Constructing a Temperature-Luminosity Diagram

Your Star: ______________________

1. Distance

$d = 1 / p$

If distance is in parsecs and parallax is in arcsec

Write down your star's parallax:

p = ________ arcseconds

Now immediately calculate the distance:

d = ________ parsecs

2. Luminosity

$L \propto b \times d^2$

Write down your star's apparent brightness. Round it to **one significant digit.**

b = ________ W/m^2

Compare its brightness with the Sun*:

$$\frac{b}{b_{Sun}} = \frac{\quad W/m^2}{10^3\ W/m^2} =$$

Compare its distance with the Sun's*:

$$\frac{d}{d_{Sun}} = \frac{\quad pc}{5 \times 10^{-6}\ pc} =$$

Finally, compare its *luminosity* with the Sun.

$$\frac{L}{L_{Sun}} = (\qquad) \times (\qquad)^2$$

$$= \qquad \times$$

$$=$$

* Normally, we compare the brightness to another (distant) star instead of the Sun, since the Sun is obviously much brighter and closer than other stars. We use the Sun here because we want to use solar units throughout.

3. Temperature

$T \propto 1 / \lambda_{peak}$

Write down the wavelength at which the star's spectrum peaks. Round to **one significant digit.**

λ_{peak} = ______ Å

Compare this with the Sun:

$$\frac{\lambda_{peak}}{\lambda_{peakSun}} = \frac{\quad Å}{5000\ Å} =$$

Compare the temperature with the Sun:

$$\frac{T}{T_{Sun}} = \frac{1}{\quad} =$$

Finally, convert this to Kelvins.

T = (   ) × 6000 K = ______ K

Once you have the temperature and the luminosity, plot your star on the board.

4. Radius *(optional)*

$R^2 \propto S \propto L / T^4$

Write down the luminosity and temperature you calculated, as compared to the Sun.

$$\frac{L}{L_{Sun}} = \qquad\qquad \frac{T}{T_{Sun}} =$$

Use these to calculate the *surface area*, compared to the Sun.

$$\frac{S}{S_{Sun}} = (\qquad) / (\qquad)^4 =$$

Now calculate the radius, compared to the Sun.

$$\frac{R}{R_{Sun}} = (\qquad)^{1/2} =$$

5. Classification (*optional)*

What is the *spectral type* of the star? (See CS-156)

What is the *evolutionary class* of the star? (See CS-160)

For comparison:

$R_{Earth} \approx 10^{-2}\ R_{Sun}$

$R_{Jupiter} \approx 10^{-1}\ R_{Sun}$

AU ≈ 200 R_{Sun}

Original worksheet by D. Perley

Constructing a Temperature-Luminosity Diagram

In this exercise, we will use the observed properties (parallax, apparent brightness, and spectrum peak) of some of the well-known stars to calculate, using the formulas and methods discussed in class, their intrinsic properties (temperature, luminosity, and radius.) We will then look for patterns in these properties by way of the H-R (temperature-luminosity) diagram.

Your group will be in charge of a particular region of the sky (north, south, or one of four seasonal groups). Each student in the group should choose, and perform the calculations for, one particular star, but please help each other out and check each other's answers.

To help speed the calculations along, you are highly encouraged to **round all numbers to one significant digit** – for example, to round the Sun's apparent brightness of $1.37\times10^{+3}$ W/m^2 to simply $1\times10^{+3}$ W/m^2. You can go for more careful precision if you have a calculator and really want to, but for the purposes of this exercise a rough estimate is sufficient.

Once you have determined the luminosity and temperature of each star, please go to the board and plot that star on the class H-R (temperature-luminosity) diagram. Calculating the radius and spectral type is optional, but strongly encouraged.

Southern Stars – Some of the most interesting stars in the sky we never see. These stars are never visible from the continental United States, though they are familiar to observers south of the equator. They include the closest star to us other than the Sun (Proxima Centauri, which is too faint to see with the unaided eye) as well as the Sun's "twin", Alpha Centauri, and the second brightest star in the night sky (Canopus).

Name	**parallax** (arcsec)	**apparent brightness** (W / m^2)	**λ_{peak}** (Å)	**distance** (parsec)	**luminosity** (L_{sun})	**temp.** (K)	**radius** (R_{sun})	**class**
Sun	N/A	$1.37\times10^{+3}$	5000	4.84×10^{-6}	1	5800	1 R_{sun}	G (MS)
Proxima Cen.	0.772	3.5×10^{-11}	9400					
Alpha Cen. A	0.742	2.6×10^{-8}	5000					
Alpha Cen. B	0.742	8.9×10^{-9}	5500					
Canopus	0.010	4.75×10^{-8}	3700					
Achernar	0.023	5.7×10^{-8}	1900					
Acrux B	0.010	5.0×10^{-8}	1100					

Minor caveat: The apparent brightnesses quoted here are integrated brightnesses at all wavelengths, including IR and UV. These values have also been corrected for absorption due to interstellar dust, which can be extremely significant for distant, blue stars.

