Phyx 320
Modern Physics

March 1, 2021

Reading: 38.5 – 38.7

Homework #5 and Reading Reflection Tuesday 11:59 pm

Bohr Hydrogen

Radii of electron orbit in hydrogen is quantized

$$r_n = a_B n^2 \qquad n = 1, 2, 3 \ldots$$

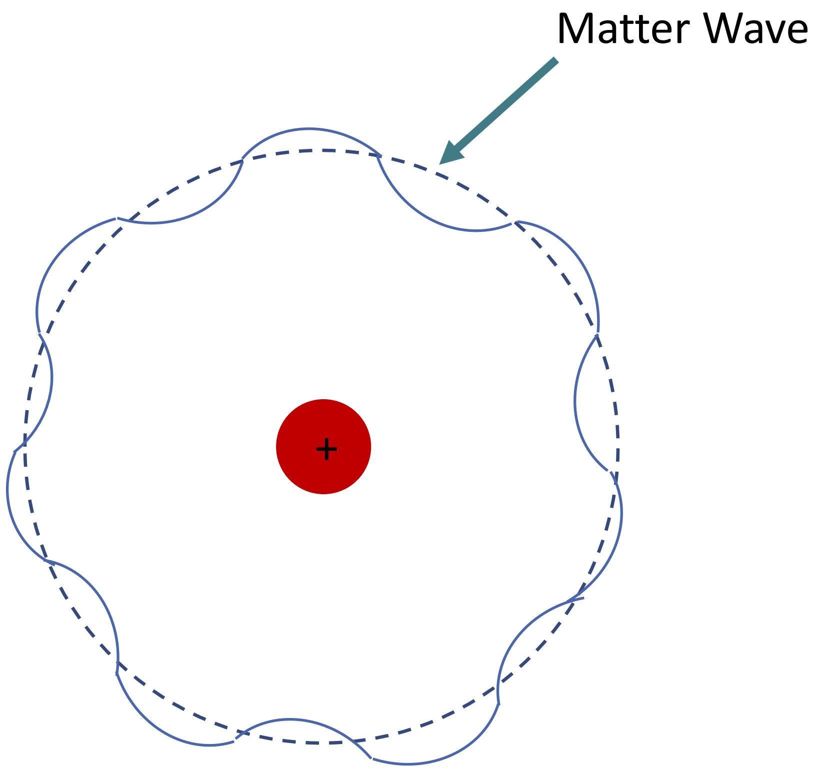
Defined Bohr radius

$$a_B = \frac{4\pi\epsilon_0\hbar^2}{me^2} = 0.0529\, nm$$

Examples of electron radius:

$$r_1 = 1a_B = 0.053\, nm$$
$$r_2 = 4a_B = 0.212\, nm$$
$$r_3 = 9a_B = 0.476\, nm$$

Hydrogen atoms at other radii **can not** exist



Bohr Hydrogen

Let’s derive the energy levels of hydrogen

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Bohr Hydrogen

Can describe hydrogen states by one quantum number: n

Energy follows $\sim 1/n^2$

Radius follows $\sim n^2$

Each n corresponds to a unique energy and radius

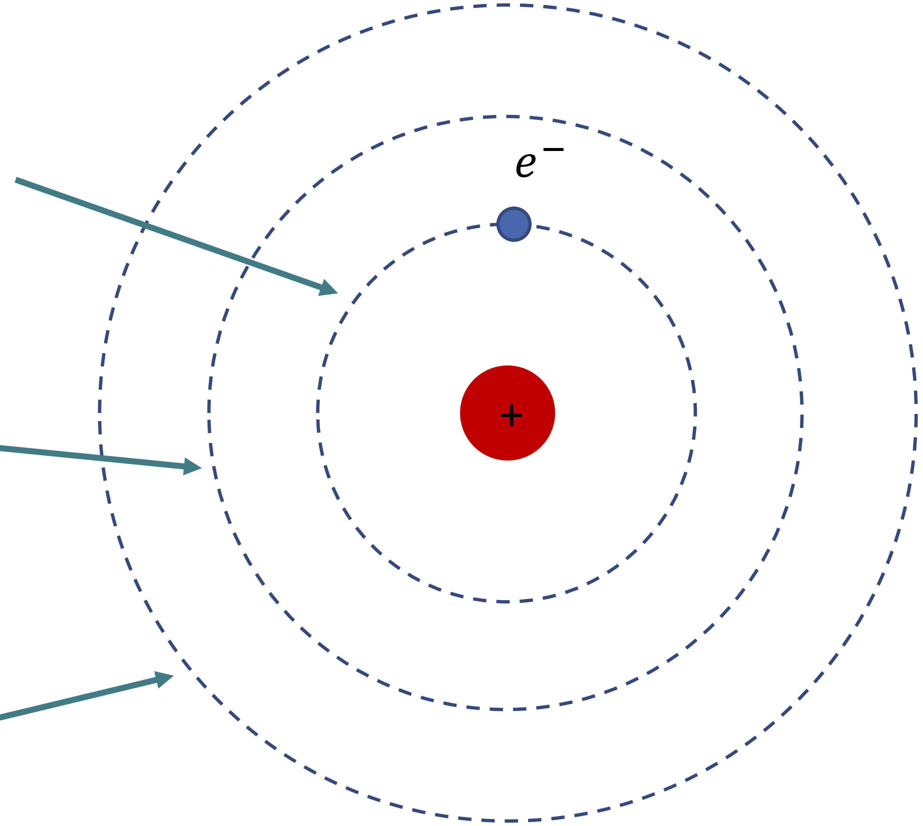
Energy is negative since the electric potential energy is only zero when $r \rightarrow \infty$

