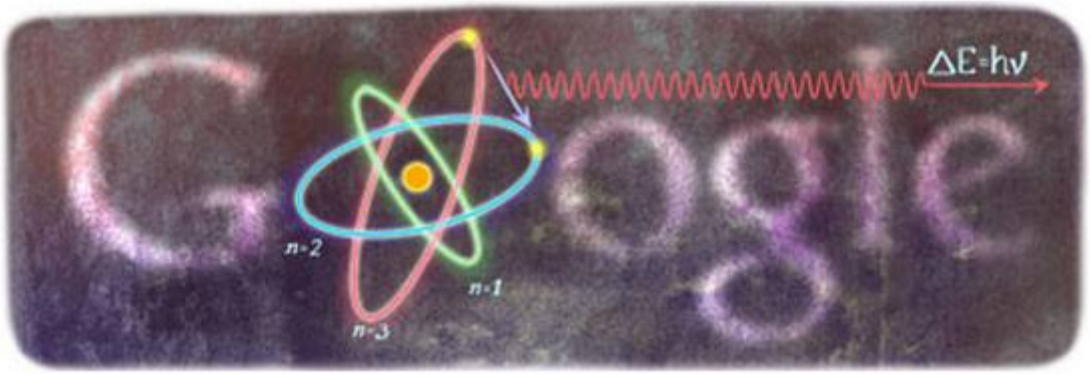


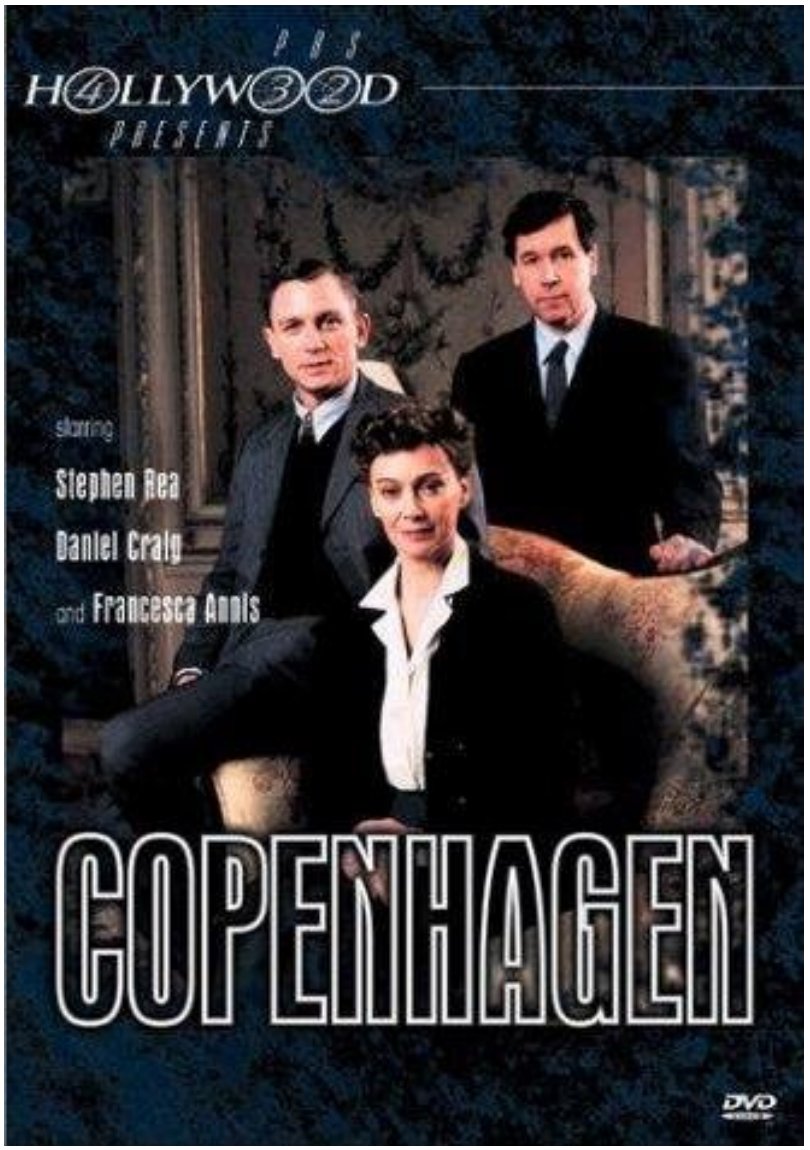



The Bohr Atom

Quickuiz

Who's your favorite Bond?

A. Connery
B. Lazenby (who?)
AB. Brosnan
AC. Craig
C. Moore
BD. al-Binni
D. Dalton
CD. Austin Powers

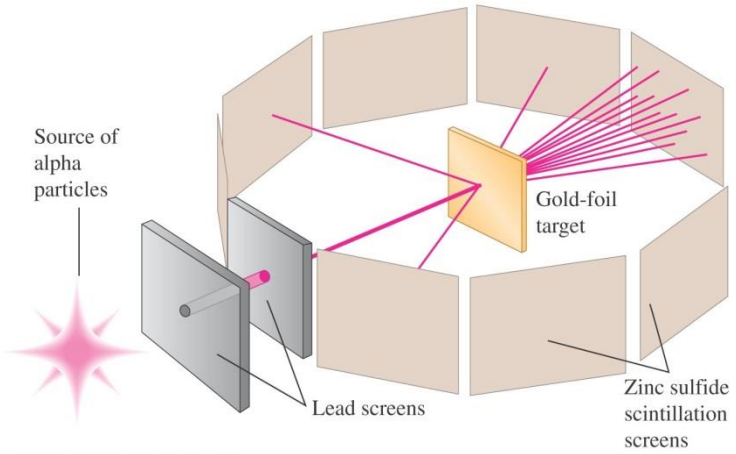


A Bohring Movie for geeks

Rutherford's Experiment (1911)

