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Закон збереження енергії

$$E = E' + \varepsilon \tag{1.1}$$

Збереження імпульсу

$$\vec{p} = \vec{p}' + \vec{k} \tag{1.2}$$

$$E^2 - p^2c^2 = (E' + \varepsilon)^2 - (\vec{p}' + \vec{k})^2 c^2 = m^2c^4$$

$$\varepsilon^2 - k^2c^2 = 0$$

$$\varepsilon = kc$$

$$E'^2 + 2E'\varepsilon + \varepsilon^2 - p'^2c^2 - 2\vec{p}'\vec{k}c^2 - k^2c^2 = m^2c^4$$

$$m^2c^4 + 2E'\varepsilon + \varepsilon^2 - 2\vec{p}'\vec{k}c^2 - k^2c^2 = m^2c^4$$

$$2E'\varepsilon + \varepsilon^2 - 2\vec{p}'\vec{k}c^2 - k^2c^2 = 0$$

$$2E'\varepsilon - 2\vec{p}'\vec{k}c^2 = 0$$

$$2E'\varepsilon - 2p'kc^2\cos\theta = 0$$

$$2E'kc - 2p'kc^2\cos\theta = 0$$

$$2E' - 2p'c\cos\theta = 0$$

$$E' = p'c\cos\theta$$

$$E' = \sqrt{m^2c^4 - p'^2c^2}$$

$$E' = 0$$

$$mc^2 = 0 \tag{1.3}$$

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Другий закон Ньютона

$$k\frac{eZe}{r^2} = ma_n = m\frac{v^2}{r} \tag{1.4}$$

Постулат Бора:

$$L_n = n\hbar$$
$$mv_nr_n = n\hbar \tag{1.5}$$

$$v_n = \frac{n\hbar}{mr_n}$$

$$k\frac{Ze^2}{r_n} = mv_n^2 = m\left(\frac{n\hbar}{mr_n}\right)^2 = \frac{n^2\hbar^2}{mr_n^2} \tag{1.6}$$

$$r_n = \frac{n^2\hbar^2}{mkZe^2} = n^2\frac{\hbar^2}{m_eke^2}\frac{1}{Z} = n^2\frac{a_0}{Z}$$

Енергія

$$E_{повне} = E_k + U = \frac{mv^2}{2} - k\frac{eZe}{r} \tag{1.7}$$

$$v_n = \frac{n\hbar mkZe^2}{mn^2\hbar^2} = \frac{kZe^2}{n\hbar} \tag{1.8}$$

$$E_n = \frac{m}{2}\left(\frac{kZe^2}{n\hbar}\right)^2 - k\frac{Ze^2 mkZe^2}{n^2\hbar^2} = \frac{mk^2Z^2e^4}{2n^2\hbar^2} - \frac{mk^2Z^2e^4}{n^2\hbar^2} = -\frac{mk^2Z^2e^4}{2n^2\hbar^2} = \\ = -\frac{1}{n^2}\frac{mk^2Z^2e^4}{2\hbar^2} \tag{1.9}$$

$$E = \hbar\omega = \frac{h}{2\pi}\omega = h\nu \\ p = E/c = h/\lambda \tag{1.10}$$

$$E_{ns} = E_s - E_n = -\frac{1}{s^2}\frac{mk^2Z^2e^4}{2\hbar^2} + \frac{1}{n^2}\frac{mk^2Z^2e^4}{2\hbar^2} \\ \hbar\omega_{ns} = -\frac{1}{s^2}\frac{mk^2Z^2e^4}{2\hbar^2} + \frac{1}{n^2}\frac{mk^2Z^2e^4}{2\hbar^2} \\ \omega_{ns} = \left(\frac{1}{n^2} - \frac{1}{s^2}\right)\frac{mk^2Z^2e^4}{2\hbar^3} = \left(\frac{1}{n^2} - \frac{1}{s^2}\right)RZ^2 \tag{1.11}$$