Requires energy to pull the electron away from the proton

$$n = 1$$
$$E_1 = -13.60\ eV$$
$$r_1 = 0.053\ nm$$

$$n = 2$$
$$E_1 = -3.40\ eV$$
$$r_1 = 0.212\ nm$$

$$n = 3$$
$$E_1 = -1.51\ eV$$
$$r_1 = 0.476\ nm$$

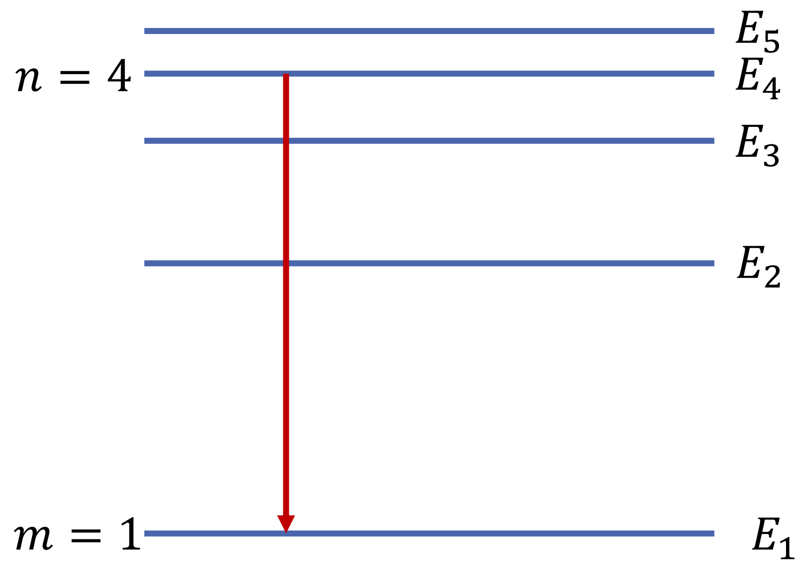


Bohr Hydrogen

What about angular momentum?

Hydrogen Spectrum

Does this model describe the hydrogen spectrum?