Geiger, Marsden supervised by Rutherford

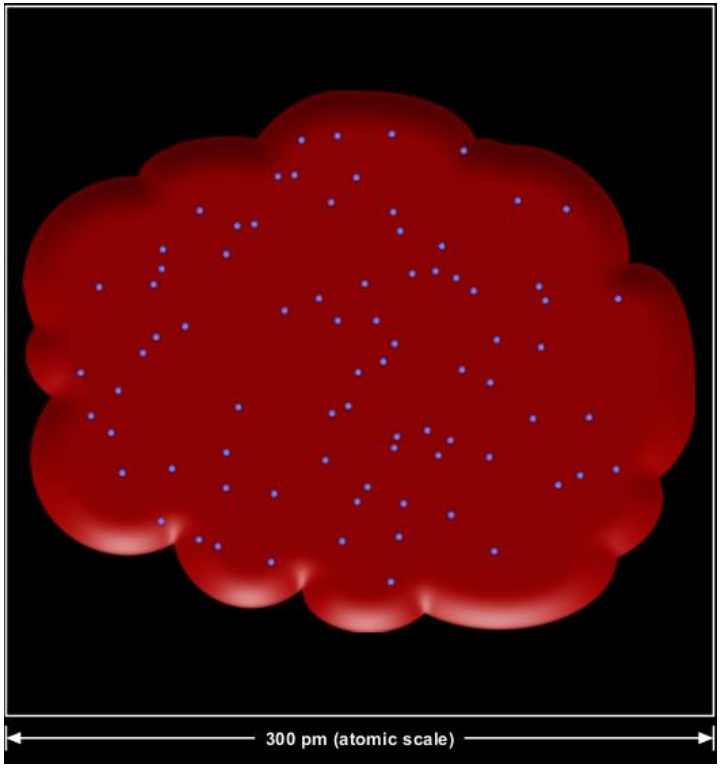
- Shoot alpha α particles on an **<u>ultra thin</u>** gold foil
- Have detectors (sensitive film) surrounding the foil
- Study the directions of deflections of the alpha particles.
  - Most particles pass through with mild deflection
  - A few suffer severe deflection



