Ch. 4. Atomic Structures

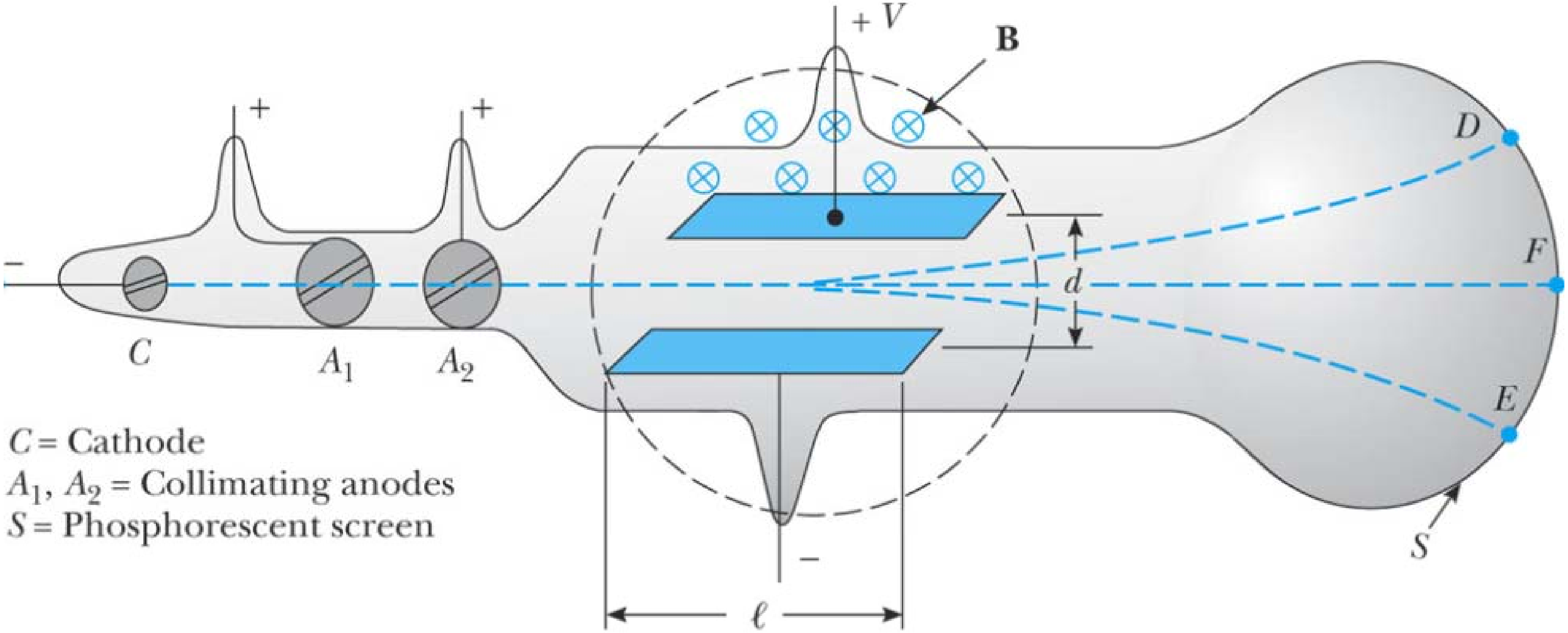
Niels Henrik David Bohr
(1885-1962)

Thomson

… he achieved the most brilliant work of his life - an original study of cathode rays culminating in the discovery of the electron, which was announced during the course of his evening lecture to the Royal Institution on Friday, April 30, 1897.

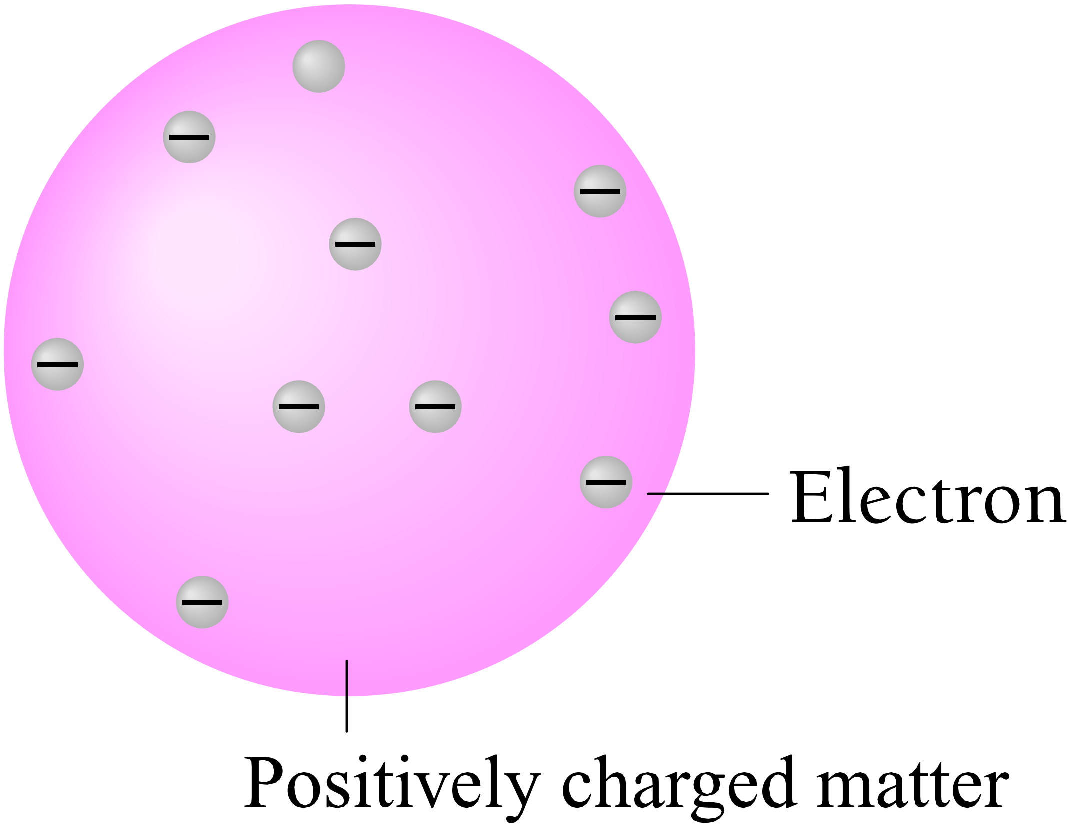
Joseph John Thomson (1856-1940)

http://nobelprize.org/physics/laureates/1906/thomson-bio.html

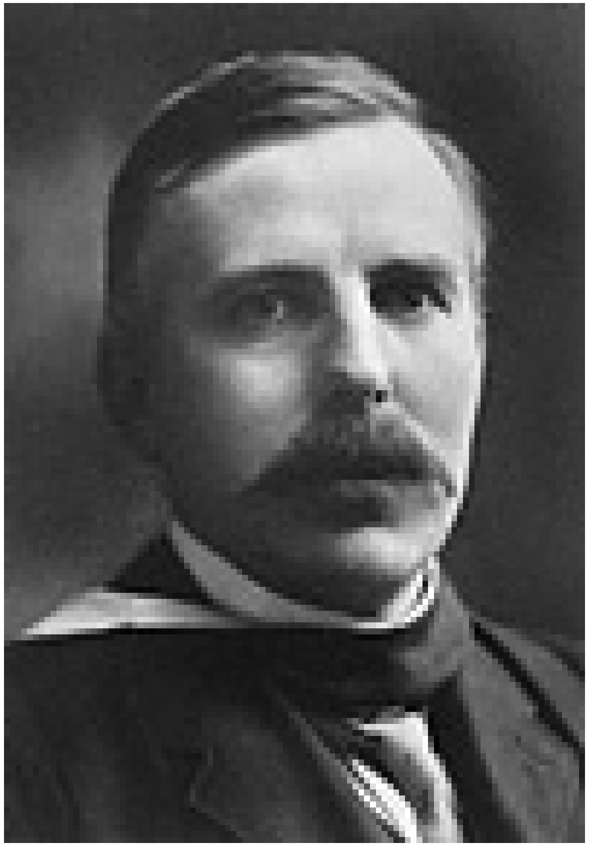


+ V
B
+
+
−
D
F
d
C
A_1
A_2
E
−
S
ℓ
C = Cathode
A_1, A_2 = Collimating anodes
S = Phosphorescent screen

