

Lecture 5: Spin

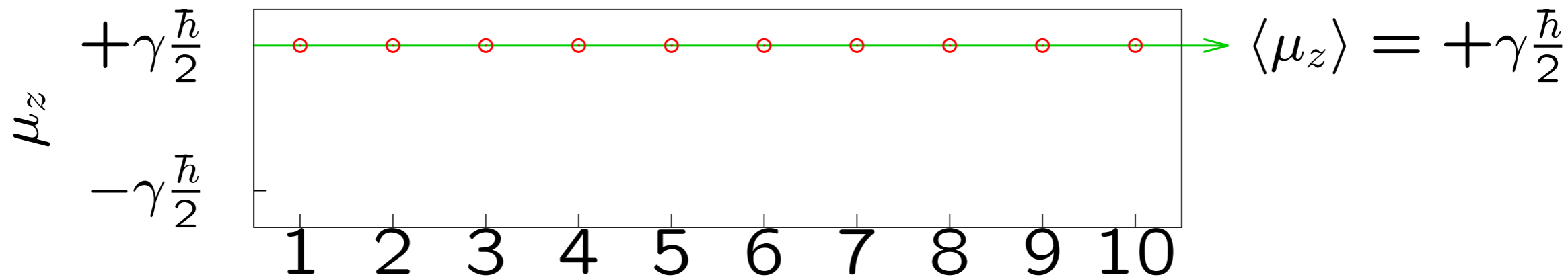
$$\begin{aligned}
& \left(i\hbar \frac{\partial}{\partial t} \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix} + ic\hbar \frac{\partial}{\partial z} \begin{pmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \\ -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{pmatrix} + ic\hbar \frac{\partial}{\partial x} \begin{pmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & 0 \\ -1 & 0 & 0 & 0 \end{pmatrix} + ic\hbar \frac{\partial}{\partial y} \begin{pmatrix} 0 & 0 & 0 & -i \\ 0 & 0 & i & 0 \\ 0 & i & 0 & 0 \\ -i & 0 & 0 & 0 \end{pmatrix} \right. \\
& \left. - m_0 c^2 \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \right) \begin{pmatrix} u_1 \psi \\ u_2 \psi \\ v_1 \psi^* \\ v_2 \psi^* \end{pmatrix} = 0
\end{aligned}$$

$$\hat{H} \approx \frac{1}{2m_0} \left(\left(i\hbar \frac{\partial}{\partial x} + QA_x \right)^2 + \left(i\hbar \frac{\partial}{\partial y} + QA_y \right)^2 + \left(i\hbar \frac{\partial}{\partial z} + QA_z \right)^2 + QV \right) \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \\ - \frac{\hbar Q}{2m_0} \left(B_x \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} + B_y \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix} + B_z \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \right)$$

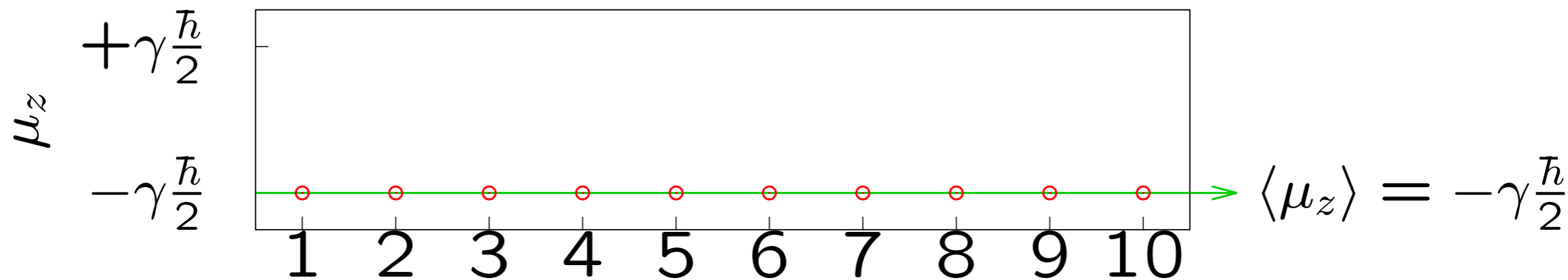
$$\gamma = 2 \frac{Q}{2m}$$

$$\hat{I}_x = \frac{\hbar}{2} \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \quad \hat{I}_y = \frac{\hbar}{2} \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix} \quad \hat{I}_z = \frac{\hbar}{2} \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \quad \hat{I}^2 = \frac{3\hbar^2}{4} \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}.$$