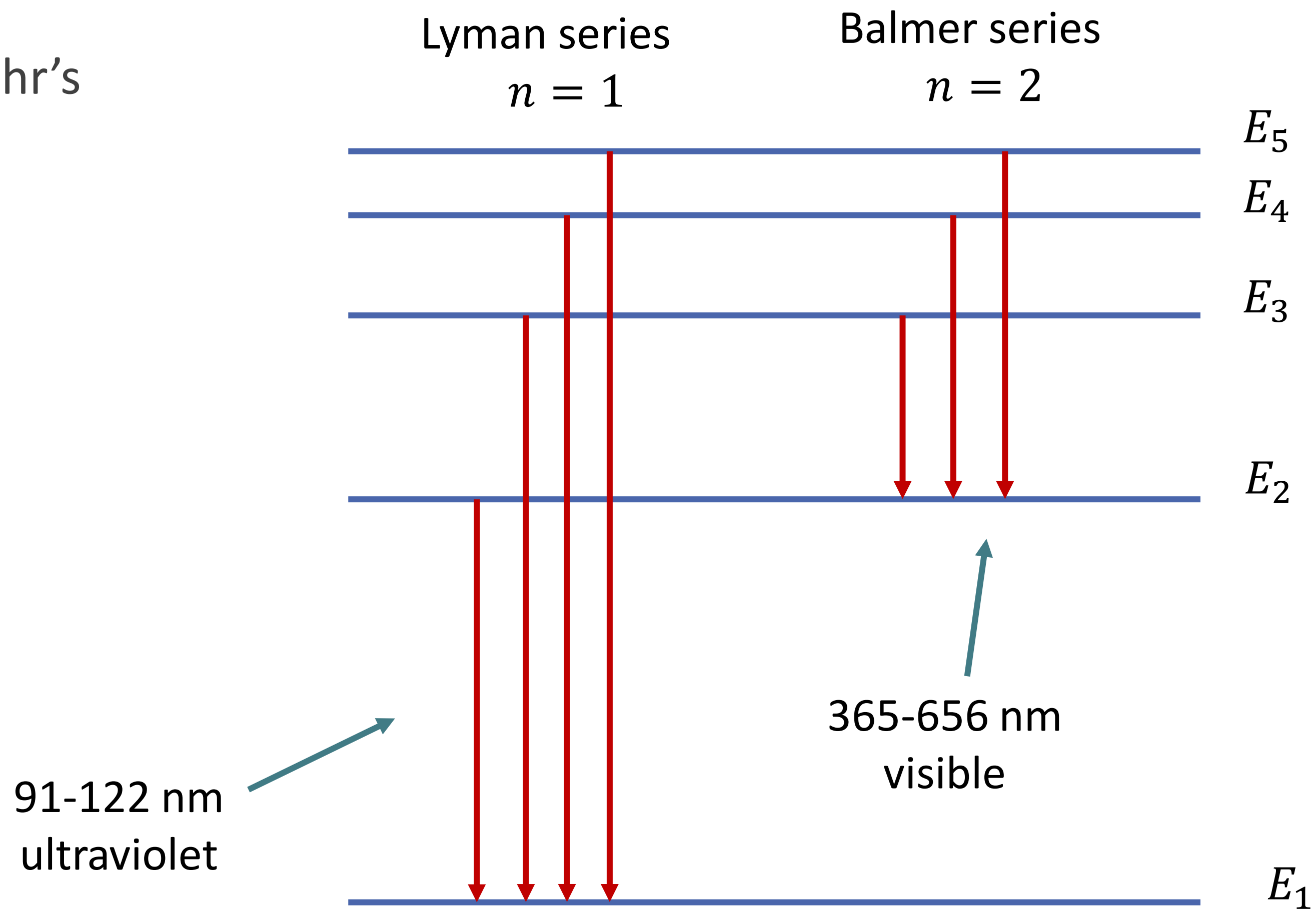
Hydrogen Spectrum

Derived the Balmer formula from Bohr's model of hydrogen:

$$\lambda = \frac{8\pi\epsilon_0 a_B hc}{e^2}\frac{1}{\frac{1}{m^2}-\frac{1}{n^2}}$$

Lyman series final state: $n = 1$

Balmer series final state: $n = 2$



Hydrogen Like Atoms

Bohr model can be used for other elements as long as they have only one electron

Atomic number = number of protons

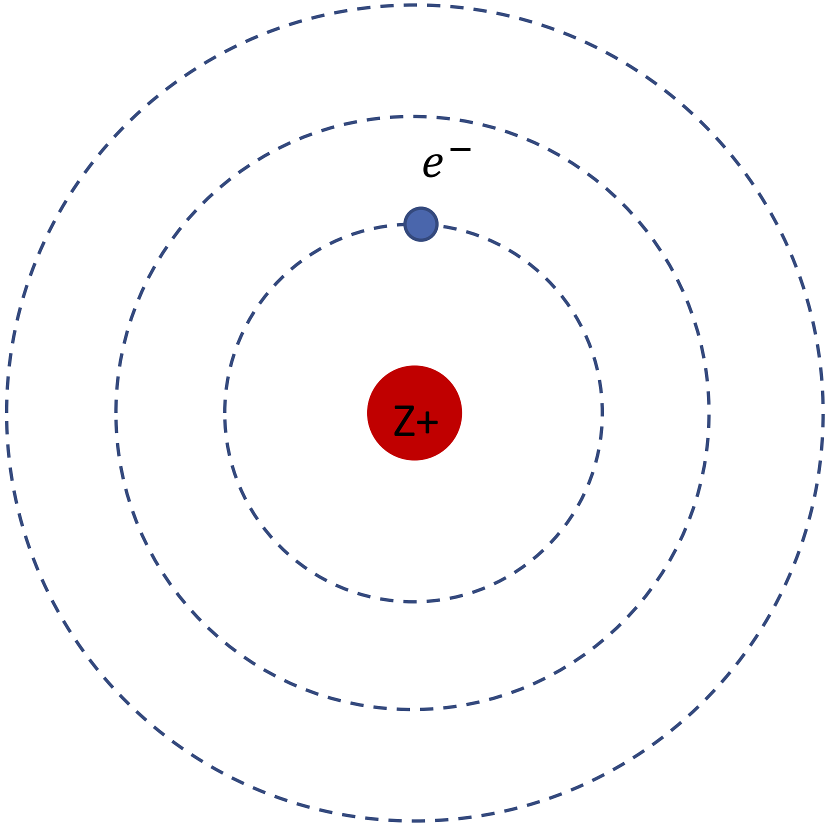
$$U_e = -\frac{Ze^2}{4\pi\epsilon_0 r}$$

Shifts all equations that we've derived

Energy and emission spectrum:

$$E = -13.60\ eV\frac{Z^2}{n^2}$$

$$\lambda_0 = \frac{91.18\ nm}{Z^2}$$



Quiz 5

1. What is the de Broglie wavelength for a neutron ($m_n = 1.675 \times 10^{-27}\ kg$) traveling at 10 m/s?

2. What is the ground state energy of a neutron in a one-dimensional box with a length of 1 angstrom ($10^{-11}\ m$)?

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