Thomson의 원자 모델



Rutherford



Ernest Rutherford (1871-1937)

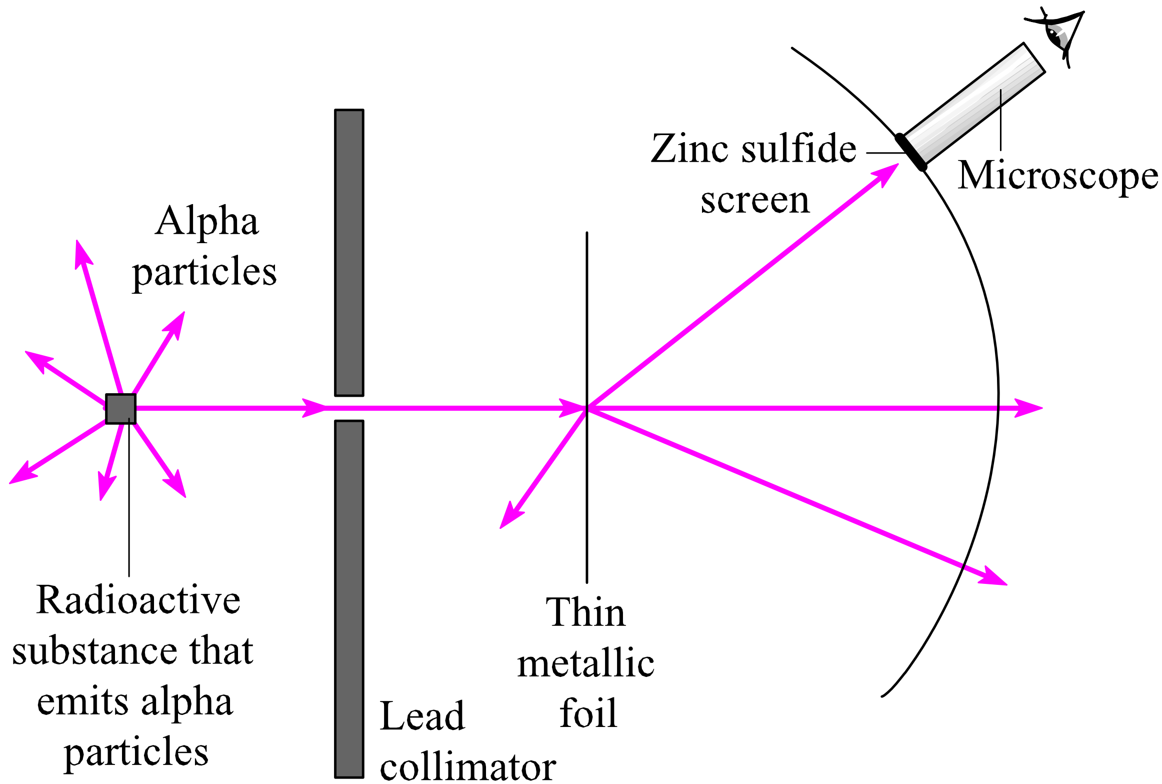
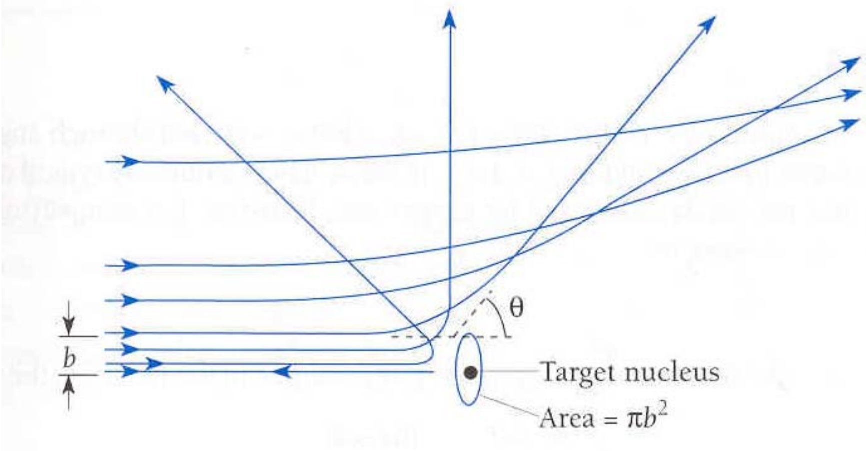
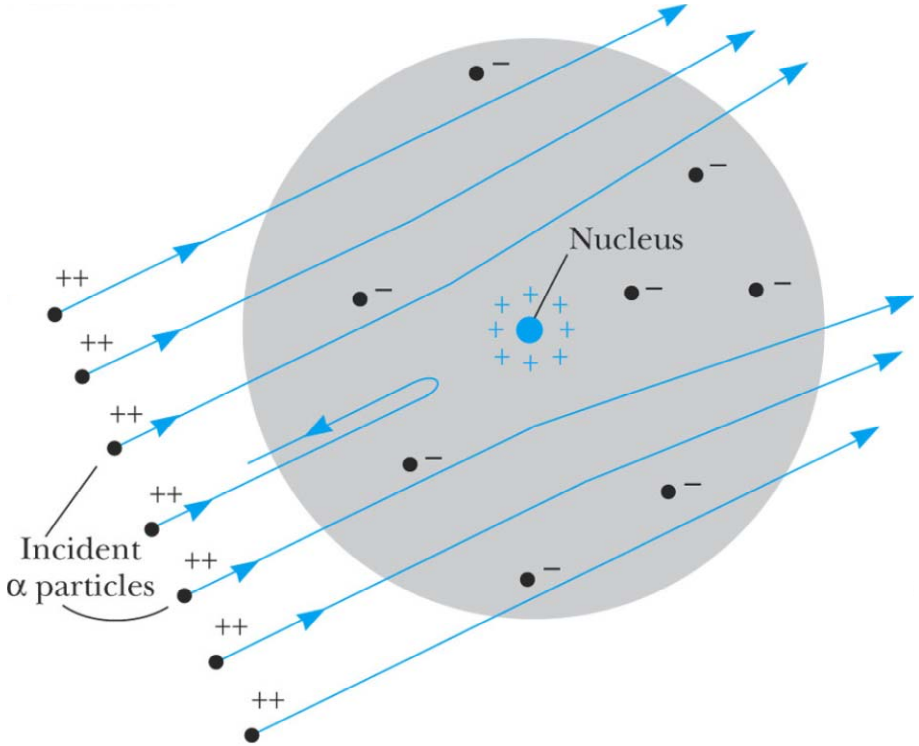