$$|\Psi\rangle = |\alpha\rangle$$

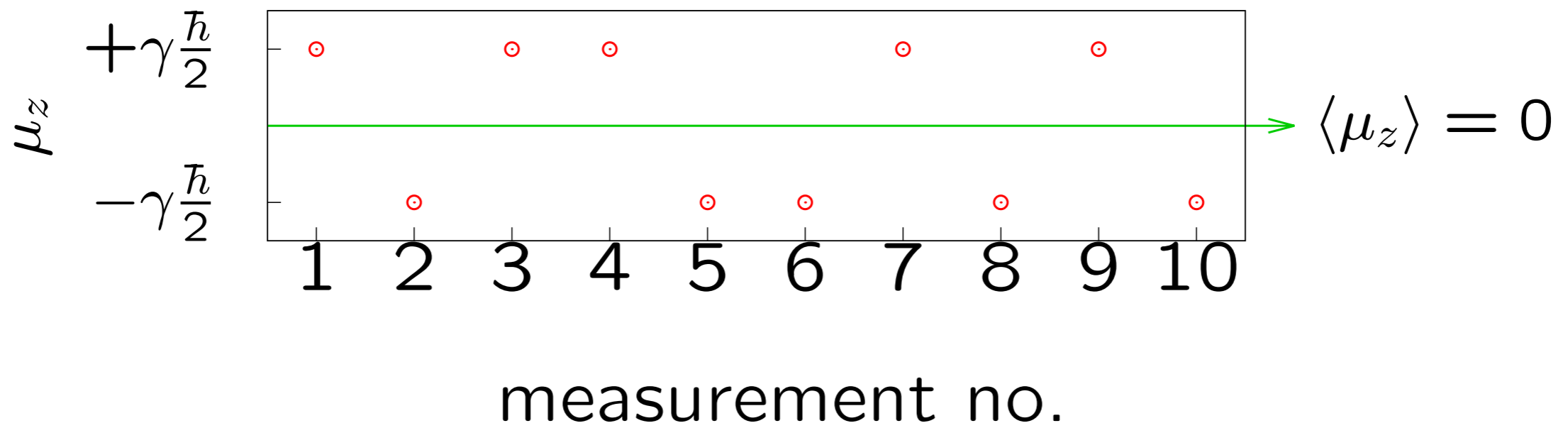


$$|\Psi\rangle = |\beta\rangle$$



measurement no.

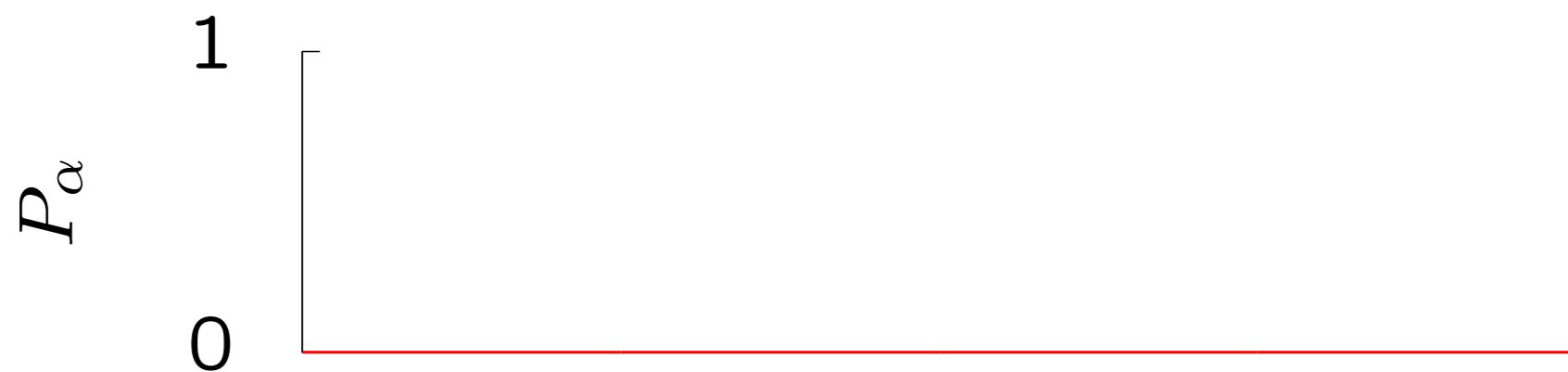
$$|\Psi\rangle = \frac{1}{\sqrt{2}}|\alpha\rangle + \frac{1}{\sqrt{2}}|\beta\rangle$$



$$|\psi\rangle(t=0) = |\alpha\rangle; \quad \hat{H} = -\gamma B_0 \hat{I}_z = \omega_0 \hat{I}_z$$



$$|\psi\rangle(t=0) = |\beta\rangle; \quad \hat{H} = -\gamma B_0 \hat{I}_z = \omega_0 \hat{I}_z$$



t

$$|\Psi\rangle(t=0) = |\alpha\rangle \quad \hat{H} = -\gamma B_1 \hat{I}_x = \omega_1 \hat{I}_x$$

