75 Re
76 Os
77 Ir
78 Pt
79 Au
80 Hg
81 Tl
82 Pb
83 Bi
84 Po
85 At
86 Rn
87 Fr
88 Ra
89 +Ac
104 Rf
105 Ha
106 Sg
107 Ns
108 Hs
109 Mt
110 110
111 111
112 112
113 113
* Lanthanide Series
+ Actinide Series
58 Ce
59 Pr
60 Nd
61 Pm
62 Sm
63 Eu
64 Gd
65 Tb
66 Dy
67 Ho
68 Er
69 Tm
70 Yb
71 Lu
90 Th
91 Pa
92 U
93 Np
94 Pu
95 Am
96 Cm
97 Bk
98 Cf
99 Es
100 Fm
101 Md
102 No
103 Lr


Missing Mass
Average Binding Energy/Nucleon (Mev)
Nucleons (A atomic mass = Z protons + N neutrons)
Fe56
U238
He4
H2
H1
fission
fusion
0
1
2
3
4
5
6
7
8
9
0
50
100
150
200
250


a
b
c
d
e
f
g



Cockroft

1897-1967

Walton

1903-1995

Nobel Prize, 1951:

"for their pioneer work on the transmutation of atomic nuclei by artificially accelerated atomic particles"

Emilio Gino Segrè

(1905-1989)

Owen Chamberlain

(1920-)

Nobel Prize of 1959:

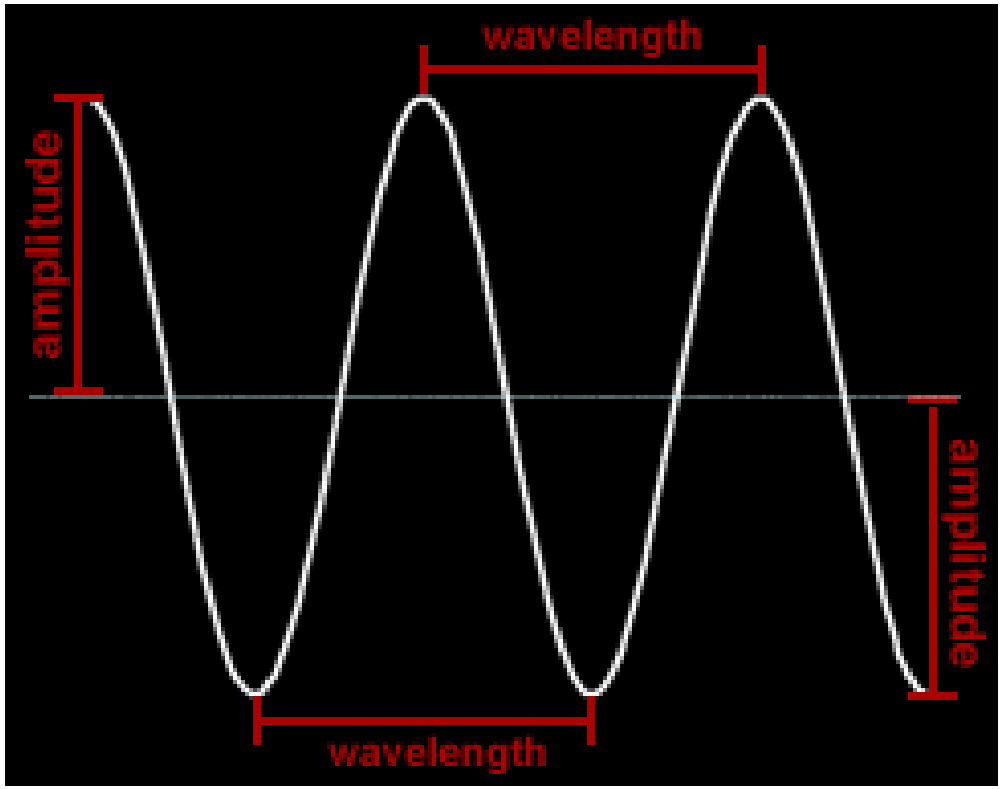
for their discovery of the antiproton

יצירת האנטי פרוטון

Bevatron

Chamberlain, Segrè,

Light Waves



Light waves:

Characterized by:

- Amplitude (A)
- Frequency (ν)
- Wavelength (λ)

