Quantum Calculations on a Ring II

Your group will be given one of the following normalized quantum wavefunctions on a ring:

$$\Phi_a(\phi) = \frac{1}{\sqrt{18\pi r_0}}\left(\sqrt{8} + e^{2i\phi}\right) \qquad \Phi_b(\phi) = \frac{1}{\sqrt{18\pi r_0}}\left(\sqrt{8}\, e^{2i\phi} + e^{-3i\phi}\right)$$

$$\Phi_c(\phi) = \frac{1}{\sqrt{18\pi r_0}}\left(\sqrt{7}\, e^{2i\phi} + \sqrt{2}\, e^{-2i\phi}\right) \qquad \Phi_d(\phi) = \frac{1}{\sqrt{18\pi r_0}}\left(\sqrt{7} + \sqrt{2}\, e^{-3i\phi}\right)$$

$$\Phi_e(\phi) = \frac{1}{\sqrt{18\pi r_0}}\left(\sqrt{6} + \sqrt{3}\, e^{2i\phi}\right) \qquad \Phi_f(\phi) = \frac{1}{\sqrt{18\pi r_0}}\left(\sqrt{6}\, e^{2i\phi} + \sqrt{3}\, e^{-3i\phi}\right)$$

$$\Phi_g(\phi) = \frac{1}{\sqrt{18\pi r_0}}\left(\sqrt{5}\, e^{2i\phi} + \sqrt{4}\, e^{-2i\phi}\right) \qquad \Phi_h(\phi) = \frac{1}{\sqrt{18\pi r_0}}\left(\sqrt{5} + \sqrt{4}\, e^{-3i\phi}\right)$$

1) If you measured the z-component of angular momentum, what is the probability that you would obtain $2\hbar$? $-3\hbar$?

2) If you measured the z-component of angular momentum, what other possible values could you obtain with non-zero probability?

3) If you measured the energy, what possible values could you obtain with non-zero probability?

4) What is the expectation value of $\hat{L}_z$ in this state? the expectation value of energy?

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