PHYSICS 20323: Scientific Analysis & Modeling - Fall 2023
Project: Anthony Gerg

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

Name	Mass	Luminosity	Lifetime	Temperature	Radius
η Car.	60. $M_\odot$	10^6 $L_\odot$	8.0×10^5 years		
ϵ Eri.	6.0 $M_\odot$	10^3 $L_\odot$		20,000 K	
σ Scu.	2.0 $M_\odot$		5.0×10^8 years		2 $R_\odot$
β Cyg.	1.3 $M_\odot$	3.5 $L_\odot$			
α Cen.	1.0 $M_\odot$				1 $R_\odot$
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 stars.

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

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

   (b) (5 points) Find the expectation values of S_x, S_y, S_z, and $\vec{S^2}$

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

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

3. The average electrostatic field in Earth's atmosphere in fair weather is given by:

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

   where A, B, α, β are positive constants and z it 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 height above the earth.