

b)  $\langle X \rangle$  observable

(2)

$$\begin{aligned} \text{I. way)} \quad H|4\rangle &= \cos 0.35 \left( \frac{1}{\sqrt{2}} (|0\rangle + |1\rangle) \right) \\ &+ e^{2\pi i 0.75} \sin 0.35 \left( \frac{1}{\sqrt{2}} (|0\rangle - |1\rangle) \right) \\ &= \frac{1}{\sqrt{2}} \left( |0\rangle (\cos 0.35 + e^{2\pi i 0.75} \sin 0.35) \right. \\ &\quad \left. + |1\rangle (\cos 0.35 - e^{2\pi i 0.75} \sin 0.35) \right) \end{aligned}$$

$$\begin{aligned} P_0 &= \left| \cos 0.35 + e^{2\pi i 0.75} \sin 0.35 \right|^2 \\ &= \left| \cos 0.35 + \sin 0.35 (\cos 2\pi 0.75 + i \sin 2\pi 0.75) \right|^2 \end{aligned}$$

= ... a little bit nasty, but obviously  
this time  $P_0$  and  $P_1$  will depend  
on the phase  $2\pi 0.75$   
so we get some information about the phase

$$P_1 = \dots$$

$$\begin{aligned} \text{II. way)} \quad \langle X \rangle &= \langle 4 | X | 4 \rangle \\ &= \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} \cos 0.35 \\ e^{2\pi i 0.75} \sin 0.35 \\ e^{2\pi i} \sin 0.35 \\ \cos 0.35 \end{pmatrix} \\ &= (\cos 0.35, e^{-2\pi i 0.75} \sin 0.35) \begin{pmatrix} e^{2\pi i 0.75} \sin 0.35 \cos 0.35 \\ -e^{-2\pi i 0.75} \sin 0.35 \cos 0.35 \end{pmatrix} = \end{aligned}$$

$$= (\cos \sqrt[2\pi]{0.75} + i \sin \sqrt[2\pi]{0.75}) \cdot (\dots) + \sin (\cos \sqrt[2\pi]{0.75} - i \sin \sqrt[2\pi]{0.75}) \cdot (\dots)$$

$$= 2 \cdot \cos \sqrt[2\pi]{0.75} \cdot \sin 0.35 \cdot \cos 0.35$$

cool, our average value depends on the phase  $2\pi 0.75$