Consider the following normalized abstract quantum state on a ring:

$$\Phi(\phi) = \sqrt{\frac{8}{5\pi r_0}} \cos^3(2\phi) \tag{1}$$

1. If you measured the z-component of angular momentum, what is the probability that you would measure $2\hbar$? $-3\hbar$?
2. If you measured the z-component of angular momentum, what other possible values could you have obtained with non-zero probability?
3. If you measured the energy, what possible values could you have obtained with non-zero probability?
4. What is the probability that the particle can be found in the region $0 < \phi < \frac{\pi}{2}$?