그림 4.2 Rutherford의 산란 실험

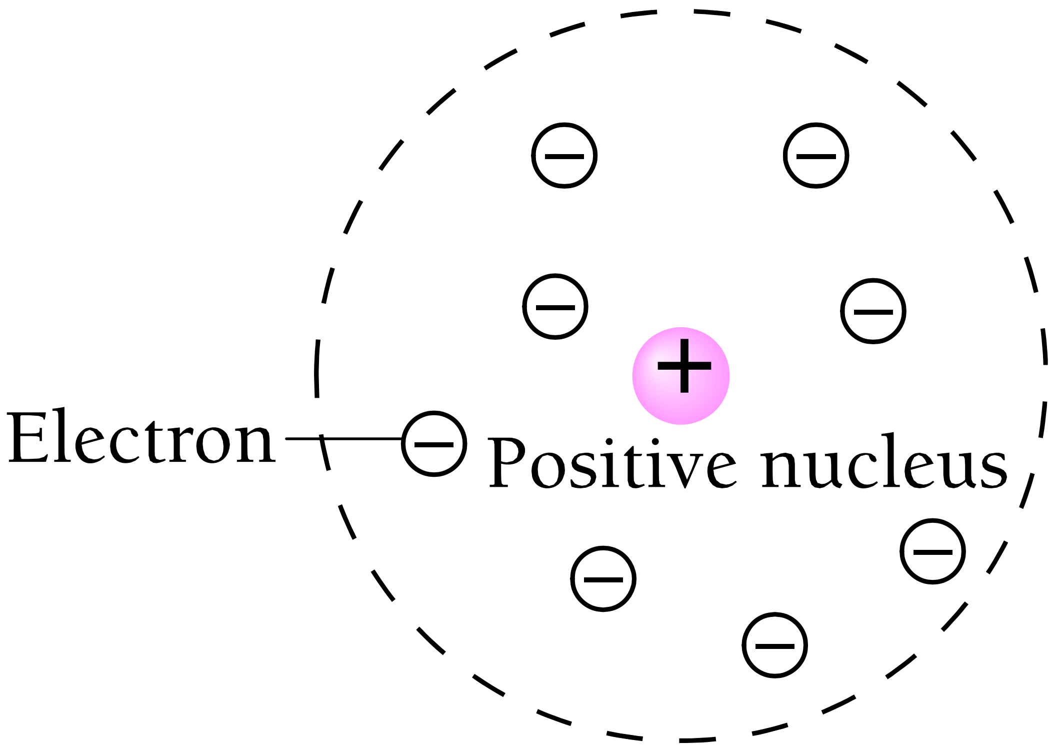


θ
b
Target nucleus
Area = πb²

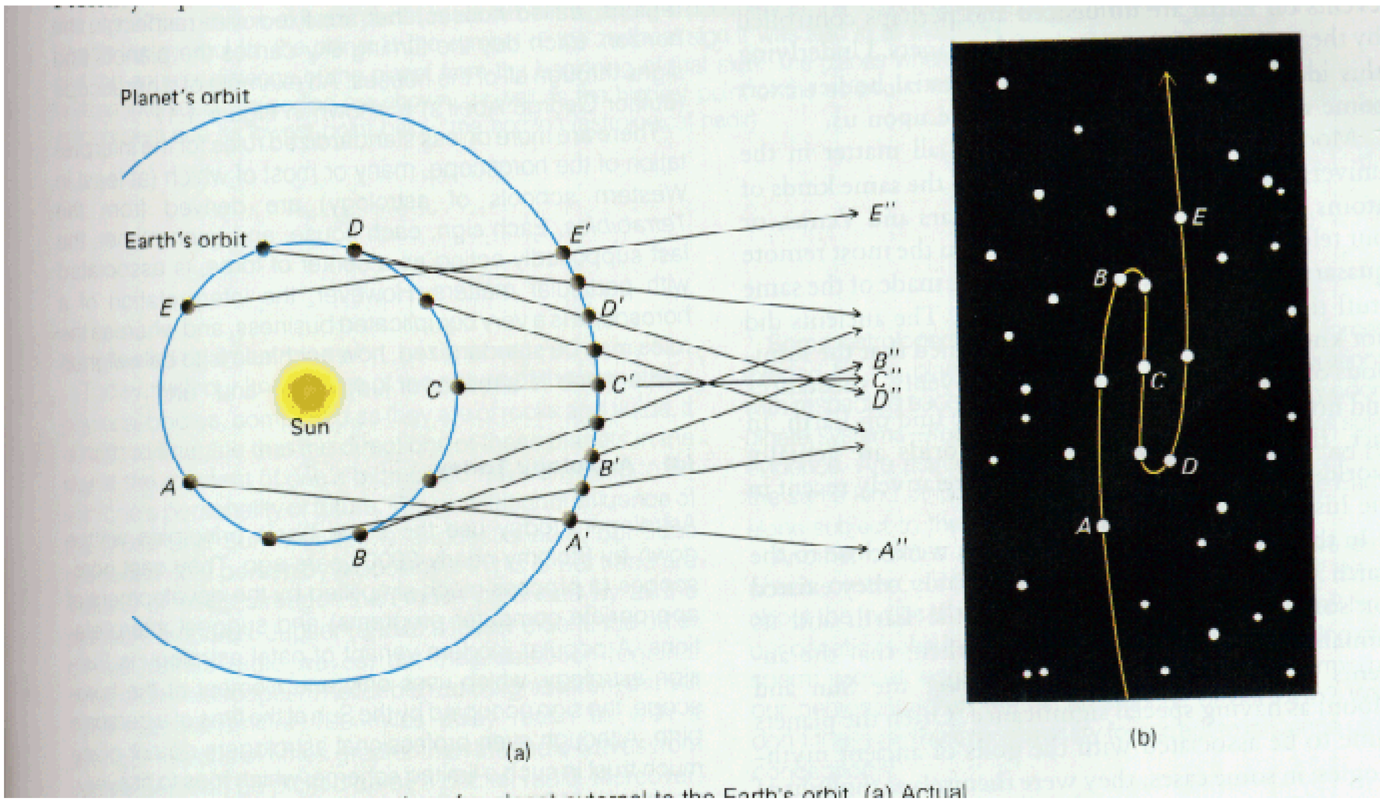


Nucleus
++
Incident
α particles

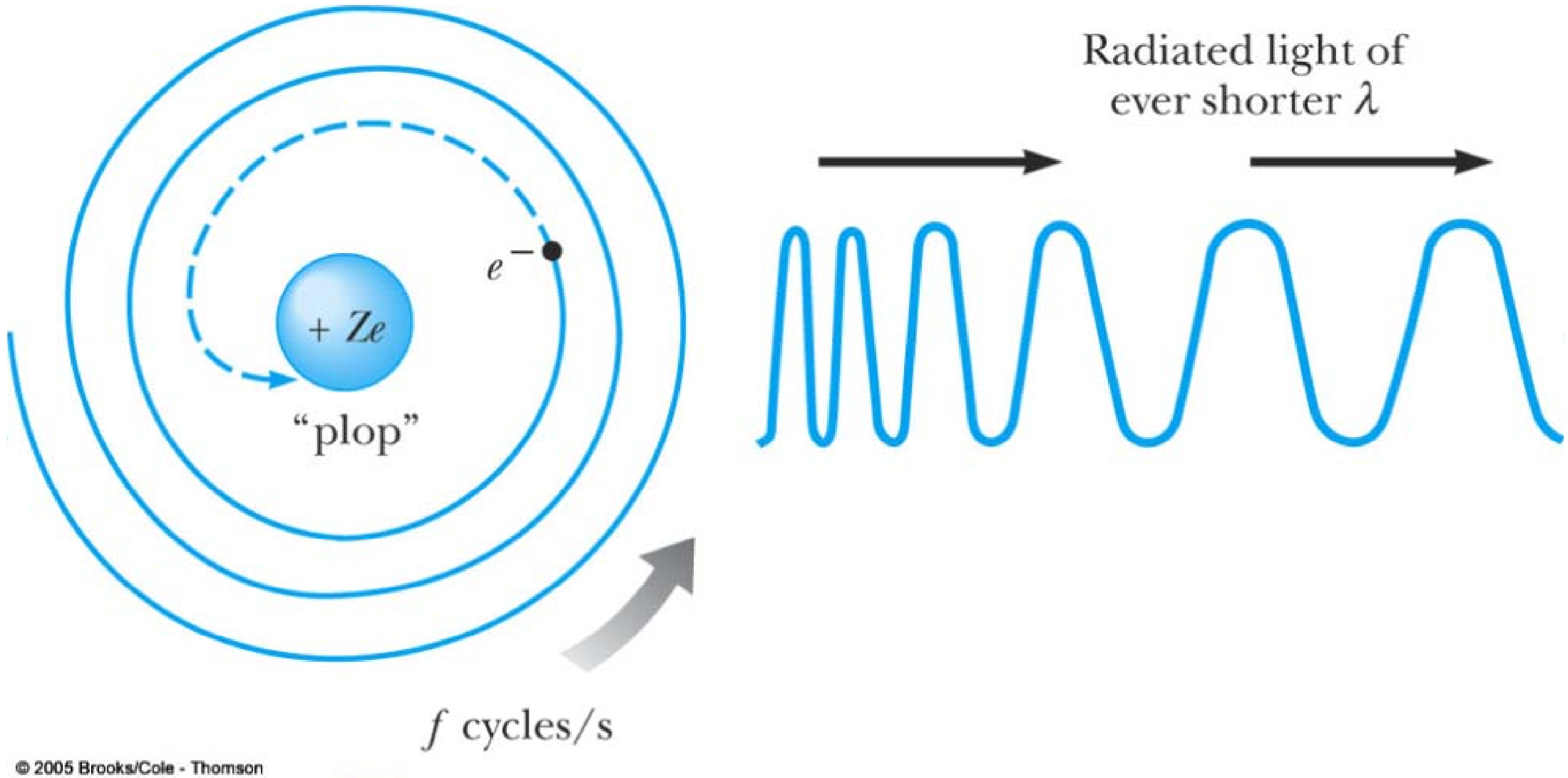
Rutherford의 원자 모델



태양과 행성 – No Problem



Dilemma


+ Ze
e^-
"plop"
Radiated light of ever shorter λ
f cycles/s
© 2005 Brooks/Cole - Thomson

