PHYS 20323/60323: Fall 2024 - LaTeX Example

1. An electron is found to be in the spin state (in the z-basis): $\chi = A\begin{pmatrix} 3i \\ 4 \end{pmatrix}$

$(a)(5 points) Determine the possible values of A such that the state is normalized.$

$(b)(5 points) Find the expectation values of the operators S_x, S_y, S_z,$ and S^2.

The matrix representations in the z-basis for the components of electron spin operators are given by:

$$S_x = \frac{\hbar}{2}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}; \quad S_y = \frac{\hbar}{2}\begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}; \quad S_z = \frac{\hbar}{2}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

2. The average electrostatic field in the earth's atmosphere in fair weather is approximately given:

$$\tilde{\mathbf{E}} = E_0(Ae^{-\alpha z} + Be^{-\beta z})\hat{z}$$

where A, B, α, β are positive constants and z is the height above the (locally flat) earth surface.

(a) (5 points) Find the average charge density in the atmosphere as a function of height.

(b) (5 points) Find the electric potential as a function of height above the earth.

3. The following questions refer to stars in the Table below.

Note: There may be multiple answers.

(a) (4 points) Which of these stars will produce a planetary nebula?

Name	Mass	Luminosity	Lifetime	Temperature	Radius
β Cyg.	1.3 $M_\odot$	3.5 $L_\odot$			$R_\odot$
α Cen.	1.0 $M_\odot$	$L_\odot$	8.0×10^{10} years		1 $R_\odot$
η Car.	60 $M_\odot$	10^6 $L_\odot$			
ε Eri.	0.6 $M_\odot$	10^3 $L_\odot$	5.0×10^9 years	20,000 K	
δ Scu.	2.0 $M_\odot$		5.0×10^8 years		2 $R_\odot$
γ Del.	0.7 $M_\odot$		4.5×10^{10} years	5000 K	

(b) (4 points) Elements heavier than Carbon will be produced in which stars? **LaTeX**

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