**Final Exam. Astronomy & Astrophysics I. 95.383/585 Fall 2011**

**Dec 20th 2011, 3pm**

Proton Mass: 1.67 x10-27 kg

Electron Mass: 9.11 x10-31 kg

Electron Charge: -1.9x10-19 C

Thompson Cross Section: σT = 6.652x10-29 m2

Sun: Mass: 1.99 x1030 kg

Mean Radius: 6.955 x105 km

Absolute Magnitude: +4.83

Apparent magnitude: -26.74

Flux at Earth: 1.4 x103 W/m2

Earth: Mass: 5.98 x1024 kg

Mean Radius: 6.38 x103 km

Earth-Sun Distance: 1AU = 150 x106 km

Milky Way Galaxy: Radius = ~20 kpc

Number of Stars = 1011

Gas Mass = 5x1010 Msun

Sun-GalacticCenter distance = 8 kpc

Planck’s Constant: 6.63 x10-34 J.s

Stefan-Boltzmann Constant: 5.67 x10-8 W/m2.K4

Boltzmann’s Constant: 1.38 x10-23 J/K

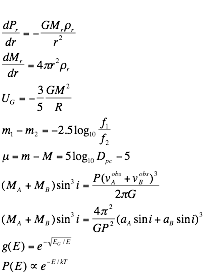
Coulomb Constant: 9 x109 N/C

Gravitational Constant: 6.67 x10-11 N.m2/kg

Wien’s Displacement Constant: 2.9x10-3 m.K

|  |  |
| --- | --- |
| Name |  |
| Multiple Choice |  |
| Problems |  |
| Total |  |

Do all the Multiple choice and FOUR Problems ONLY



Hydrostatic Equilibrium

Mass Distribution

Gravitational Potential Energy of a solid sphere

Magnitudes

Distance modulus and absolute magnitude

Kepler’s Law

Gamow function

Maxwell Distribution

1. Angular resolution of ground based optical telescopes is limited primarily by:
   1. The telescope aperture
   2. The wavelength of the radiation being detected
   3. The turbulence of the atmosphere
   4. The size of CCD pixels
2. Which law relates the temperature of a star to its color?
   1. Stefan-Boltzmann Law
   2. Planck’s function
   3. The photometric law
   4. Wien’s Law
3. The Solar spectrum peaks at 5020 A. What is the effective temperature of the solar photosphere in terms of an equivalent black body?
   1. 5777 K
   2. 7800 K
   3. 577.7 K
   4. 3500 K
4. The surface temperature of Sirius A is 9940 K, and its radius is 1.7 RSun. What is its intrinsic luminosity?
   1. 1 LSun
   2. 26 LSun
   3. 12 Lsun
   4. 96 Lsun
5. The nearest star to the Sun is Proxima Centauri, its annual parallax is 768.7mas. How far away is it?
   1. 768.7 pc
   2. 1.309 pc
   3. 0.0013 pc
   4. 0.768 pc
6. The absolute magnitude of the Sun is +4.83 mag. How bright would the Sun appear if it were viewed from the Pleiades star cluster, 130 pc away?
   1. +10.4
   2. +15.4
   3. +10.7
   4. +5.57
7. Absorption lines in a stellar spectrum are primarily an indicator of:
   1. Chemical composition
   2. Temperature
   3. Age
   4. Mass
8. A spectroscopic binary can reveal the exact masses of both stars when sufficient data is available. What is the minimum requirement?
   1. The Radial velocity curve of one star only
   2. The radial velocity curves of both stars
   3. A single RV curve and an eclipse profile
   4. Both RV curves and an eclipse profile
9. Of the Proton-Proton Chain, which statement is not correct?
   1. The overall effect is to convert 4 protons to one helium nucleus
   2. One neutrino is released for each He nucleus produced
   3. Most of the energy is released as gamma rays and heat (KE).
   4. The first step (P+P) takes ~ 1010 years.
10. Which phenomena can be exhibited by a neutron star but not by a black hole.
    1. Hard X-ray spectrum
    2. An Accretion Disk
    3. Periodic pulsations
    4. A Mass above 1.4 MSun
    5. Mass below 3 Msun
11. A supergiant star of 10 times the mass of the Sun, with a 15 day rotation period, goes supernova, ejecting 80% of its mass into space. Only the core survives, after collapsing by a factor of ~1000 in radius. Predict the rotation period of the relic, in this case a neutron star pulsar of radius 15 km.
    1. 3 ms
    2. 130 ms
    3. 1 day
    4. 0.33 s
    5. 3 min
12. The majority of the elements heavier than hydrogen were created:
    1. During the Big Bang
    2. In supernovae originating in the explosive ignition of white dwarf stars
    3. In supernovae originating in the core-collapse of massive stars
    4. During the nucleosynthesis reactions in the cores of massive stars.
13. During a supernova, which of the following are not true?
    1. The majority of the gravitational binding energy released is carried off by neutrinos.
    2. The luminosity in the visible spectrum is greater than that of an entire galaxy.
    3. The supernova reaches its maximum brightness within a few milliseconds, and then fades over a period of weeks.
    4. Rate of decline in brightness is driven by the half-life of Ni56 and its daughter isotopes.
14. The Jeans instability:
    1. Favors the collapse of massive gas clouds
    2. Prevents Stellar pulsation except in a narrow range luminosity and temperature.
    3. Favors the collapse of dense gas clouds
    4. Drives stellar pulsation
15. Of M-Sigma relation, check all that are true:
    1. Is a theoretical prediction about Black hole mass and host galaxy mass.
    2. Is an observed correlation between super-massive black hole mass and the velocity dispersion of stars in the host galaxy.
    3. Holds across at least 4 orders of magnitude in BH mass
    4. Was recently disproved by the discovery of black holes with mass >109 Msun
16. The present day value of Hubble’s constant (71 km/s/Mpc) implies that the age of the universe as inferred from the Hubble-Time is:
    1. 13x109 years
    2. 13.8x109 years
    3. Infinitely long
    4. 71x109 years
17. The Schwarzschild Radius (via the semi-classical approximation) of a 24 Msun black hole is:
    1. 35 km
    2. 71 km
    3. 2.9 km
    4. about 1 cm
    5. about 1 AU
18. If the solar constant is 1.3 kW/m2, how much mass is converted to energy in the Sun’s core per second?
    1. 4.3 x109 kg
    2. 325 kg
    3. 3.25x108 kg
    4. 4.08 x109 kg
    5. about 1 kg