왜? - Maxwell's Equations

$$\vec{\nabla}\cdot\vec{D}=\rho$$

$$\vec{\nabla}\cdot\vec{B}=0$$

$$\vec{\nabla}\times\vec{E}=-\frac{\partial\vec{B}}{\partial t}$$

$$\vec{\nabla}\times\vec{H}=\vec{J}+\frac{\partial\vec{D}}{\partial t}$$

cf. $\vec{D}=\varepsilon\vec{E},\quad \vec{B}=\mu\vec{H}$

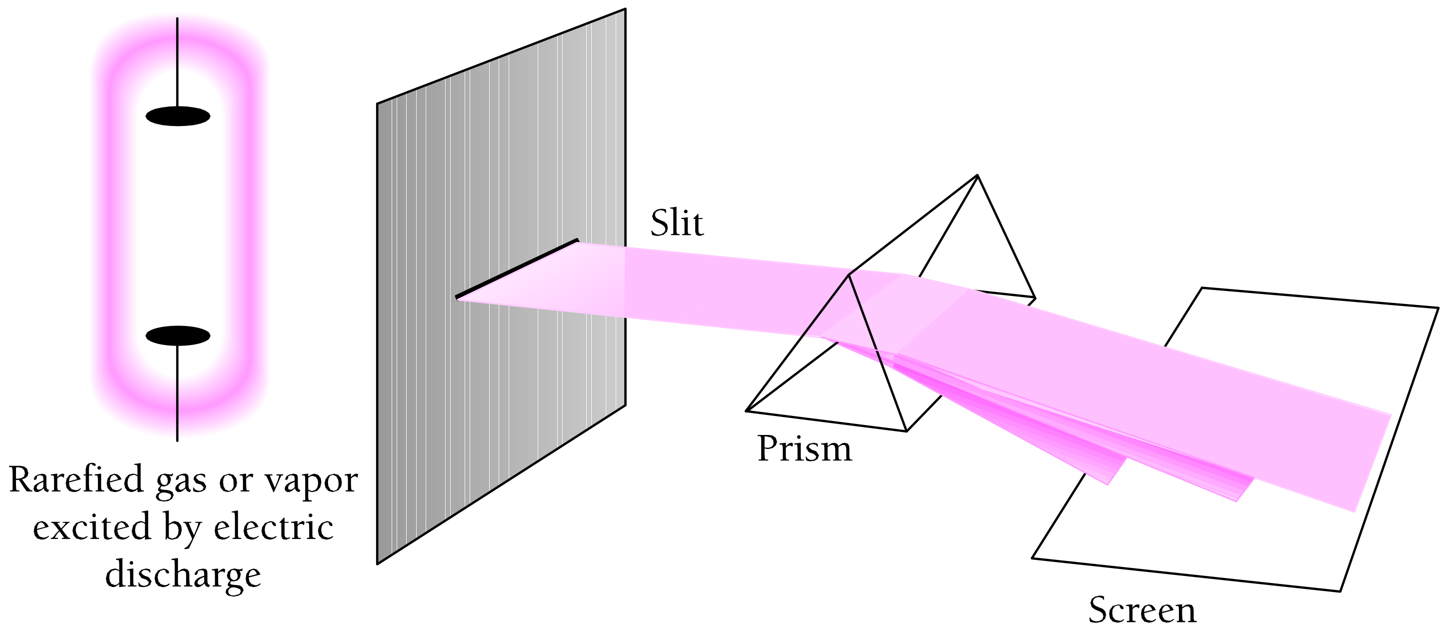
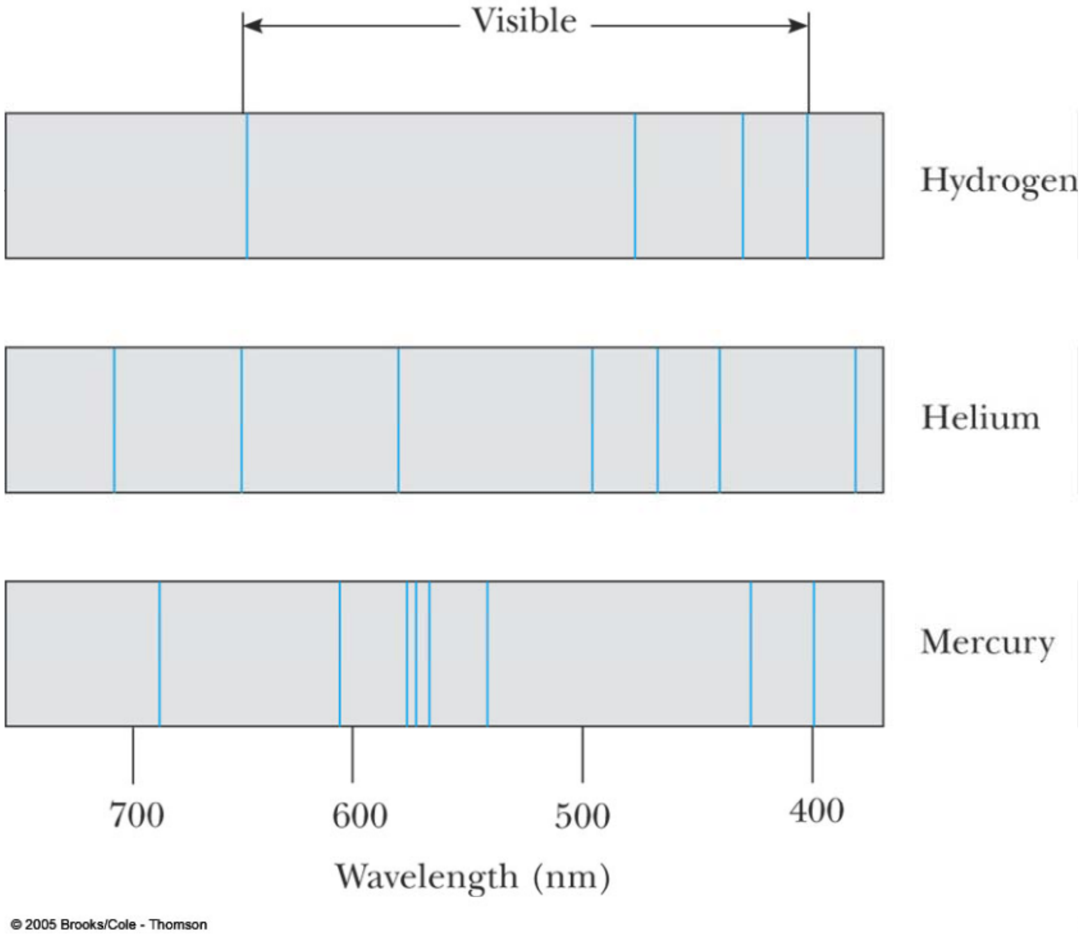
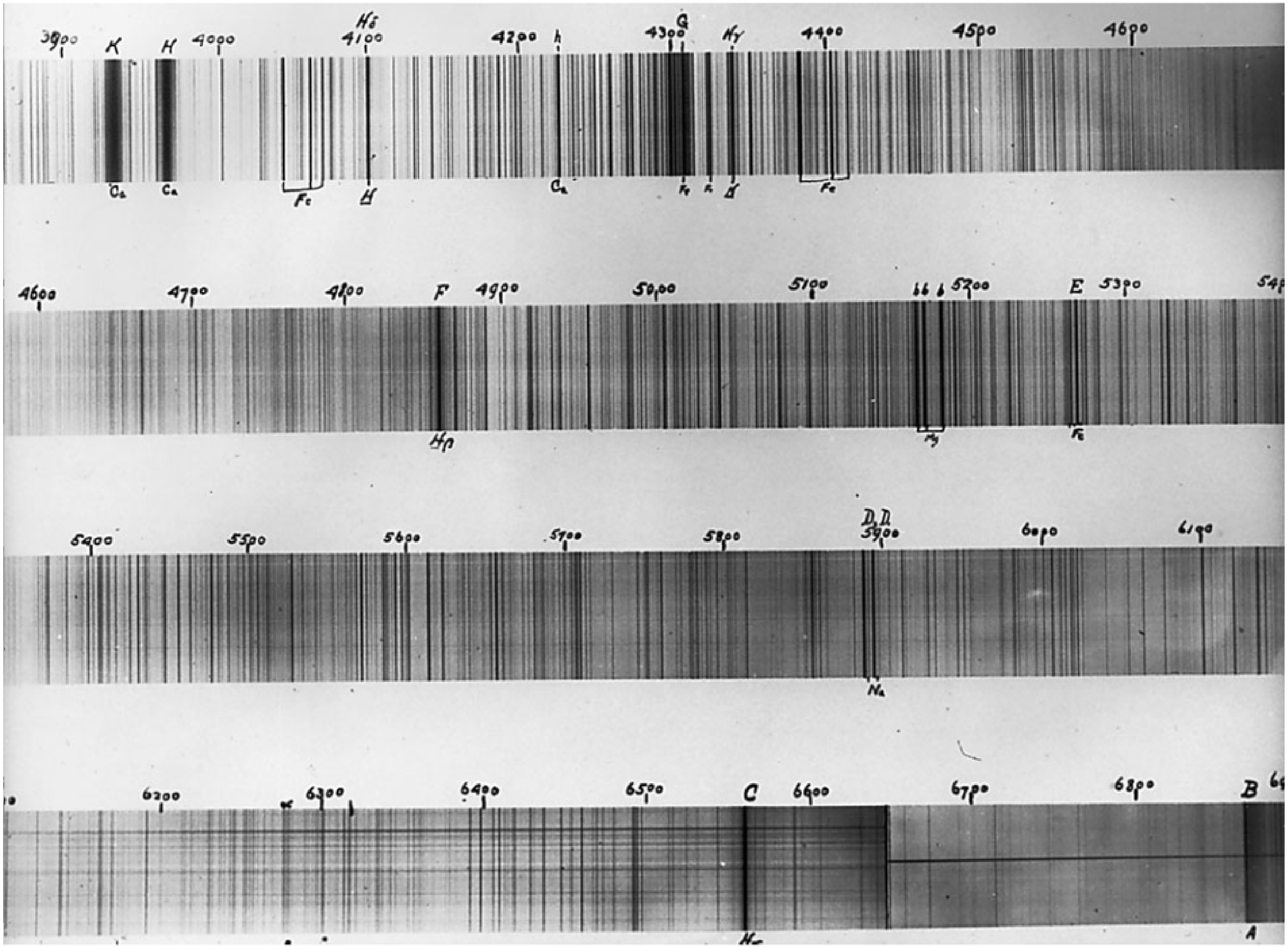