Energy α A^2

המיקום של הפוטון

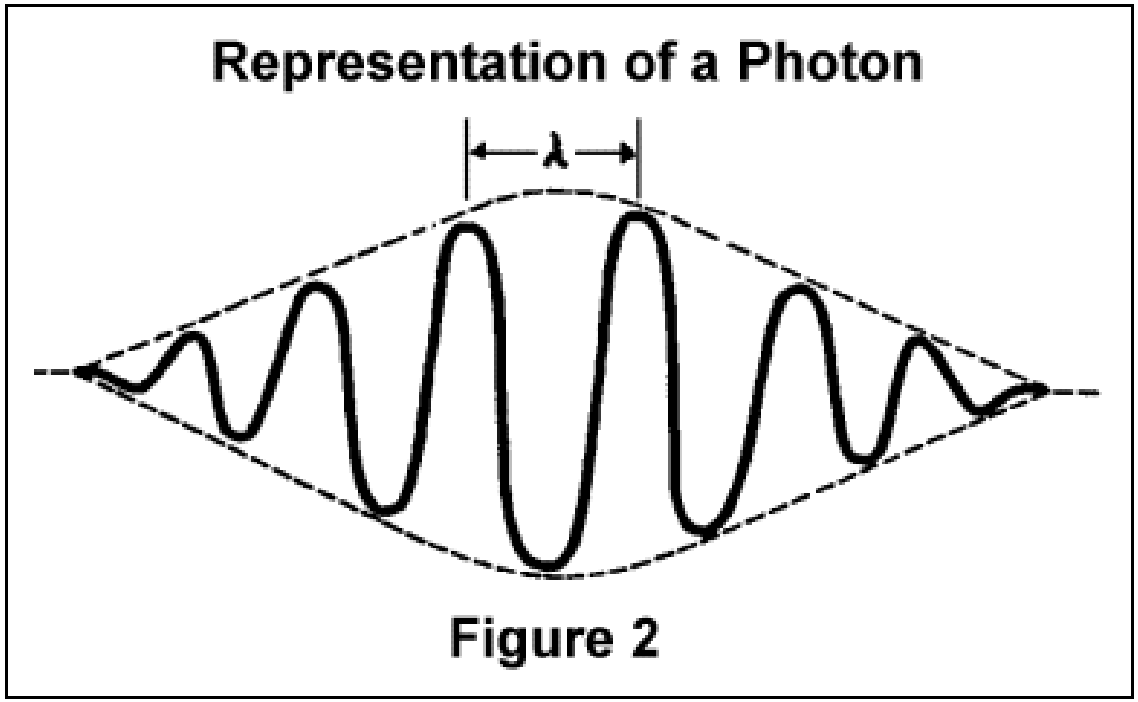
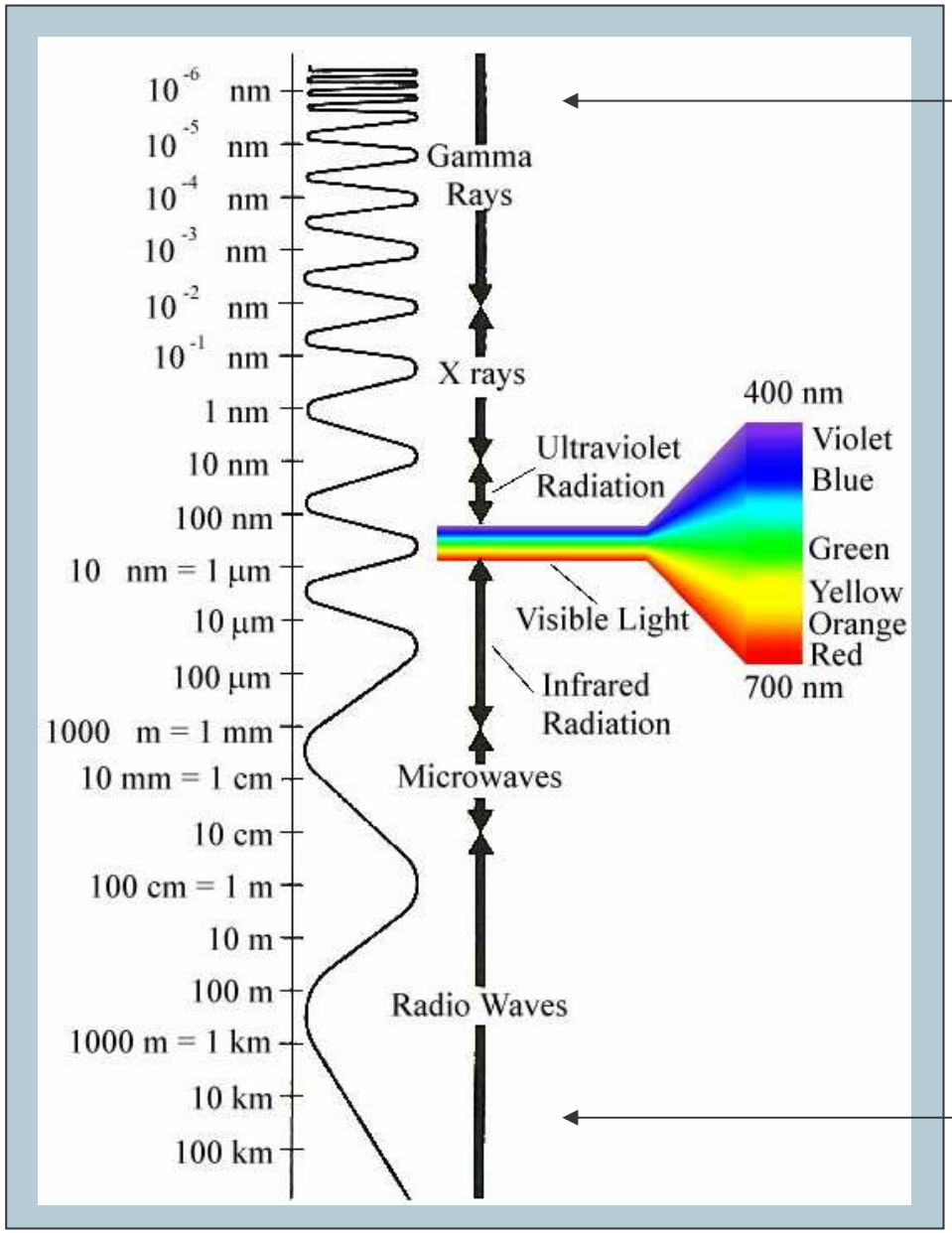