Problem 1: The Hertzprung Russell Diagram

A. Sketch the HR Diagram (T vs L/Lsun) with order of magnitude labels. Indicate the location of the following features: The Sun, Main sequence, Red giants, White dwarfs. [8 points]

B. Draw two lines on the diagram, representing the locus of stars in a young cluster such as the Pleiades, and the stars in an old globular cluster. [2 points]

Problem 2: Stellar Luminosity, Radius and Temperature

Sirius A’s spectrum peaks at λ≈300nm, the faint companion Sirius B’s spectrum peaks at λ≈115nm. Observations of the Sirius system show Sirius A is about 1000 times brighter than B, yet both are at the same distance from the Earth.

1. Compute the ratio of luminosities LA/LB  [3 points]
2. Calculate the ratio of the radii RA/RB  [3 points]
3. What spectral types are these two stars? [2]
4. Explain the key differences in the internal structure of these stars. [2 points]

Problem 3: The Initial Mass Function

A. Sketch the universal initial mass function dN/dM ~ M-α where α=2.5 [2 points]

B. Calculate an estimate for the number of core-collapse supernovae that have occurred in the in the Milky Way galaxy. [4 points]

C. Make a prediction for the metallicity (ratio of Fe/H abundance) of interstellar gas. Assuming that a typical Core collapse SN produces (and ejects into space) 0.05 Msun of heavy elements. [2points]

D. Give a possible explanation for the Galaxy Mass – Metallicity relation. [2 points]

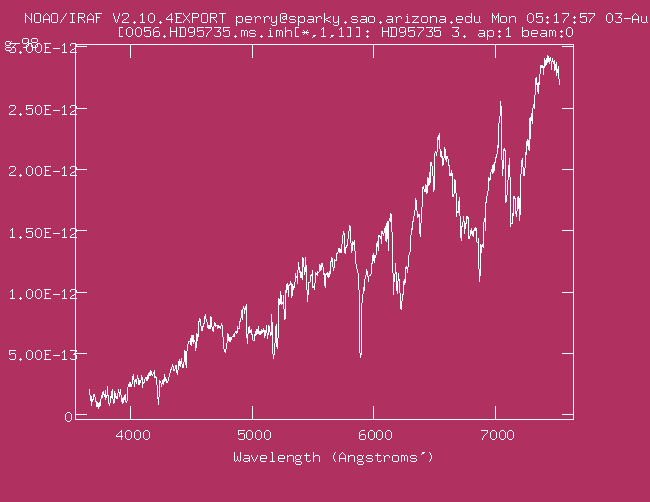
Problem 4. Stellar Physics.   
A. Use the Equation of Hydrostatic Equilibrium to estimate the pressure at the center of the Sun [5 points]

B. Apply the Virial Theorem, (plus any other relevant stellar physics) to estimate the temperature deep inside the Sun. [5 points]

Problem 5: The Origin of Spectral Lines.

A. Explain the reason for the appearance (or lack thereof) of the Hydrogen Balmer lines in O, A, and M stars [4 points]

B. List 3 physical processes that give spectral lines their finite width and shape. [3 points]



C. Identify the star whose spectrum is shown below. Label 3 defining characteristics. [3]

Problem 6. Orbital Dynamics of Binary Stars

The maximal radial velocities of two stars in a dual-lined spectroscopic binary are 30 km/s and 8 km/s. An eclipse is seen every 4 years. The eclipse ingress takes 0.4 days, minimum lasts for 1.1 days, and egress then takes another 0.4 days.

A. Find the masses of the two stars (in kg or Msun) [5 points]

B. Sketch the eclipse brightness profile and an accompanying diagram showing the configuration of the two stars at each inflection point of the lightcurve. [3 points]

C. Find the physical radius of the larger of the two stars (in meters) [2 points]

Problem 7: Nuclear Reaction Rates

1. Sketch the Coulomb Barrier that must be broached in order for two protons to fuse together in the first stage of the P-P chain. Indicate the energy and separation scales of the barrier. [4 points]
2. Calculate the average kinetic energy of protons in the core of a star, at T=107 K [2 points]
3. Calculate the required energy to bring a proton within one de Broglie wavelength of another proton in the core of the star. [3 points]
4. What is the significance of this in regard to the nuclear fusion reaction rates in stellar cores. [1]