그림 4.7 이상적인 분광기.

Oh, My God…



$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$



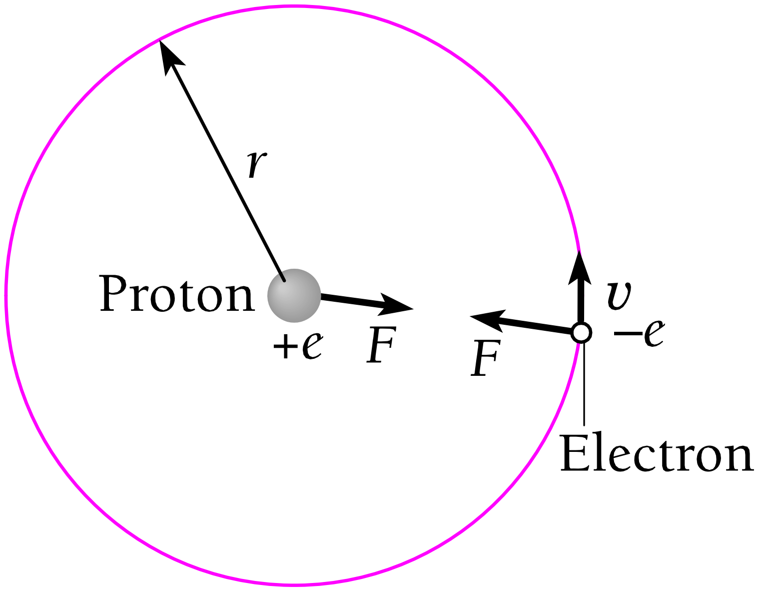
3900 K H 4000 Hδ 4100 4200 h 4300 G Hγ 4400 4500 4600
Ca Ca Fe H Ca Fe Fe Fe
4600 4700 4800 F 4900 5000 5100 b b b 5200 E 5300
Hβ Mg Fe
5400 5500 5600 5700 5800 D D 5900 6000 6100
Na
6200 6300 6400 6500 C 6600 6700 6800 B
A

Bohr

Niels Henrik David Bohr
(1885-1962)

Niels Bohr Institute Group Photo 1960

Bohr의 원자 모델



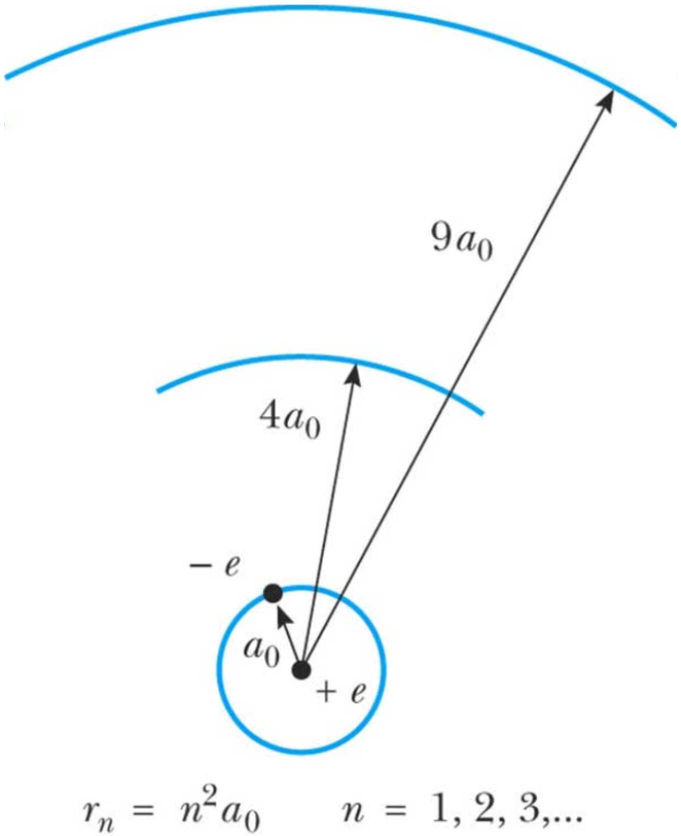
$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$$

$$v = \frac{e}{\sqrt{4\pi\varepsilon_0 mr}}$$

$$\mathrm{KE} = \frac{1}{2}mv^2 \qquad \mathrm{PE} = -\frac{e^2}{4\pi\varepsilon_0 r}$$

