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[50] Theorem: for every observable A and a normalized state $|\psi\rangle$, we have: $A|\psi\rangle = \langle A\rangle|\psi\rangle + \Delta A|\psi_\perp\rangle$ for some state $|\psi_\perp\rangle$ which is orthogonal to $|\psi\rangle$. To prove this, we begin with: $A|\psi\rangle = \langle A\rangle|\psi\rangle + A|\psi\rangle - \langle A\rangle|\psi\rangle$ now, we set: $|\widetilde{\psi_\perp}\rangle = A|\psi\rangle - \langle A\rangle|\psi\rangle$, so: $\langle\widetilde{\psi_\perp}|\psi\rangle = (\langle\psi|A - \langle\psi|\langle A\rangle)|\psi\rangle = \langle\psi|A|\psi\rangle - \langle A\rangle\langle\psi|\psi\rangle = 0$ now we set: $|\psi_\perp\rangle = b|\widetilde{\psi_\perp}\rangle$, where $|\psi_\perp\rangle$ is normalized and b real (note that $\langle\psi|\psi_\perp\rangle = 0$). so: $A|\psi\rangle = \langle A\rangle|\psi\rangle + b|\psi_\perp\rangle$. Now we multiply from the left by $\langle\psi_\perp|$, and we get: $\langle\psi_\perp|A|\psi\rangle = b$. Now we can see that: $\langle\psi|A^2|\psi\rangle = \langle\psi|A(\langle A\rangle|\psi\rangle + b|\psi_\perp\rangle) = \langle\psi|(\langle A\rangle^2|\psi\rangle + b\langle A\rangle|\psi_\perp\rangle + bA|\psi_\perp\rangle) = \langle A\rangle^2 + b\langle\psi|A|\psi_\perp\rangle$ so: $\langle A^2\rangle - \langle A\rangle^2 = b\langle\psi|A|\psi_\perp\rangle = b^2$ which means that: $b = \sqrt{\langle A^2\rangle - \langle A\rangle^2} = \Delta A$ and the result: $A|\psi\rangle = \langle A\rangle|\psi\rangle + \Delta A|\psi_\perp\rangle$ is proved.

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[58] The identity $\exp\{i\alpha\hat{\sigma}_{\vec{n}}\} = \cos\alpha + i\hat{\sigma}_{\vec{n}}\sin\alpha$ is easily proven using the fact that for any integer k: $\sigma_{\hat{n}}^{2k} = I$ and $\sigma_{\hat{n}}^{2k+1} = \sigma_{\hat{n}}$ and now it follows that: $e^{i\alpha\sigma_{\hat{n}}} = \sum_{k=0}^{\infty}\frac{(i\alpha)^k\sigma_{\hat{n}}^k}{k!} = \sum_{k=0}^{\infty}\frac{(i\alpha)^{2k}}{(2k)!} + \sigma_{\hat{n}}\sum_{k=0}^{\infty}\frac{(i\alpha)^{2k+1}}{(2k+1)!} = e^{i\alpha\sigma_{\hat{n}}} = \cos\alpha + i\sigma_{\hat{n}}\sin\alpha$ and the identity is proven.

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[67] Proof: Given that $\hat{\mathbf{P}}_A = \sum_n a_n|\alpha_n\rangle\langle\alpha_n|$, if an eigenvalue, e.g. $\hat{\mathbf{P}}_A = a_n$, is obtained with certainty, then for $n \neq m$, $\hat{\mathbf{P}}_A \equiv |\alpha_m\rangle\langle\alpha_m| = 0$ because the probability to obtain another eigenvalue by ABL is $\propto \langle\Psi_{\rm fin}|\alpha_m\rangle\langle\alpha_m|\Psi_{\rm in}\rangle = 0$. In this case, the weak-value $(\hat{\mathbf{P}}_A)_{\rm w} = (|\alpha_m\rangle\langle\alpha_m|)_{\rm w} = \frac{\langle\Psi_{\rm fin}|\alpha_m\rangle\langle\alpha_m|\Psi_{\rm in}\rangle}{\langle\Psi_{\rm fin}|\Psi_{\rm in}\rangle} = 0$. In addition, $\sum_m \frac{\langle\Psi_{\rm fin}|\alpha_m\rangle\langle\alpha_m|\Psi_{\rm in}\rangle}{\langle\Psi_{\rm fin}|\Psi_{\rm in}\rangle} = 1$ because $\sum_m |\alpha_m\rangle\langle\alpha_m| = 1$. But since $\langle\Psi_{\rm fin}|\alpha_m\rangle\langle\alpha_m|\Psi_{\rm in}\rangle = 0$ for $n \neq m$, the only term left is n. Therefore, the weak-value is 1, the same as the ideal value.

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