Physics 115B Third Problem Set

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1. In this problem, work through the uncertainty principle for the operators for the 3 components of spin-1/2:

$$\mathbf{s}_x \doteq \frac{\hbar}{2}\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \quad , \quad \mathbf{s}_y \doteq \frac{\hbar}{2}\begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix} \quad , \quad \mathbf{s}_z \doteq \frac{\hbar}{2}\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

   (a) Use the matrices to evaluate the commutator and anticommutator of $\mathbf{s}_x$ and $\mathbf{s}_y$, and use (9.2.12) on page 239 of your text to develop an inequality for $(\Delta s_x)^2(\Delta s_y)^2$.

   (b) Find the column vector representation of the general state $|\psi\rangle$ for which the right hand side of the inequality from part (a) is 0.

   (c) Find the matrices that represent the operators $\hat{\mathbf{s}}_x$ and $\hat{\mathbf{s}}_y$, defined in analogy with (9.2.3) on page 238 of your text; use the state $|\psi\rangle$ from part (b) to evaluate $\langle \mathbf{s}_x \rangle$ and $\langle \mathbf{s}_y \rangle$.

   (d) Find the column vectors that represent $|\hat{\mathbf{s}}_x\psi\rangle$ and $|\hat{\mathbf{s}}_y\psi\rangle$, where $|\psi\rangle$ is the state you found in part (b).

   (e) Use the norms of the states found in part (d) to evaluate the left hand side of the inequality from part (a).

   (f) When the inequality is an equality, do you get the relationship between the states found in part (d) that you expect from the Schwartz (in)equality?

2. Exercise 9.4.1 on page 244 of your text.

3. Exercise 9.4.3 on page 244 of your text.

4. Exercise 9.4.4 on page 244 of your text.