Early Models of the Atom
(Interpreting Rutherford's Experiment)

Simulation:
http://phet.colorado.edu/en/simulation/rutherford-scattering

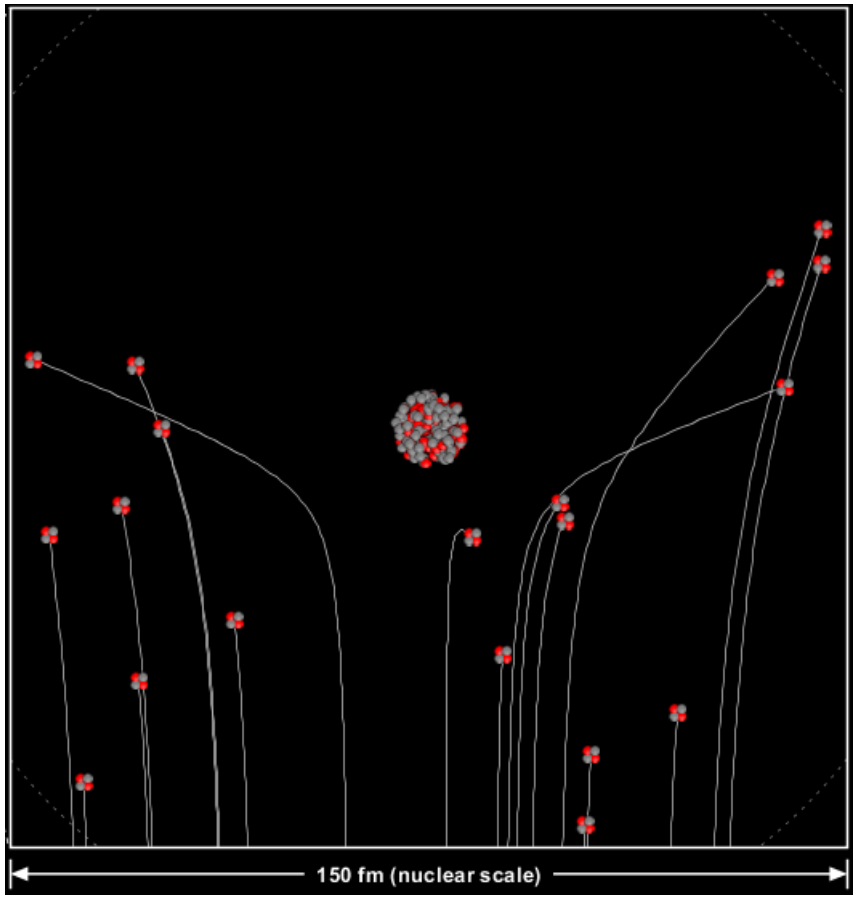
- Thomson's "plum pudding" model
  - Stable atom
  - Assumes electrons (negative charge) is embedded in a continuous positive medium.
  - Cannot explain Rutherford scattering of alpha particles
  - Emits light at a single wavelength



