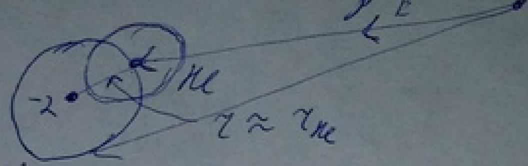
Лінійний ефект Штарка

$$\hat H = -\frac{\hbar^2}{2m_e}\Delta - \frac{4e^2}{r} - 2e\,\vec r\cdot\vec E$$

$\vec E = const$



$\vec p \perp \vec E$

$r \approx r_{He}$

$$V = (\vec d\,\vec E)$$

$$\vec d = e\langle\vec r\rangle = \frac{3}{2} e\, a_0^3 \vec E, \quad \text{де } a_0 = \frac{\hbar^2}{m_e e^2} \qquad \langle\vec r\rangle = \frac{3}{2} a_0^3 \vec E$$

$$V = \frac{3}{2} e a_0^3 E^2 = (\vec d\,\vec E)$$

$$\vec E = \vec E(\vec r) = \frac{ze\vec p}{p^3} \text{ - не однорід.}$$

$$\hat A\psi = \underbrace{\mathcal{E}}_{\text{енергія}}\psi$$

$$-\frac{\hbar^2}{2m_e}\Delta\psi - \frac{4e^2}{r}\psi - 2e^2 z\frac{(\vec r\vec p)}{p^3}\psi = \mathcal{E}\psi$$

$$\boxed{\Delta\psi + \frac{2m_e}{\hbar^2}\left(\mathcal{E} + \frac{4e^2}{r} + \frac{2e^2 z}{p^3}(\vec r\vec p)\right)}$$

$$\cancel{\Delta\psi + \frac{2m_e}{\hbar^2}\left(\mathcal{E} + \frac{(4+2)e^2}{r}\right)\psi = 0}$$

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial\psi}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial\psi}{\partial\theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2\psi}{\partial\varphi^2} + \frac{2m_e}{\hbar^2}(\mathcal{E} + \ldots)\psi = 0$$

$$\psi = \psi_{nlm}(r,\theta,\varphi) = R_{nl}(r)\,Y_{lm}(\theta,\varphi)$$

$$U(r,p) = \frac{4e^2}{r} + \frac{2ze^2}{p^3}(\vec r,\vec p)$$

$$\vec F = -\nabla U = \frac{4e^2}{r^2}\vec e_r + \frac{6ze^2}{p^5}(\vec r,\vec p)\vec p - \frac{2ze^2}{p^3}\left([\vec r\times\mathrm{rot}\,\vec p] + [\vec p\times\mathrm{rot}\,\vec r] + (\vec p\nabla)\vec r + (\vec r\nabla)\vec p\right)$$

$$\boxed{\begin{gathered}\frac{m_e v^2}{r}\vec e_r = -\nabla U \\ \mathcal{E} = \frac{m_e v^2}{2} - \frac{4e^2}{r} - 2e\vec r\vec E\end{gathered}}$$

$$m_e v r = n\hbar$$

$$v = \frac{n\hbar}{m_e r}$$

$$V = (\vec d\,\vec E)$$

$$\vec d = e\langle\vec r\rangle$$

$$\langle\vec r\rangle = \int_0^\infty \psi^*\hat{\vec r}\,\psi\, dV$$

$$\frac{m_e v^2}{2} = \frac{|-\nabla U|r}{2}; \quad \mathcal{E} = \frac{|-\nabla U|r}{2} - \frac{4e^2}{r} - 2e\vec r\vec E$$