Figure 2

הספקטרום האלקטרומגנטי



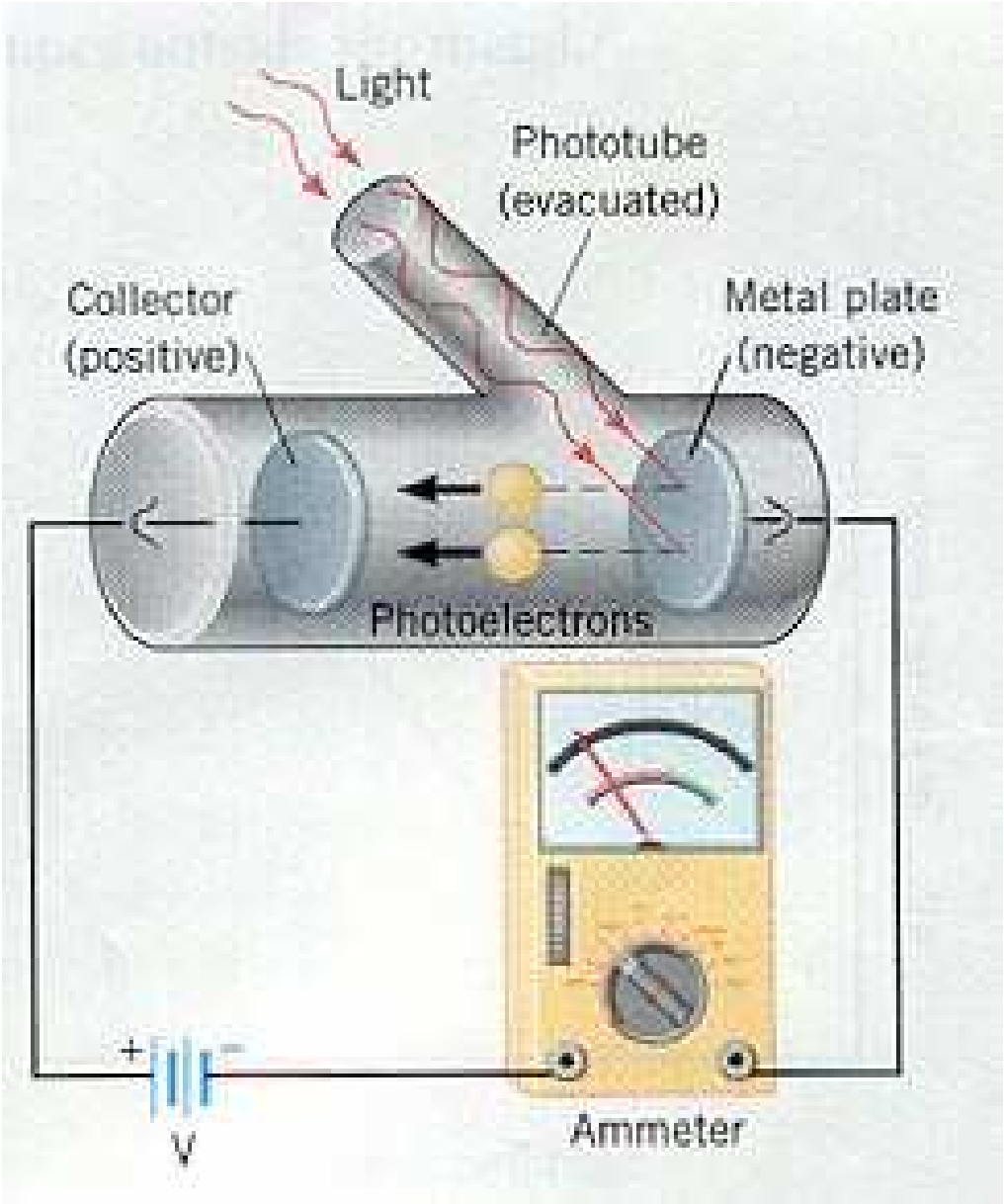
Shortest wavelengths
(Most energetic photons)