What the Rutherford Experiment Tells Us

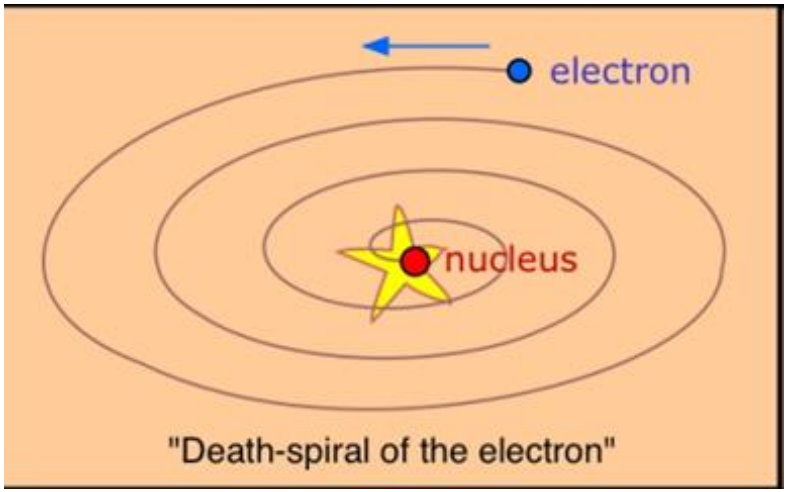
- Positive charge is at the center of the atom.
- The nucleus is heavier than electron
- Radius of nucleus is $\sim 10^{-15}$ m
- Discovery of atomic nuclei

- http://phet.colorado.edu/en/simulation/rutherford-scattering

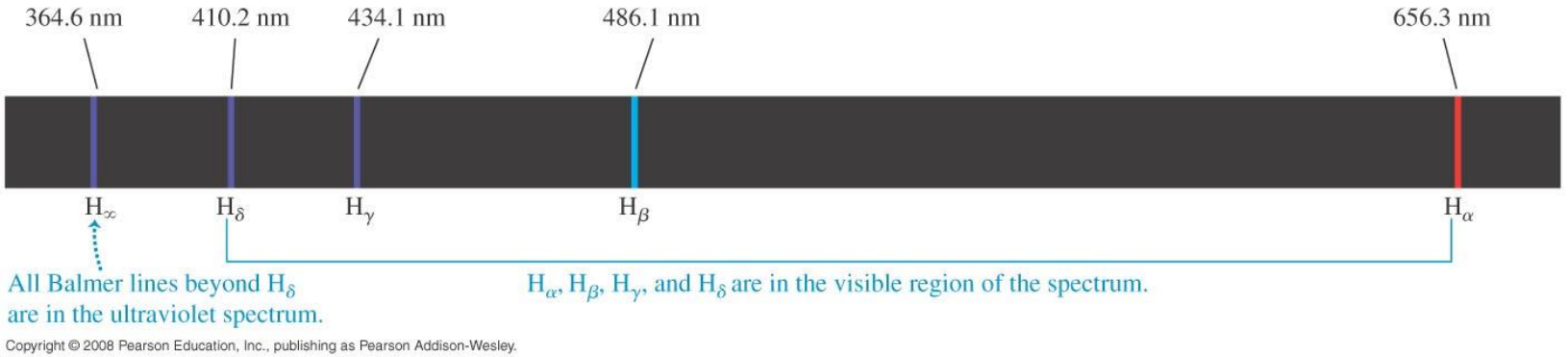


Early Models of the Atom
(Interpreting Rutherford's Experiment)

- Solar system model
  - Able to explain Rutherford scattering of alpha particles
  - Unstable (atom decays quickly; 'death spiral of the electron')
  - Emits light at all wavelength briefly while dying away

