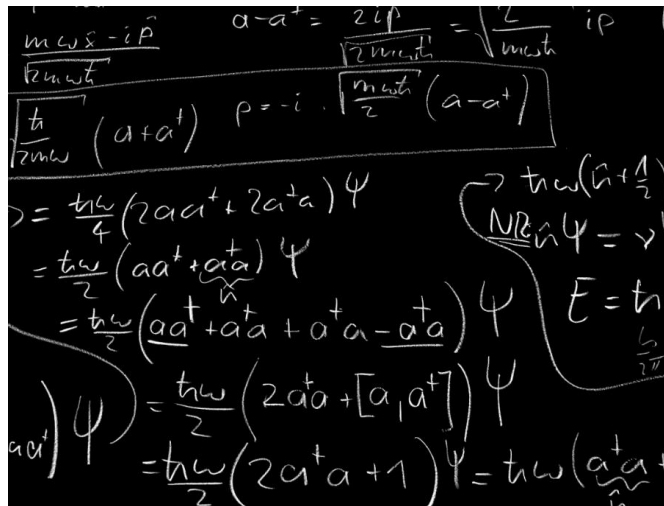


「量子力學的原理」工作紙

觀看視像 07:20 至 16:25，回答以下問題：



Handwritten mathematical derivations for the harmonic oscillator energy levels using ladder operators:

$$a - a^\dagger = \frac{2i\hat{p}}{\sqrt{2m\omega\hbar}} = \sqrt{\frac{2}{m\omega\hbar}} i\hat{p}$$

$$\frac{\hbar}{2m\omega} (a + a^\dagger) \hat{p} = -i \frac{m\omega\hbar}{2} (a - a^\dagger)$$

$$\hat{p} = \frac{\hbar\omega}{4} (2aa^\dagger + 2a^\dagger a) \psi$$

$$= \frac{\hbar\omega}{2} (aa^\dagger + a^\dagger a) \psi$$

$$= \frac{\hbar\omega}{2} (aa^\dagger + a^\dagger a + a^\dagger a - a^\dagger a) \psi$$

$$= \frac{\hbar\omega}{2} (2a^\dagger a + [a, a^\dagger]) \psi$$

$$= \frac{\hbar\omega}{2} (2a^\dagger a + 1) \psi = \hbar\omega \left(a^\dagger a + \frac{1}{2} \right) \psi$$

Annotations on the right side of the image:

- $\rightarrow \hbar\omega \left(n + \frac{1}{2} \right)$
- $N\hbar\omega \psi = \psi$
- $E = \hbar\omega \left(n + \frac{1}{2} \right)$

1. 量子力學與《西遊記》中孫悟空的「分身術」有甚麼關係？
2. 為甚麼潘建偉教授說「量子力學」從哲學的角度上講，是非常積極的？