Name _____

Astronomy 141 – Life in the Universe
Autumn Quarter 2008 – Prof. Gaudi
Homework #4

Due Monday, November 24 in class

Instructions

Answer the following seven questions by circling the correct answer. Each question is worth the number of points given in parentheses (out of a total of 100). I may award partial credit if you show your work. In addition, there are two extra credit questions. These are tough but worth 30 points each if you get them right.

No late homework will be accepted.

These questions concern the concept of targets for searches for extrasolar planets, specifically (a) the number of targets available for these searches for stars of various types, (b) the suitability of stars of various types, and (c) the sizes of the signals for planets orbiting stars of various types and using various methods.

Assume that the space density of all main-sequence stars in the solar neighborhood is 0.1 stars per cubic parsec. When necessary, use the 'typical' values for the physical parameters of stars of various spectral types taken from my notes.

Question 1 (10 points)

Estimate the number of A stars within 10 parsecs of the Sun.

a) 4
b) 0
c) 42
d) 419
e) 4189

Question 2 (10 points)

Estimate the number of G stars within 10 parsecs of the Sun.

a) 2932
b) 293
c) 1
d) 7
e) 29

Question 3 (10 points)

Estimate the number of M stars within 5 parsecs of the Sun.

a) 1
b) 393
c) 39
d) 314
e) 5

Question 4 (25 points)

Assume that it takes 1.5 Gyr for intelligent life to evolve. Further assume that the Sun has a lifetime of 10 Gyr, and the lifetime of a main sequence star is proportional to M^{-3}, where M is the mass of the star. What kinds of main sequence stars should *not* be targeted for searches for intelligent life?

a) Stars with mass less than about 5.5 times the mass of the Sun.
b) Stars with mass less than about 1.9 times the mass of the Sun.
c) Stars with mass greater than about 1.9 times the mass of the Sun.
d) Stars with mass greater than about 0.53 times the mass of the Sun
e) Stars with mass less than about 6.7 times the mass of the Sun.

For the following three questions, pick the answer that is correct to within an order-of-magnitude (in other words, pick the closest power of ten).

Question 5 (15 points)

A Jupiter-sized planet transits in front of an A0 main-sequence star. By how much will the star dim when the planet passes in front of it?

a) about 0.001%
b) about 0.01%
c) about 0.1%

d) about 1%
e) about 10%

Question 6 (15 points)

A Mars-sized planet transits in front of an G2 main-sequence star. By how much will the star dim when the planet passes in front of it?

a) about 0.001%
b) about 0.01%
c) about 0.1%
d) about 1%
e) about 10%

Question 7 (15 points)

A Mars-sized planet transits in front of an M8 main-sequence star. By how much will the star dim when the planet passes in front of it?

a) about 0.001%
b) about 0.01%
c) about 0.1%
d) about 1%
e) about 10%

Extra Credit Questions:

Question 8 (30 points)

Assume that the tidal locking radius as a function of the mass of the primary star is given by,

$$d_{lock} = 0.4\,\mathrm{AU}\left(\frac{M}{M_{Sun}}\right)^{1/2},$$

where M is the mass of the star. For what primary masses will any planets in the optimistic habitable zone be tidally locked? (*Hint: Adopt the mass-luminosity relationship I showed in class to derive a relationship between the habitable zone distance and primary mass.)*

a) 0.11 M_{Sun} and below
b) 0.25 M_{Sun} and below
c) 0.38 M_{Sun} and below
d) 0.89 M_{Sun} and below

Question 9 (30 points)

The solar-like star Alpha Centauri is one of the closest stars to the Sun. If Alpha Centauri were orbited by an Earth-mass planet near the outer edge of the optimistic habitable zone, by what angle would Alpha Centauri appear to move back-and-forth as the Earth-mass planet completes its orbit?

a) about 1 arcsecond
b) about 0.1 arcseconds
c) about 10^{-5} arcseconds
d) about 0.001 arcseconds
e) about 10^{-7} arcseconds