$$E = \mathrm{KE} + \mathrm{PE} = -\frac{e^2}{8\pi\varepsilon_0 r}$$

Bohr의 원자 모델



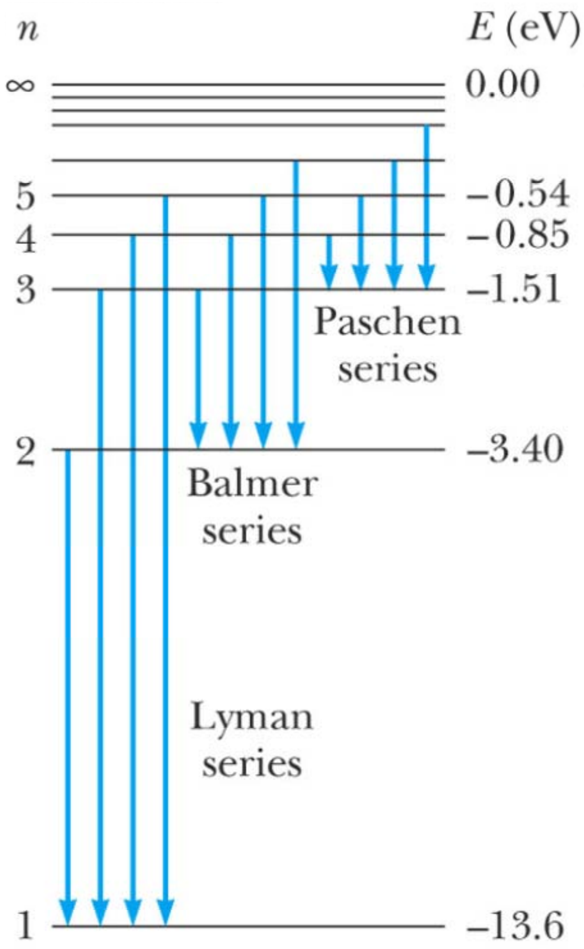
$$mvr = n\hbar \quad (n = 1, 2, 3, \dots)$$

$$\left(\hbar = \frac{h}{2\pi}\right)$$

$$r_n = \frac{n^2 h^2 \varepsilon_0}{\pi m e^2} = n^2 a_0 \quad (n = 1, 2, 3, \dots)$$

$$E_n = -\frac{me^4}{8\varepsilon_0^2 h^2}\frac{1}{n^2} = -\frac{13.6\text{eV}}{n^2} \quad (n = 1, 2, 3, \dots)$$

Bohr의 원자 모델



$$E_n = -\frac{me^4}{8\varepsilon_0^2 h^2}\frac{1}{n^2} = -\frac{13.6\text{eV}}{n^2} \qquad (n = 1, 2, 3, \ldots)$$

$$E_i - E_f = hf$$

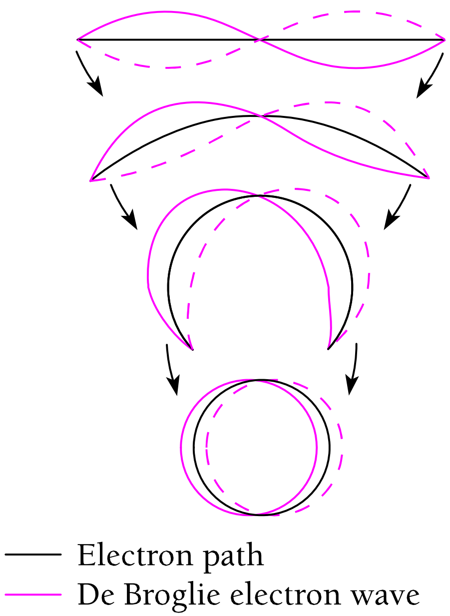
$$\frac{1}{\lambda} = \frac{f}{c} = \frac{me^4}{8\varepsilon_0^2 ch^3}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