Original worksheet by D. Perley

Constructing a Temperature-Luminosity Diagram

In this exercise, we will use the observed properties (parallax, apparent brightness, and spectrum peak) of some of the well-known stars to calculate, using the formulas and methods discussed in class, their intrinsic properties (temperature, luminosity, and radius.) We will then look for patterns in these properties by way of the H-R (temperature-luminosity) diagram.

Your group will be in charge of a particular region of the sky (north, south, or one of four seasonal groups). Each student in the group should choose, and perform the calculations for, one particular star, but please help each other out and check each other's answers.

To help speed the calculations along, you are highly encouraged to **round all numbers to one significant digit** – for example, to round the Sun's apparent brightness of $1.37\times10^{+3}$ W/m^2 to simply $1\times10^{+3}$ W/m^2. You can go for more careful precision if you have a calculator and really want to, but for the purposes of this exercise a rough estimate is sufficient.

Once you have determined the luminosity and temperature of each star, please go to the board and plot that star on the class H-R (temperature-luminosity) diagram. Calculating the radius and spectral type is optional, but strongly encouraged.

Summer Stars – If you've been to any of the star parties this semester, you've probably seen these stars – Vega, Deneb, and Altair form the "summer triangle" still prominent in the western sky after sunset; the two stars of Albeiro (A and B) comprise the "Cal star" – star A is yellowish-gold and B is a faint blue. Soon these stars will vanish until spring as the Sun passes in front of them, so if you haven't been to a star party yet, act quickly!

Name	**parallax** (arcsec)	**apparent brightness** (W / m^2)	λ_{peak} (Å)	**distance** (parsec)	**luminosity** (L_{sun})	**temp.** (K)	**radius** (R_{sun})	**class**
Sun	N/A	$1.37\times10^{+3}$	5000	4.84×10^{-6}	1	5800	1 R_{sun}	G (MS)
Vega	0.130	2.88×10^{-8}	3000					
Deneb	*0.001?*	9.9×10^{-9}	3400					
Altair	0.194	1.3×10^{-8}	3800					
Albireo A	0.008	2.2×10^{-10}	7100					
Albireo B	0.008	1.5×10^{-8}	*1500?*					

Minor caveat: The apparent brightnesses quoted here are integrated brightnesses at all wavelengths, including IR and UV. These values have also been corrected for absorption due to interstellar dust, which can be extremely significant for distant, blue stars.

Constructing a Temperature-Luminosity Diagram

In this exercise, we will use the observed properties (parallax, apparent brightness, and spectrum peak) of some of the well-known stars to calculate, using the formulas and methods discussed in class, their intrinsic properties (temperature, luminosity, and radius.) We will then look for patterns in these properties by way of the H-R (temperature-luminosity) diagram.

Your group will be in charge of a particular region of the sky (north, south, or one of four seasonal groups). Each student in the group should choose, and perform the calculations for, one particular star, but please help each other out and check each other's answers.

To help speed the calculations along, you are highly encouraged to **round all numbers to one significant digit** – for example, to round the Sun's apparent brightness of $1.37\times10^{+3}$ W/m^2 to simply $1\times10^{+3}$ W/m^2. You can go for more careful precision if you have a calculator and really want to, but for the purposes of this exercise a rough estimate is sufficient.

Once you have determined the luminosity and temperature of each star, please go to the board and plot that star on the class H-R (temperature-luminosity) diagram. Calculating the radius and spectral type is optional, but strongly encouraged.

Autumn Stars – The stars of fall are not very well-known. Capella is a double system containing two nearly-identical stars with temperatures very similar to the Sun's; Epsilon Eridani is a faint star with the distinction of having a recently discovered planet orbiting it.

Name	**parallax** (arcsec)	**apparent brightness** (W / m^2)	λ_{peak} (Å)	**distance** (parsec)	**luminosity** (L_{sun})	**temp.** (K)	**radius** (R_{sun})	**class**
Sun	N/A	$1.37\times10^{+3}$	5000	4.84×10^{-6}	1	5800	1 R_{sun}	G (MS)
Fomalhaut	0.130	8.6×10^{-9}	3400					
Aldebaran	0.054	3.3×10^{-8}	7300					
Alpheratz	0.033	7.0×10^{-9}	2200					
Eps. Eridani	0.311	8.5×10^{-10}	5700					
Capella A	0.078	1.5×10^{-8}	5300					
Capella B	0.078	1.0×10^{-8}	5300					

Minor caveat: The apparent brightnesses quoted here are integrated brightnesses at all wavelengths, including IR and UV. These values have also been corrected for absorption due to interstellar dust, which can be extremely significant for distant, blue stars.

