1. Buktikan jika ψ_1 dan ψ_2 memiliki paritas yang definit, maka μ_{11} dan $\mu_{22} = 0$

Jawab:

ψ_1 adalah fungsi ganjil (odd) dan ψ_2 adalah fungsi genap (even), maka:

$\psi_1(x) = -\psi_1(-x) \rightarrow odd$

$\psi_2(-x) = \psi_2(x) \rightarrow even$

Definisi μ_{11} dan μ_{22}

$\mu_{11} = \int_{-\infty}^{\infty} \psi_1^*(x)\ x\ \psi_1(x)dx$

$\mu_{22} = \int_{-\infty}^{\infty} \psi_2^*(x)\ x\ \psi_2(x)dx$

Hitung gunakan fakta bahwa $\psi_1$dan ψ_2 adalah fungsi dengan definite parity

$\psi(x) = x^3$

$$\begin{aligned}\mu_{11} &= \int_{-\infty}^{\infty} \psi_1^*(x)\ x\ \psi_1(x)dx \\ &= \int_{-\infty}^{\infty} x^3\ x\ x^3 dx \\ &= \int_{-\infty}^{\infty} x^7 dx \\ &= 0\end{aligned}$$

$\psi(x) = x^2$

$$\begin{aligned}\mu_{22} &= \int_{-\infty}^{\infty} \psi_2^*(x)\ x\ \psi_2(x)dx \\ &= \int_{-\infty}^{\infty} x^2\ x\ x^2 dx \\ &= \int_{-\infty}^{\infty} x^5 dx \\ &= 0\end{aligned}$$

2. Telusuri dan kotret persamaan-persamaan di section 14.5 dari nomor rumus 14.24 s.d. 14.40

$$\hat{H}_p = e\mathrm{E}z = -\mathrm{E}\hat{\mu}$$

$$\mu_{mn} = -e\langle\Psi_m|z|\Psi_n\rangle$$

$$\left(\hat{H}_p\right)_{mn} = H_{mn} = -\mathrm{E}\mu_{mn}$$

$$\mu_{11} = \mu_{22} = 0$$

$$H_{p11} = H_{p22} = 0$$

$$\mu_{12} = \mu_{21} = \mu_d$$

$$\hat{\mu} = \begin{bmatrix} 0 & \mu_d \\ \mu_d & 0 \end{bmatrix}$$

$$\hat{H}_p = \begin{bmatrix} 0 & -\mathrm{E}\mu_d \\ -\mathrm{E}\mu_d & 0 \end{bmatrix}$$

$$\hat{H} = \hat{H}_0 + \hat{H}_p = \begin{bmatrix} E_1 & -\mathrm{E}\mu_d \\ -\mathrm{E}\mu_d & E_2 \end{bmatrix}$$

$$\rho = \begin{bmatrix} \rho_{11} & \rho_{12} \\ \rho_{21} & \rho_{22} \end{bmatrix}$$

$$\begin{aligned}
\rho\hat{H} &= \frac{i}{\hbar}\left(\rho\hat{H} - \hat{H}\rho\right) \\
&= \frac{i}{\hbar}\left(\begin{bmatrix} \rho_{11} & \rho_{12} \\ \rho_{21} & \rho_{22} \end{bmatrix}\begin{bmatrix} E_1 & -\mathrm{E}\mu_d \\ -\mathrm{E}\mu_d & E_2 \end{bmatrix} - \begin{bmatrix} E_1 & -\mathrm{E}\mu_d \\ -\mathrm{E}\mu_d & E_2 \end{bmatrix}\begin{bmatrix} \rho_{11} & \rho_{12} \\ \rho_{21} & \rho_{22} \end{bmatrix}\right) \\
&= \frac{i}{\hbar}\left(\begin{bmatrix} \rho_{11}E_1 - \rho_{12}\mathrm{E}\mu_d & \rho_{11}(-\mathrm{E}\mu_d) + \rho_{12}E_2 \\ \rho_{21}E_1 - \rho_{22}\mathrm{E}\mu_d & \rho_{21}(-\mathrm{E}\mu_d) + \rho_{22}E_2 \end{bmatrix} - \begin{bmatrix} E_1\rho_{11} - \mathrm{E}\mu_d\rho_{21} & E_1\rho_{12} - \mathrm{E}\mu_d\rho_{22} \\ -\mathrm{E}\mu_d\rho_{11} + E_2\rho_{21} & -\mathrm{E}\mu_d\rho_{12} + E_2\rho_{22} \end{bmatrix}\right) \\
&= \frac{i}{\hbar}\begin{bmatrix} -\mathrm{E}\mu_d(\rho_{12} - \rho_{21}) & -\mathrm{E}\mu_d(\rho_{11} - \rho_{22}) + (E_2 - E_1)\rho_{12} \\ (E_1 - E_2)\rho_{21} - \mathrm{E}\mu_d(\rho_{22} - \rho_{11}) & -\mathrm{E}\mu_d(\rho_{21} - \rho_{12}) \end{bmatrix}
\end{aligned}$$

$$\begin{aligned}
\frac{d\rho_{21}}{dt} &= \frac{i}{\hbar}\left((\rho_{11} - \rho_{22})\mathrm{E}\mu_d - (E_2 - E_1)\rho_{21}\right) \\
&= -i\omega_{21}\rho_{21} + i\frac{\mu_d}{\hbar}\mathrm{E}(\rho_{21} - \rho_{21}^*)
\end{aligned}$$

$$\frac{d}{dt}(\rho_{11} - \rho_{22}) = 2i\frac{\mu_d}{\hbar}\mathrm{E}(\rho_{21} - \rho_{21}^*)$$

$$\frac{d}{dt}(\rho_{11} - \rho_{22}) = 2i\frac{\mu_d}{\hbar}\mathrm{E}(\rho_{21} - \rho_{21}^*) - \frac{(\rho_{11} - \rho_{22}) - (\rho_{11} - \rho_{22})_0}{T_1}$$

$$\frac{d\rho_{21}}{dt} = -i\omega_{21}\rho_{21} + i\frac{\mu_d}{\hbar}\mathrm{E}(\rho_{11} - \rho_{22})$$

$$\frac{d\rho_{21}}{dt} = -i\omega_{21}\rho_{21} + i\frac{\mu_d}{\hbar}\mathrm{E}(\rho_{11} - \rho_{22}) - \frac{\rho_{21}}{T_2}$$