$$E = h\nu = hc/\lambda$$

$h = 6.6 \times 10^{-34}$ [J*sec]
(Planck's constant)

Longest wavelengths
(Least energetic photons)

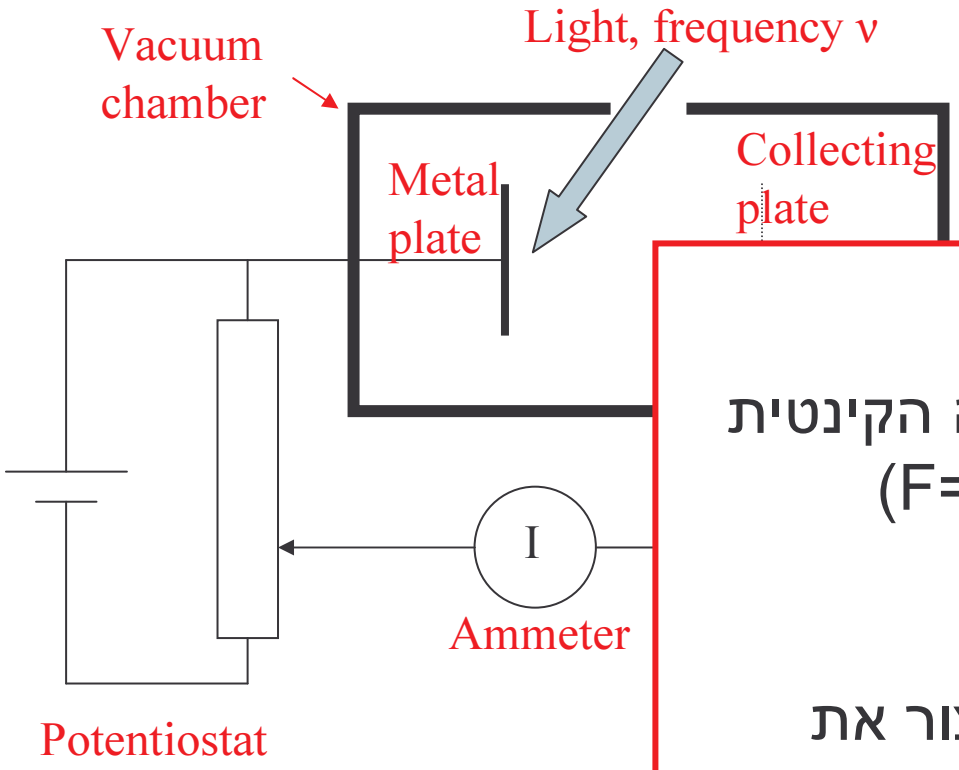
האפקט הפוטואלקטרי



PHOTOELECTRIC EFFECT

Hertz *J.J. Thomson*

When UV light is shone on a metal plate in a vacuum, it emits charged particles (Hertz 1887), which were later shown to be electrons by J.J. Thomson (1899).