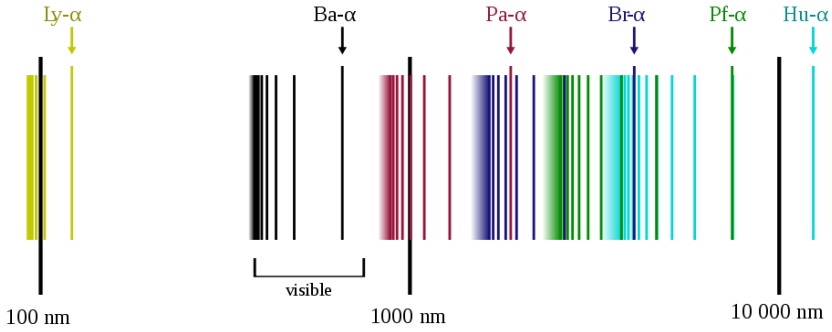


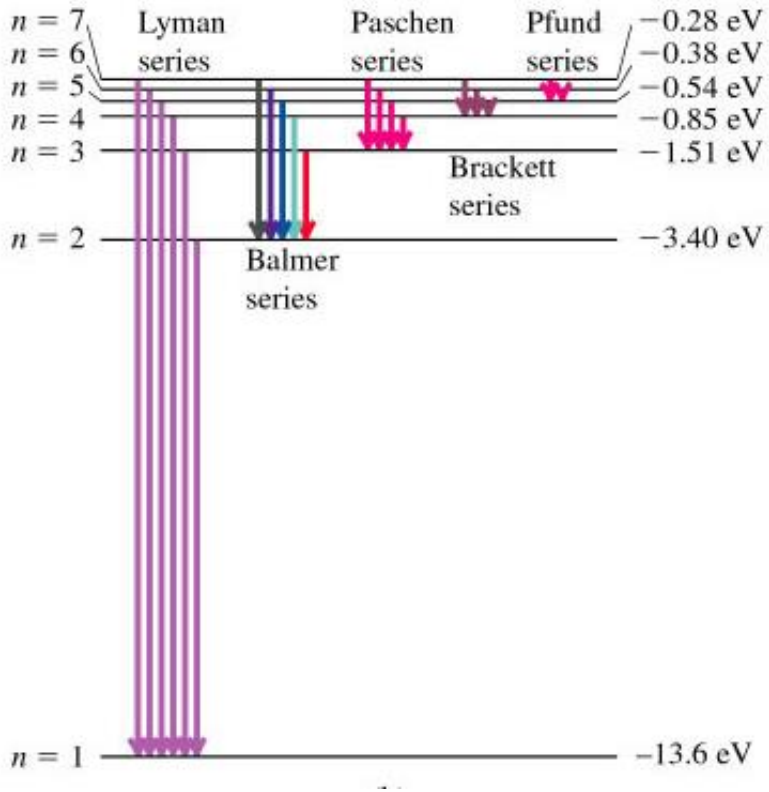
Atomic Spectra Puzzle



- Why is it that heated gases emit light only at certain frequencies?

Other Series





It was observed experimentally for hydrogen emission spectra that:

$$\frac{1}{\lambda} = R_\infty \left(\frac{1}{n_s^2} - \frac{1}{n^2} \right)$$

$R_\infty = 1.097 \times 10^7 m^{-1}$ called Rydberg constant

The lines we saw in lab were the Balmer series with $n_s = 2$

Things Bohr was Thinking About (1913)

- **Photoelectric effect**: explained by quantizing light waves (1905)
- **Rutherford's experiment** indicates a nuclear atom with electrons orbiting the nucleus (1911)
- But the **atom is stable** (or we wouldn't be hear debating this!)
- **Atomic spectra experiments** show atoms emit light at certain frequencies only (19^{th} and early 20^{th} centuries)

Bohr's Model of the Hydrogen Atom

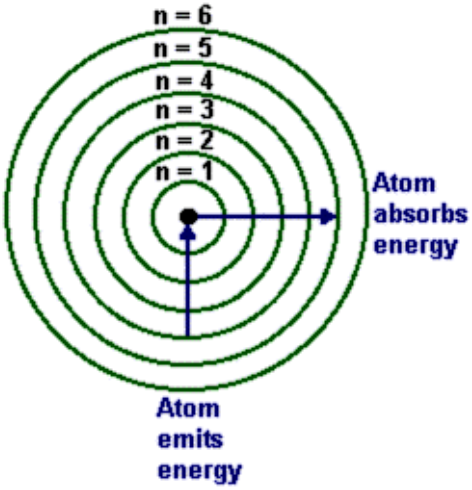
- Small, positively charged nucleus like solar system model (**Rutherford's Model**)
- There is a lowest energy orbit, called the ground state. (**Stability**)
- Only certain orbits with higher energy are allowed:

$$L_n = \frac{nh}{2\pi}, \qquad n = 1,2,3,..$$

- Emission/absorption of photons with energies equal to the difference in energies of two allowed orbits:

$$E_{photon} = |E_n - E_{n'}| = hf = \frac{hc}{\lambda}$$

That latter one **reproduces the hydrogen spectrum**!



