University of Calgary
Winter semester 2007

PHYS 443: Quantum Mechanics I

Second midterm examination

March 22, 2007

Open books. Attempt all questions. Partial credit will be given.

<u>Problem 1.</u> (30 pts) Express the states $|\Phi^+\rangle = (|HH\rangle + |VV\rangle)/\sqrt{2}$ and $|\Phi^-\rangle = (|HH\rangle - |VV\rangle)/\sqrt{2}$ in the circular polarization basis. For each state, what are the outcome probabilities for a measurement in this basis?

<u>Problem 2.</u> Consider a potential energy operator, which is a function of the position observable:

$$\hat{V} = V_0\, e^{-\hat{x}^2/d^2}.$$

a) (15 pts) What is the matrix element $\left\langle x \middle| \hat{V} \middle| x' \right\rangle$ of this operator in the position basis?

b) (25 pts) What is the matrix element $\left\langle p \middle| \hat{V} \middle| p' \right\rangle$ of this operator in the momentum basis?

<u>Problem 3.</u> (30 pts) Alice and Bob perform measurements on multiple copies of some bipartite entangled state $|\Psi\rangle$ and find the following:

- if Alice measures in the diagonal basis:

  - whenever Alice detects $|+\rangle$, Bob gets $|H\rangle$;
  - whenever Alice detects $|-\rangle$, Bob gets $|V\rangle$;

- if Alice measures in the canonical basis:

  - whenever Alice detects $|H\rangle$, Bob gets $|L\rangle$.
  - whenever Alice detects $|V\rangle$, Bob gets $|R\rangle$.

What is $|\Psi\rangle$?