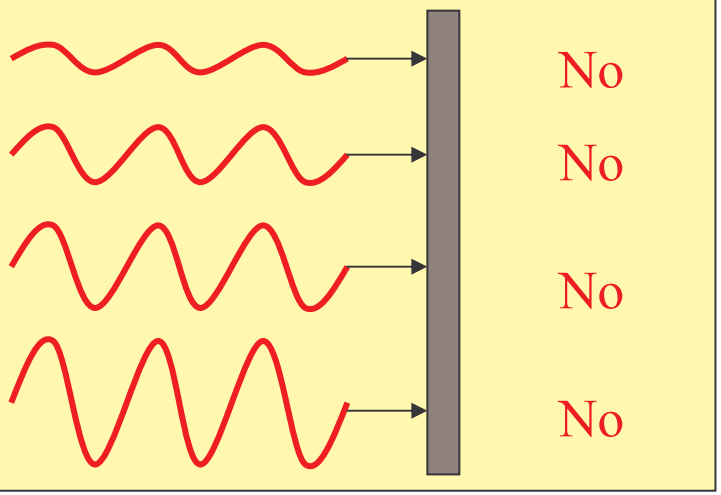
תיאוריה קלסית:

1. עצמת האור תגדיל את האנרגיה הקינטית של האלקטרונים הנפלטים (F=eE)
2. האפקט קיים לכל תדירות
3. בעצמה נמוכה דרוש זמן כדי ליצור את האפקט