Simulation: http://phet.colorado.edu/en/simulation/hydrogen-atom

Quickuiz

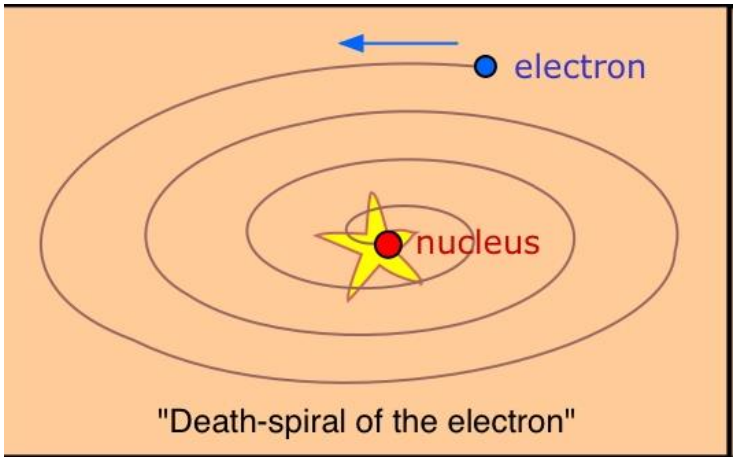
Which of the following models of the atom predict that the atom will emit no electromagnetic radiation?

A. The plum pudding model

B. The solar system model

C. The Bohr model

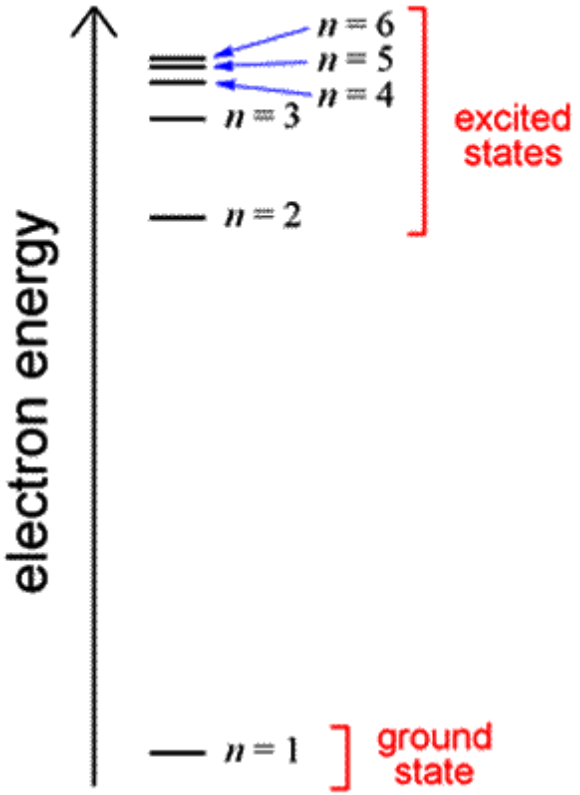
D. None of the above models



Energy Levels of Hydrogen (Hydrogen Spectrum)

- Using the ideas of Bohr's model, it is possible to derive an equation for the energy levels of hydrogen:

$$E_n = -\frac{13.6\ \text{eV}}{n^2}$$



Quickuiz

In a hydrogen gas-discharge tube, a hydrogen atom initially in the **ground state** ($n = 1$) can emit the visible light associated with the transition from the $n = 3$ state to the $n = 2$ state if it is first excited from the ground state $n = 1$ into:

A. The $n = 3$ state

B. The $n = 4$ state

C. The $n = 5$ state

D. Any of these states