PHYSICS 20323: Scientific Analysis & Modeling - Fall 2023
Project: Mudit Panda

1. **The following questions refer to stars in the table below.**
Note: There may be multiple answers.

Name	Mass	Luminosity	Lifetime	Temperature	Radius
μ Car.	60. $M_\odot$	$10^6 L_\odot$	8.0×10^5		
σ Eri.	6.0 $M_\odot$	$10^3 L_\odot$		20,000 K	
δ Scu.	2.0 $M_\odot$		5×10^8 years		$2R_\odot$
β Cyg.	1.3 $M_\odot$	$3.5 L_\odot$			
α Cen.	1.0 $M_\odot$				$1R_\odot$
γ Del.	0.7 $M_\odot$		4.5×10^{10} years	5000 K	

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

(b) (4 points) Elements heavier than *Carbon* will be produced in which starts.

2. 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 $\vec{S^2}$

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

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

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

$$\vec{E} = E_0(Ae^{-\alpha z} + Be^{-\beta z})\hat{z} \tag{1}$$

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.