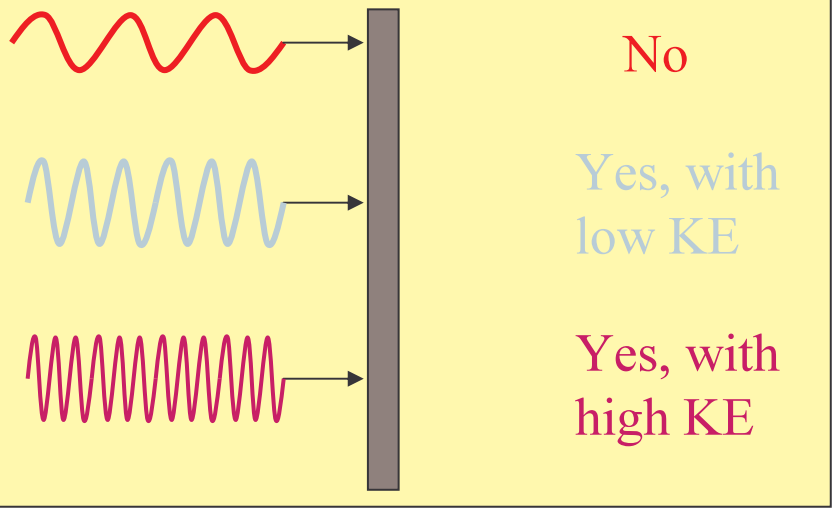
האפקט הפוטואלקטרי

השיטה הקלסית

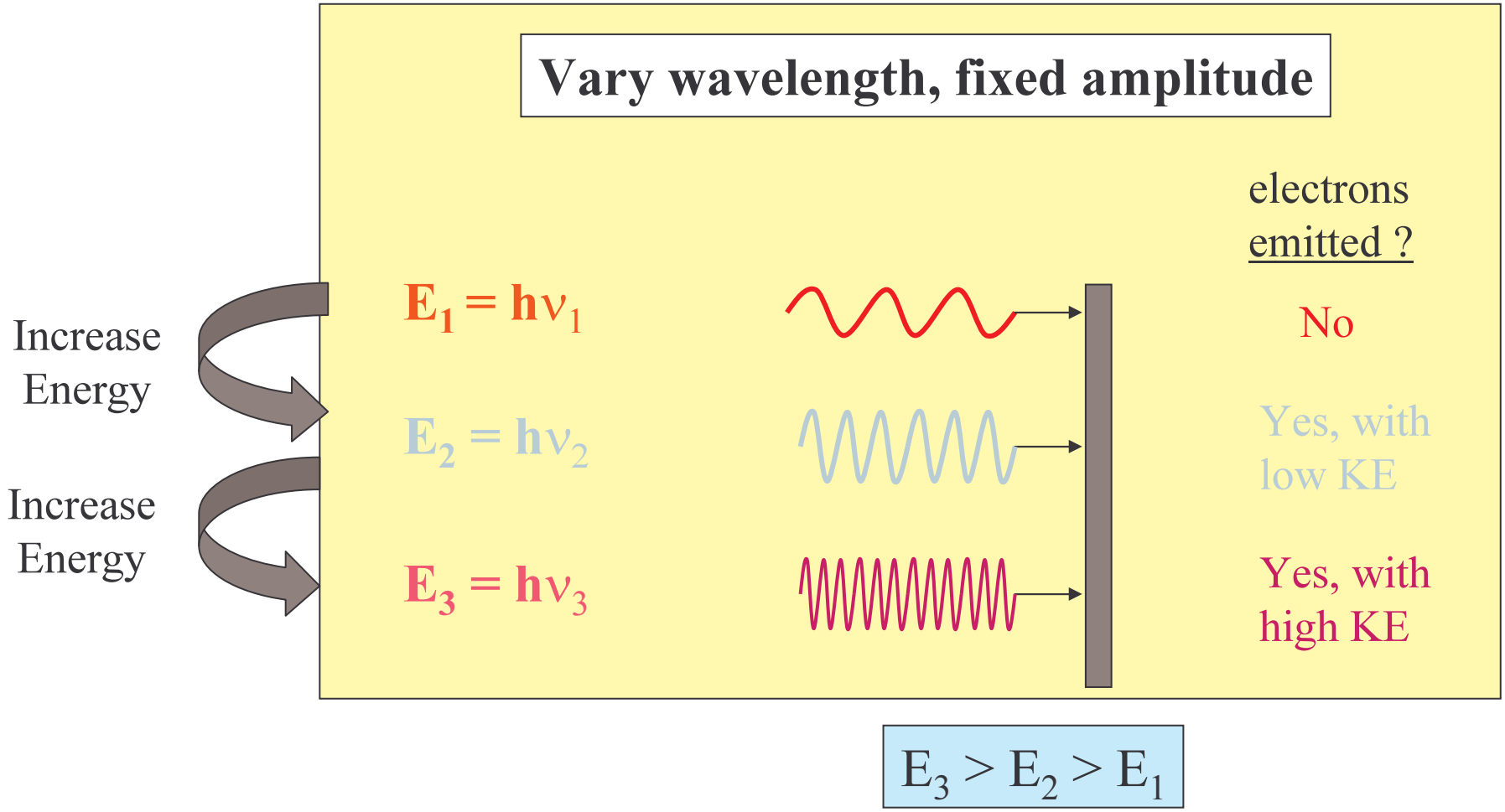
הגדלת האנרגיה על ידי עצמת הגל



שנוי באורך הגל



ההסבר של הניסוי:



PHOTOELECTRIC EFFECT (cont)

Einstein

Millikan

Actual results:

Maximum KE of ejected electrons is independent of intensity, but dependent on ν

For $\nu<\nu_0$ (i.e. for frequencies below a cut-off frequency) no electrons are emitted

There is no time lag. However, rate of ejection of electrons depends on light intensity.

Einstein's interpretation (1905):

Light comes in packets of energy (*photons*)

$$E = h\nu$$

An electron absorbs a single photon to leave the material

The maximum KE of an emitted electron is then

$$K_{\max} = h\nu - W$$

Planck constant: universal constant of nature

$h = 6.63\times10^{-34}$ Js

Work function: minimum energy needed for electron to escape from metal (depends on material, but usually 2-5eV)

Verified in detail through subsequent experiments by Millikan

רוברט מיליקן(1868-1953)