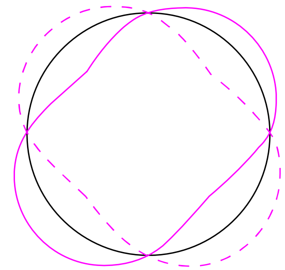
De Broglie

$$\lambda = \frac{h}{p}$$

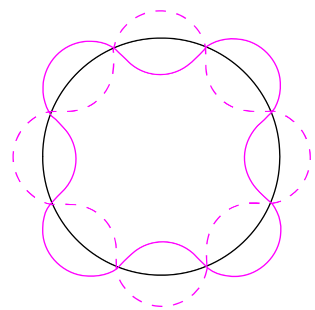
$$2\pi r_n = n\lambda_n$$

$$(n = 1, 2, 3, \dots)$$

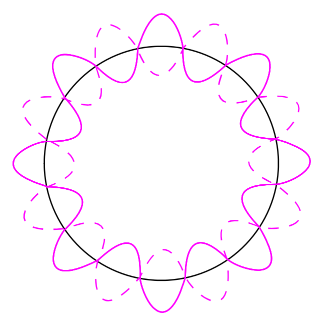




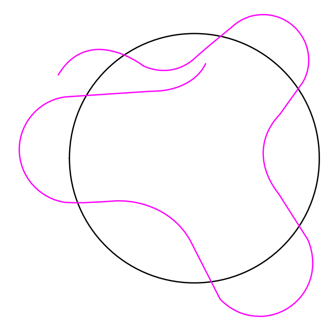
Circumference = 2 wavelengths



Circumference = 4 wavelengths



Circumference = 8 wavelengths



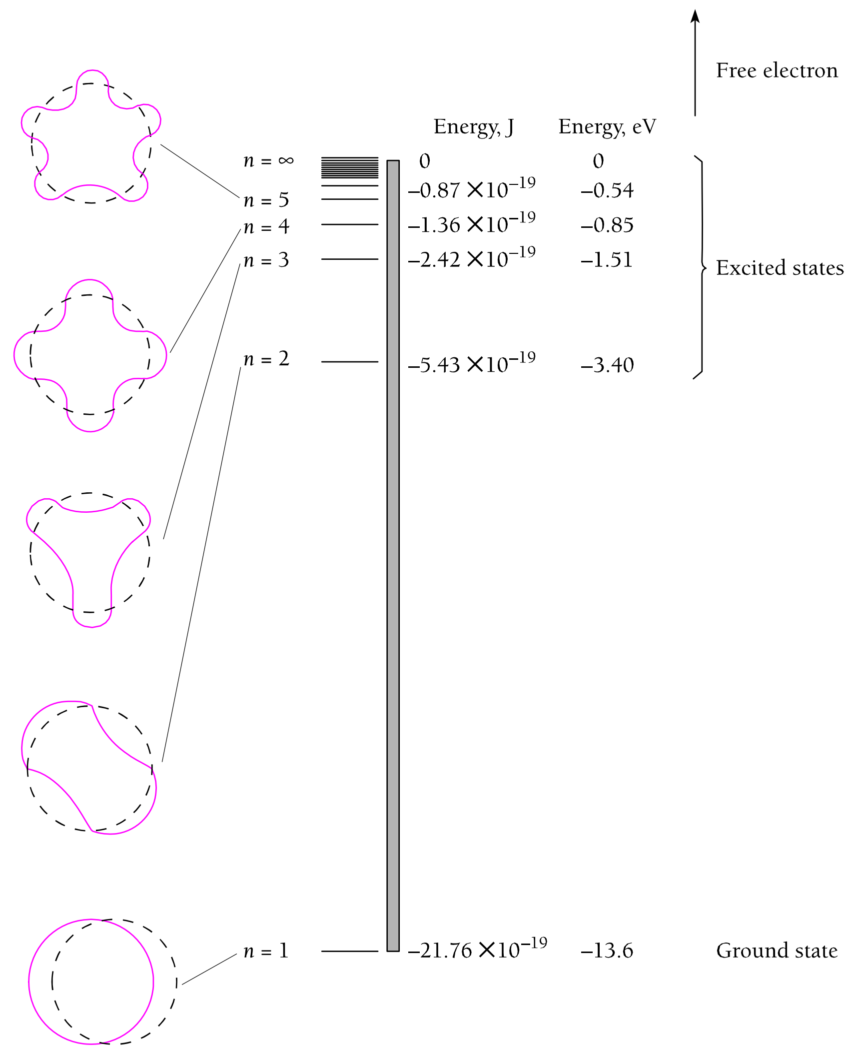


그림 4.15 수소 원자의 에너지 준위

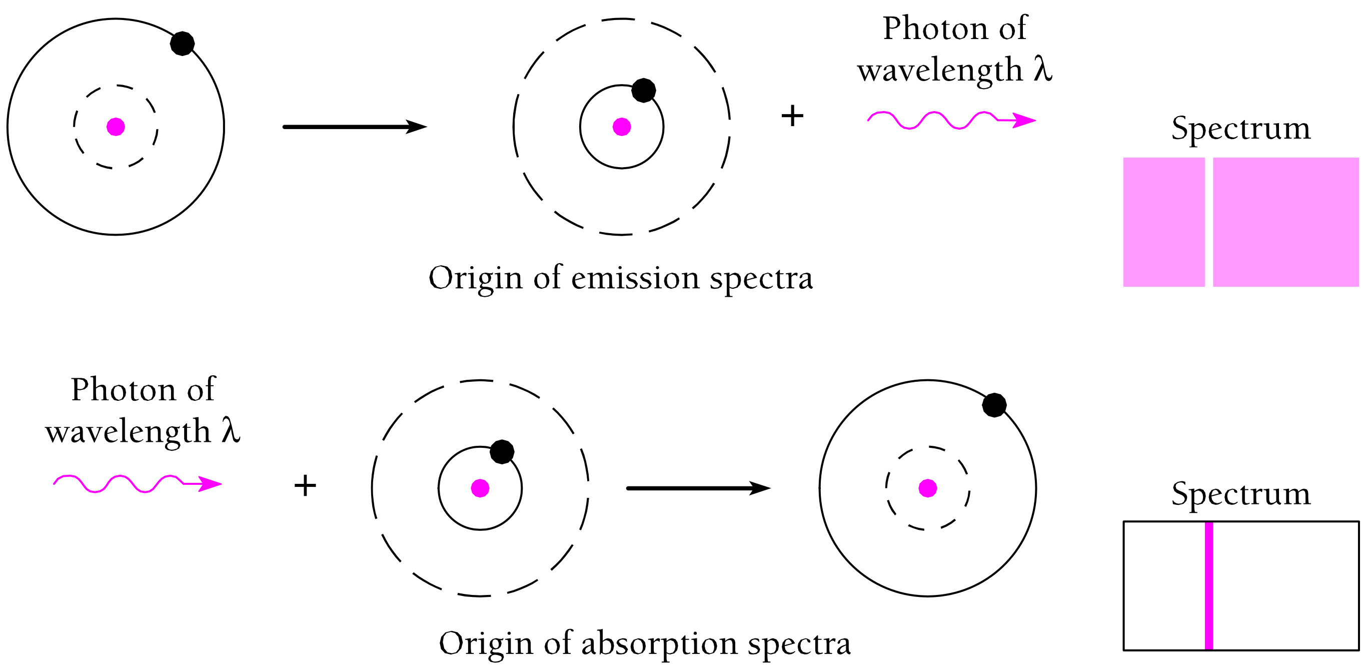
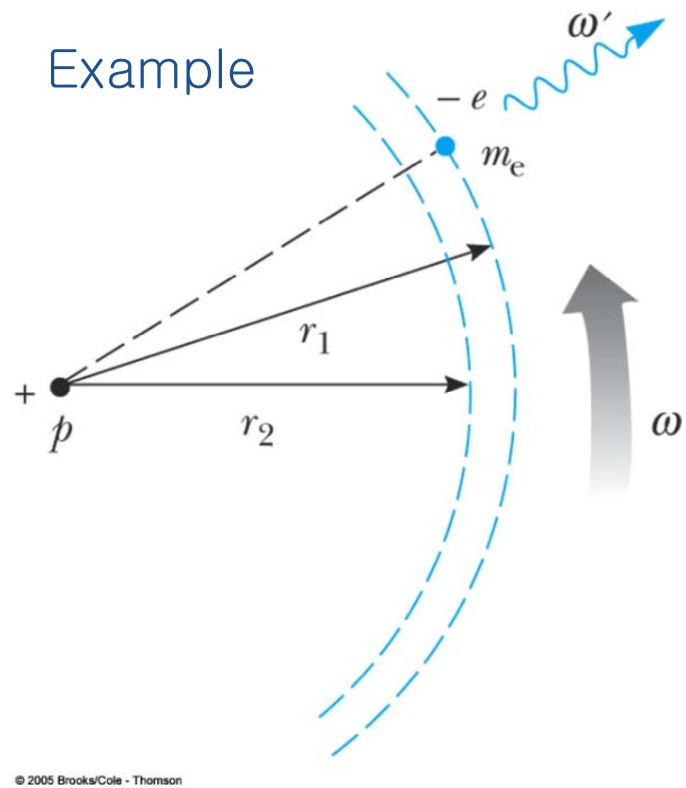


그림 4.19 방출 스펙트럼과 흡수 스펙드럼의 기원.

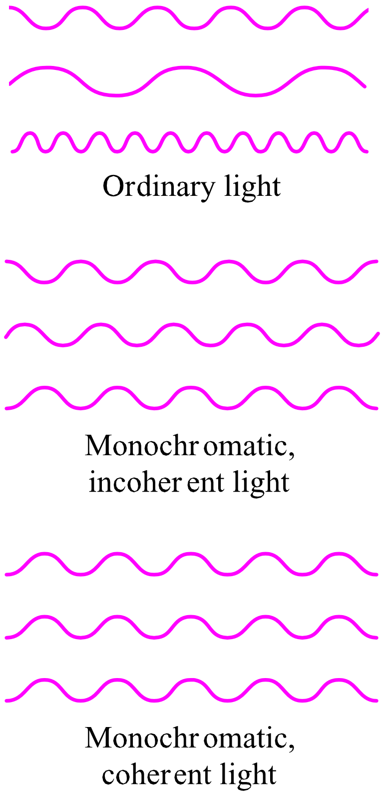
Correspondence Principle

$h \to 0$ or $n \to \infty$: Classical limit

Example



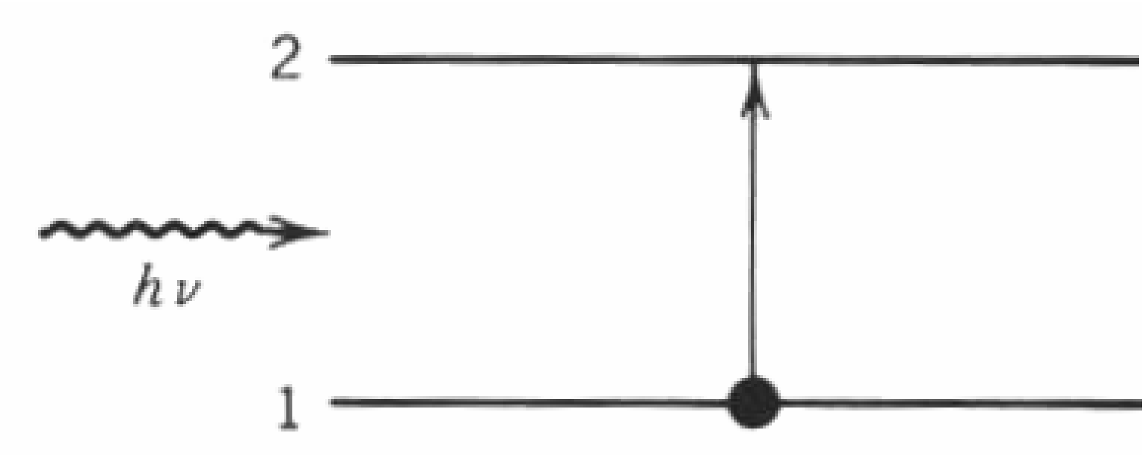
Laser의 특성



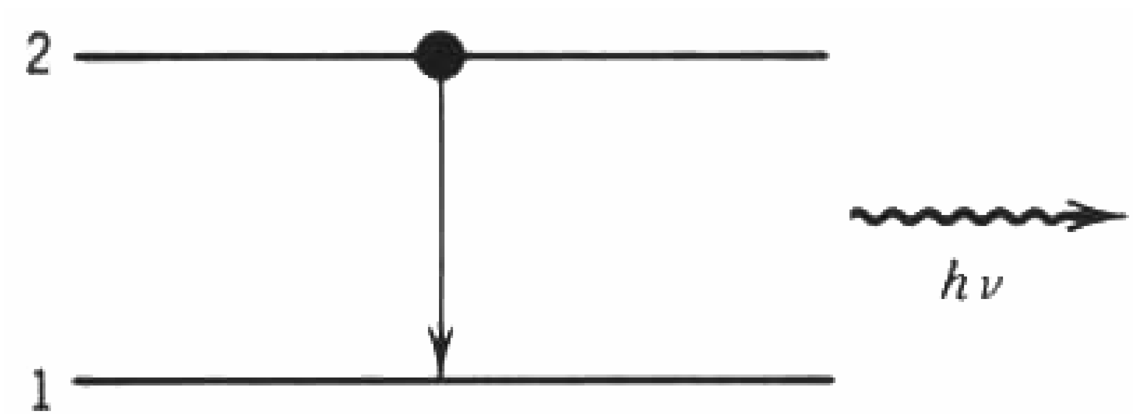
- 단색성
- 고휘도
- 지향성
- 가간섭성(Coherency)

그림 4.23 레이저는 모든 광파들이 같은 진동수를 가지고(단색광) 서로 위상이 같은(결맞음) 빛을 발생시킨다. 또한, 레이저빔은 매우 잘 평행하게 줄맞춤 된 빔이어서, 먼 거리를 지나가도 잘 퍼지지 않는다.

