Name:

Midterm Exam. Astronomy & Astrophysics I

1. Angular Resolution of Telescopes
   Calculate the theoretical angular resolution of:

A. The Gemini optical Telescope (8m aperture, at visible wavelengths)

B. Global VLBI (Radio, at ~ 1GHz)

C. Given that atmospheric turbulence (or astronomical "Seeing") limits resolution to ≥0.5", what is the primary purpose of large optical telescopes?

2. From the observation that the Sun's energy output peaks in the yellow part of the spectrum (λ_{Max}=500 nm), estimate its effective surface temperature and luminosity.

3. Luminosity and Distance
The bright star Omicron Eridani (m_V=4.4, T=5,300 K) has an annual parallax motion of 0.2".

A. Find the distance to Omicron Eridani (in pc)

B. Absolute magnitude of Omicron Eridani

C. Hence calculate the luminosity (in solar units) of Omicron Eridani.

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4. Luminosity, Radius, Temperature, Relationship
Omicron Eridani has a binary companion (actually it's a triple system).
Star B is much fainter, despite being hotter (m_V=9.5, T=16,500 K)

A. Find the stellar radii of R_A & R_B in solar units. (hint: find the ratio first)

B. Comment on what types of stars these are.

5. Spectral Types

A. State the three most important spectral characteristic of stars of spectral types:
O, A M, and briefly note the physical condition responsible.

O:

A:

M:

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6. Orbital Dynamics of Binary Stars

The stars β Aurigae A and β Aurigae B, constitute a dual-lined eclipsing spectroscopic binary with an orbital period of 3.96 days. The observed radial velocity curves have amplitudes v_A =108 km/s and v_B=111 km/s.

Calculate the masses of the two stars.

7. Sketch the Hertzprung Russell Diagram.

Label the key features, and indicate order-of-magnitude values for Temperature, Luminosity, and Radius.

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8. Stellar Physics.
Apply the Virial Theorem, (plus any other relevant stellar physics) to estimate the temperature deep inside the Sun.

9. Nuclear Reactions
Write out the steps of the Proton-Proton chain

10. Nuclear Reaction Conditions.
Estimate the interaction energy required for protons to get close enough together to have a reasonable probability of undergoing quantum tunneling, and compare this to the typical kinetic energy of solar protons.

C. What is likely the dominant energy production process (and why) in:

A. The Sun

B. Sirius

C. Brown Dwarfs

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Formulae:

Wien's Law	$\lambda_{max} = \frac{T}{2.9 \times 10^{-3} m.K}$
Hydrostatic Equilibrium	$\frac{dP_r}{dr} = -\frac{GM_r\rho_r}{r^2}$
Mass Distribution	$\frac{dM_r}{dr} = 4\pi r^2 \rho_r$
Gravitational Potential Energy	$U_G = -\frac{3}{5}\frac{GM^2}{R}$
Magnitudes	$m_1 - m_2 = -2.5\log_{10}\frac{f_1}{f_2}$
Distance modulus and absolute magnitude	$\mu = m - M = 5\log_{10} D_{pc} - 5$
	$(M_A + M_B)\sin^3 i = \frac{P(v_A^{obs} + v_B^{obs})^3}{2\pi G}$
Kepler's Law	$(M_A + M_B)\sin^3 i = \frac{4\pi^2}{GP^2}(a_A \sin i + a_B \sin i)^3$

Proton Mass: 1.67×10^{-27} kg
Electron Mass: 9.11×10^{-31} kg
Electron Charge: -1.9×10^{-19} C
Sun: Mass: 1.99×10^{30} kg
Mean Radius: 6.38×10^{5} km
Absolute Magnitude: +4.83
Apparent magnitude: -26.74
Flux at Earth: 1.4×10^{3} W/m^2
Earth: Mass: 5.98×10^{24} kg
Mean Radius: 6.38×10^{3} km
Earth-Sun Distance: 1AU = 150 $\times 10^{6}$ km
Plank's Constant: 6.63×10^{-34} J.s
Stefan-Boltzmann Constant: 5.67×10^{-8} W/m^2.K^4
Boltzmann's Constant: 1.38×10^{-23} J/K
Coulomb Constant: 9×10^{9} N/C
Gravitational Constant: 6.67×10^{-11} N.m^2/kg