Nobel Prize, 1923,

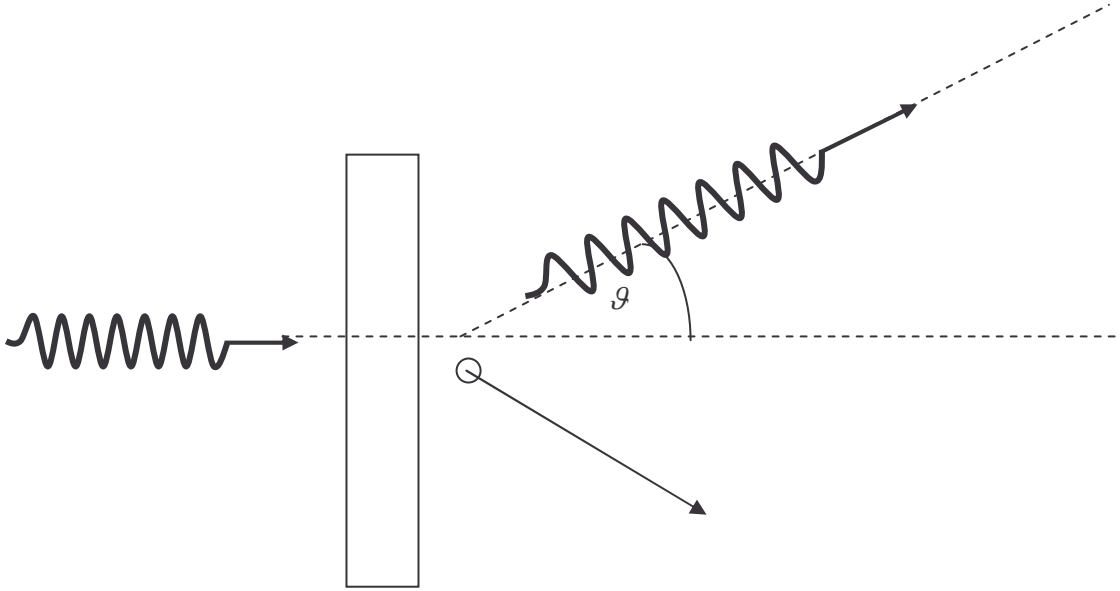
for his work on the elementary charge of electricity and on the photoelectric effect.

Compton (1892-1962)

Nobel prize, 1927,

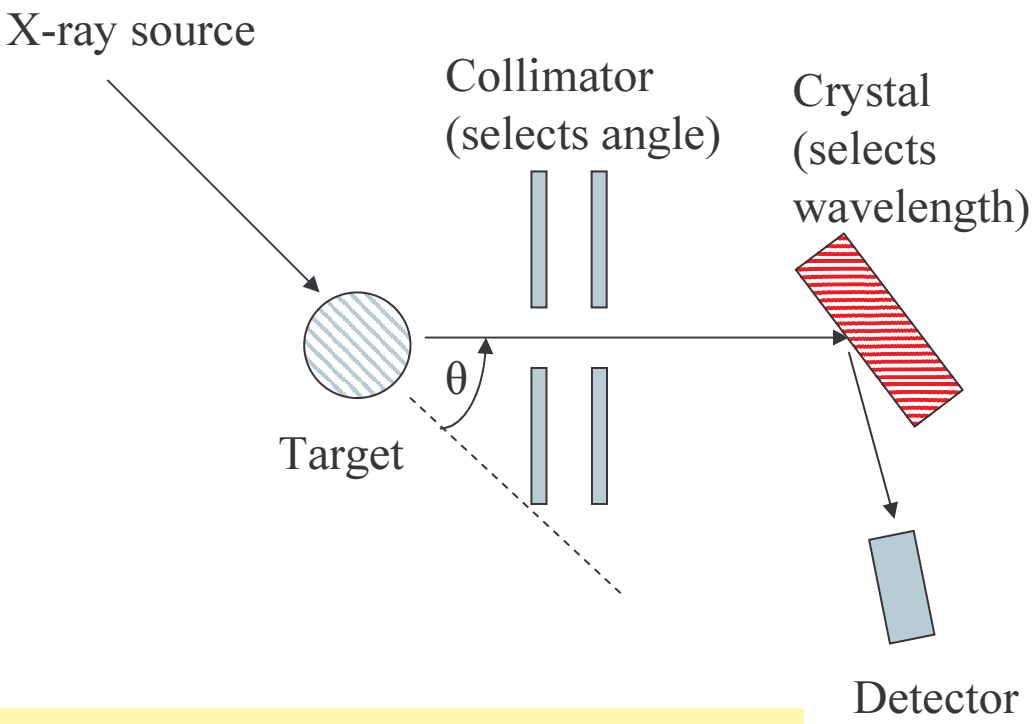
for his discovery of the effect named after him (performed in 1922)