흡수와 자발방출



흡수(Absorption)

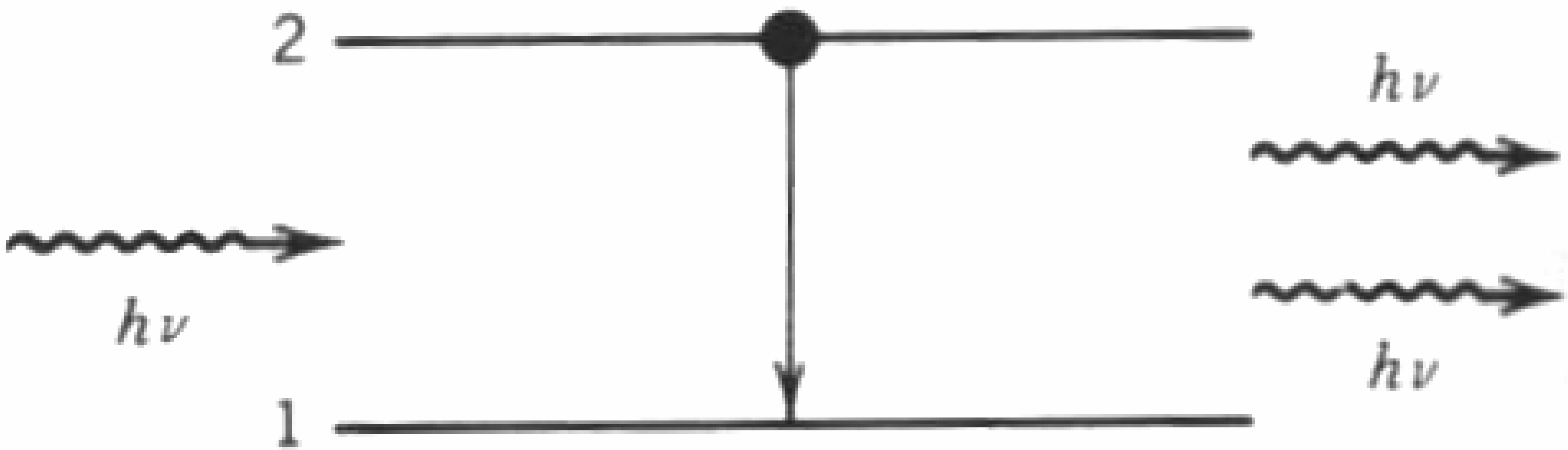


자발방출

(Spontaneous Emission)

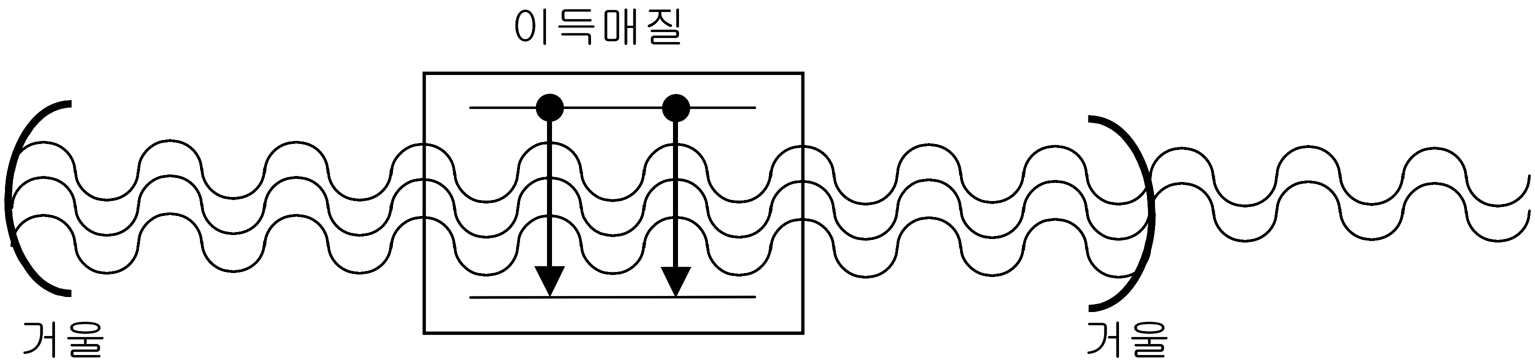
유도방출(Stimulated Emission)

1917 Einstein



Laser

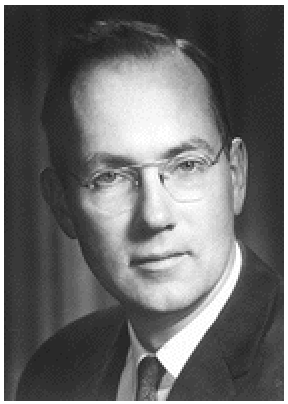
Light Amplification by Stimulated Emission of Radiation



Laser의 역사

- 1917 Einstein – Stimulated Emission
- 1940s Fabrikant – 박사학위 논문
- 1950s Townes, Weber, Prokhorov, Basov – MASER
- 1954 Gordon, Townes, Zeiger – 최초의 maser
- 1957 Gould – LASER 특허출원
- 1958 Schawlow, Townes – "Intrared and Optical Masers" 논문
- 1960. 5. 16. Maiman – 최초의 레이저 동작 (Ruby laser)
- 1960. 12. 12. Javan, Bennett, Herriott – 최초의 cw 레이저 동작 (He-Ne laser)
- … laser flood

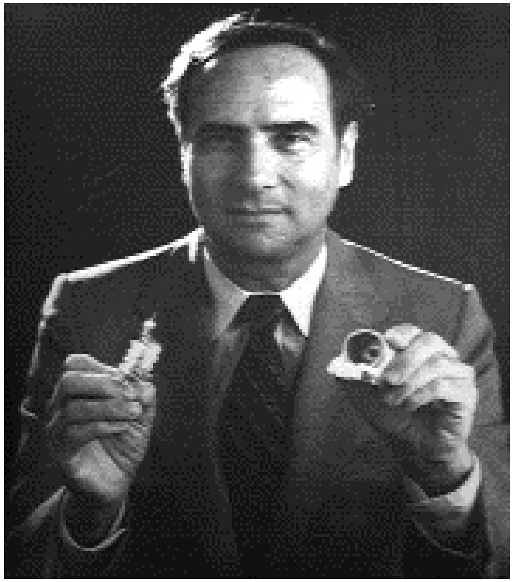
Laser가 늦게 발명된 이유



Charles H. Townes (1915-)

“대부분의 물리학자들은 전자공학과 증폭기에 대해서 몰랐었고, 전기공학자들은 대개 양자역학을 배우지 않았다. 하지만 제 2차 세계대전으로 인해 레이다 (radar) 개발을 위해 공학자들과 자연과학자들이 함께 일하게 되었고, 물리학자들이 전자공학에 접근할 수 있게 되었다.”

최초의 Laser – Ruby Laser



❖ 최초의 레이저 : 1960년, Maiman이 만든 세계 최초의 레이저, 루비를 레이저 매질로 사용