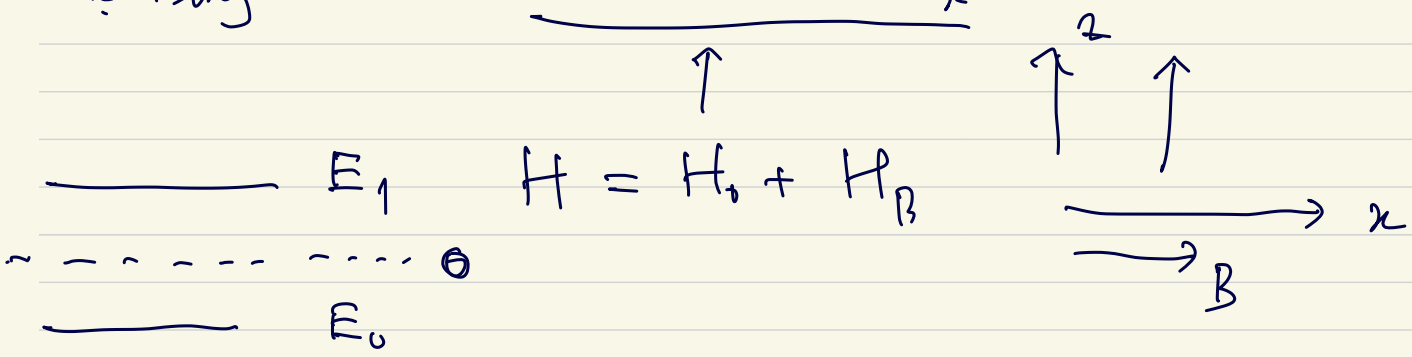
Hệ Ising $\quad H = -\sigma_z - h\,\sigma_x$



$$H_0 = \begin{bmatrix} E_0 & 0 \\ 0 & E_1 \end{bmatrix} \Rightarrow \begin{bmatrix} E_0 & 0 \\ 0 & E_1 \end{bmatrix} - \frac{E_0+E_1}{2}\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{E_0-E_1}{2} & 0 \\ 0 & \frac{E_1-E_0}{2} \end{bmatrix} = -\frac{E_1-E_0}{2}\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

$$H_0 = -\frac{\hbar\omega_{10}}{2}\sigma_z$$

1 spin $\quad \boxed{\hat{H} = -\sigma_z - h\,\sigma_x} \quad (h > 0)$

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle = \cos\frac{\theta}{2}|0\rangle + \sin\frac{\theta}{2}\,e^{i\phi}|1\rangle$$

Tìm $|\psi_{GS}\rangle$ cho $\hat{H}$.

$$\langle\psi|\hat{H}|\psi\rangle \geq \langle\psi_{GS}|\hat{H}|\psi_{GS}\rangle$$

$$|\psi(\theta,\phi)\rangle = \cos\frac{\theta}{2}|0\rangle + \sin\frac{\theta}{2}\,e^{i\phi}|1\rangle$$

Tìm $\theta, \phi \qquad \langle\psi|\hat{H}|\psi\rangle = E(\theta,\phi)$.

Hệ Ising 1 spin có 3 cách tiếp cận

(1) – tính giải tích: – tìm θ, ϕ để $E(\theta, \phi)$ cực tiểu ($\Leftrightarrow$ ground state) (1)

(2) – Chéo hoá ma trận. (Exact)

$$H = -\sigma_z - h\sigma_x = \begin{bmatrix} -1 & -h \\ -h & 1 \end{bmatrix}$$

tìm hàm sóng, trị riêng (2)

– Mạch lượng tử.

Hệ Ising 2 spin

$$H = -\vec{S}_1 \cdot \vec{S}_2 + \vec{S}_1 \vec{B}' - \vec{S}_1 \vec{B}$$

$$H = -\sigma_z' \otimes \sigma_z^2 - h(\sigma_x' + \sigma_x')$$

$$= -\sigma_z^1 \otimes \sigma_z^2 - h(\sigma_z' \otimes I' + \sigma_z^2 \otimes I')$$

$$|\psi\rangle = |\psi\rangle_1 \otimes |\psi_2\rangle$$

$$= |\psi(\theta_1, \phi_1)\rangle \otimes |\psi_2(\theta_2, \phi_2)\rangle$$

$$H = \sigma_z' \otimes I + I \otimes \sigma_x^2$$