אפקט קומפטון



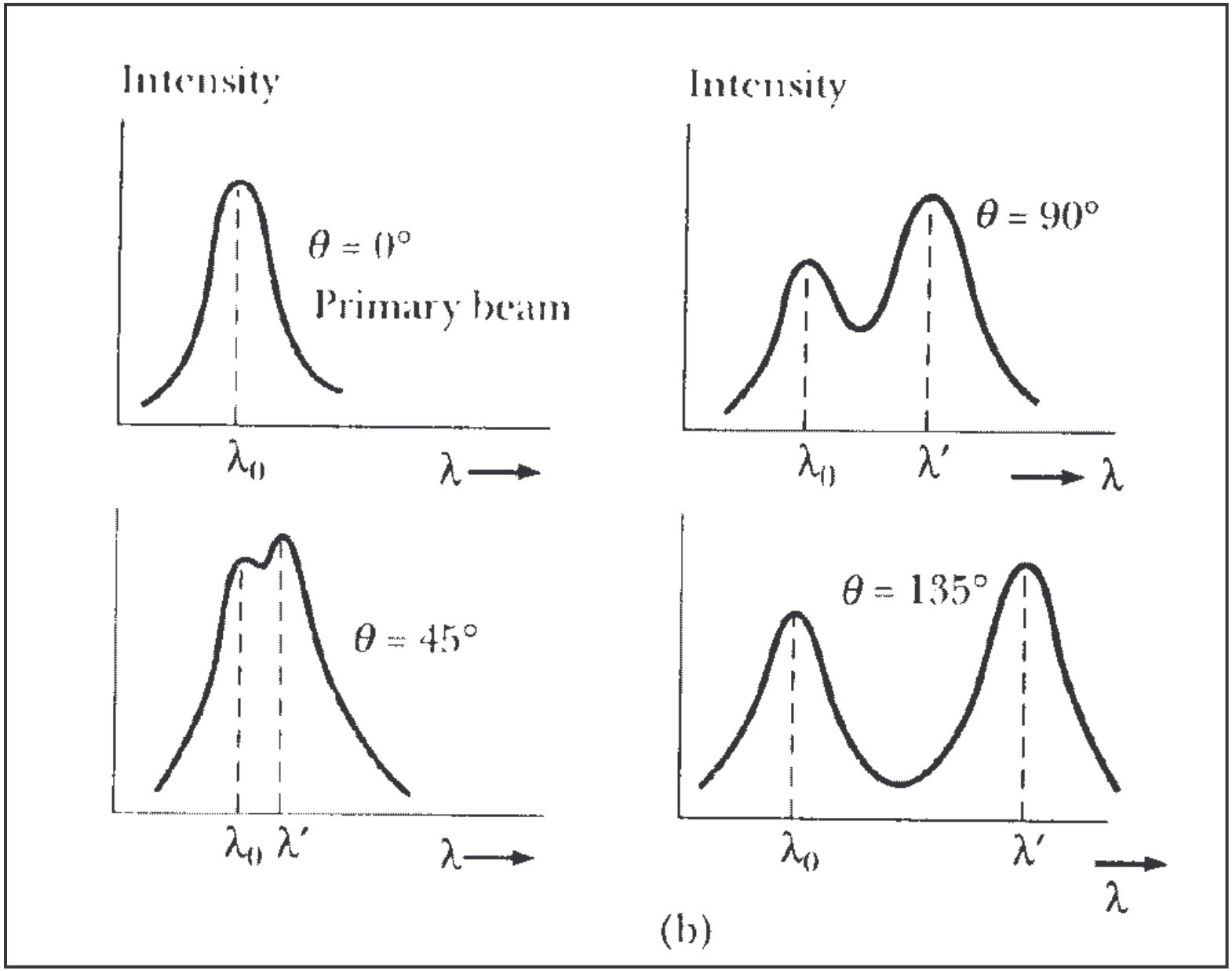
COMPTON SCATTERING

Compton (1923) measured intensity of scattered X-rays from solid target, as function of wavelength for different angles. He won the 1927 Nobel prize.



Result: peak in scattered radiation shifts to longer wavelength than source. Amount depends on θ (but not on the target material).

A.H. Compton, *Phys. Rev.* **22** 409 (1923)


Intensity
θ = 0°
Primary beam
λ0
λ
Intensity
θ = 90°
λ0
λ′
λ
θ = 45°
λ0 λ′
λ
θ = 135°
λ0
λ′
λ

(b)

אפקט קומפטון

$$\lambda_{compton} = \frac{h}{mc}$$

$$\lambda_{compton}(e) = 0.024 \ \mathring{A}$$