Constructing a Temperature-Luminosity Diagram

In this exercise, we will use the observed properties (parallax, apparent brightness, and spectrum peak) of some of the well-known stars to calculate, using the formulas and methods discussed in class, their intrinsic properties (temperature, luminosity, and radius.) We will then look for patterns in these properties by way of the H-R (temperature-luminosity) diagram.

Your group will be in charge of a particular region of the sky (north, south, or one of four seasonal groups). Each student in the group should choose, and perform the calculations for, one particular star, but please help each other out and check each other's answers.

To help speed the calculations along, you are highly encouraged to **round all numbers to one significant digit** – for example, to round the Sun's apparent brightness of $1.37\times10^{+3}$ W/m^2 to simply $1\times10^{+3}$ W/m^2. You can go for more careful precision if you have a calculator and really want to, but for the purposes of this exercise a rough estimate is sufficient.

Once you have determined the luminosity and temperature of each star, please go to the board and plot that star on the class H-R (temperature-luminosity) diagram. Calculating the radius and spectral type is optional, but strongly encouraged.

Winter Stars – The brightest and most spectacular stars in the sky belong to the winter. Betelgeuse, the ridiculously huge supergiant mentioned in lecture; Meissa, a rare superhot O star in Orion's belt; and dog star Sirius: the brightest of all stars are all winter stars. These stars are already visible late at night, and will migrate into the evening sky towards the end of the semester. Castor (in the constellation Gemini) is a six-star system; one of its fainter members is included in the table below.

Name	**parallax** (arcsec)	**apparent brightness** (W / m^2)	**λ_{peak}** (Å)	**distance** (parsec)	**luminosity** (L_{sun})	**temp.** (K)	**radius** (R_{sun})	**class**
Sun	N/A	$1.37\times10^{+3}$	5000	4.84×10^{-6}	1	5800	1 R_{sun}	G (MS)
Rigel	0.004	3.72×10^{-8}	2600					
Betelgeuse	0.008	1.12×10^{-7}	9400					
Procyon A	0.290	1.86×10^{-8}	4460					
Procyon B	0.290	1.5×10^{-12}	3300					
Sirius A	0.379	1.1×10^{-7}	3100					
Sirius B	0.379	3.6×10^{-11}	1080					
Meissa	0.003	2.3×10^{-8}	800					
Castor C-a	0.064	6.5×10^{-12}	8840					

Minor caveat: The apparent brightnesses quoted here are integrated brightnesses at all wavelengths, including IR and UV. These values have also been corrected for absorption due to interstellar dust, which can be extremely significant for distant, blue stars.

Constructing a Temperature-Luminosity Diagram

In this exercise, we will use the observed properties (parallax, apparent brightness, and spectrum peak) of some of the well-known stars to calculate, using the formulas and methods discussed in class, their intrinsic properties (temperature, luminosity, and radius.) We will then look for patterns in these properties by way of the H-R (temperature-luminosity) diagram.

Your group will be in charge of a particular region of the sky (north, south, or one of four seasonal groups). Each student in the group should choose, and perform the calculations for, one particular star, but please help each other out and check each other's answers.

To help speed the calculations along, you are highly encouraged to **round all numbers to one significant digit** – for example, to round the Sun's apparent brightness of $1.37\times10^{+3}$ W/m^2 to simply $1\times10^{+3}$ W/m^2. You can go for more careful precision if you have a calculator and really want to, but for the purposes of this exercise a rough estimate is sufficient.

Once you have determined the luminosity and temperature of each star, please go to the board and plot that star on the class H-R (temperature-luminosity) diagram. Calculating the radius and spectral type is optional, but strongly encouraged.

Spring Stars – These stars recently disappeared from view, and are currently hidden behind the Sun. They will not be visible for a few more months, when they emerge as early-morning stars.

Name	**parallax** (arcsec)	**apparent brightness** (W / m^2)	**λ_{peak}** (Å)	**distance** (parsec)	**luminosity** (L_{sun})	**temp.** (K)	**radius** (R_{sun})	**class**
Sun	N/A	$1.37\times10^{+3}$	5000	4.84×10^{-6}	1	5800	1 R_{sun}	G (MS)
Barnard's Star	0.549	9.6×10^{-12}	9100					
Antares	0.005	3.7×10^{-8}	8500					
Arcturus	0.088	5.3×10^{-8}	6800					
Spica A	0.013	6.6×10^{-8}	1300					
Regulus	0.043	1.4×10^{-8}	2400					

Minor caveat: The apparent brightnesses quoted here are integrated brightnesses at all wavelengths, including IR and UV. These values have also been corrected for absorption due to interstellar dust, which can be extremely significant for distant, blue stars.

Original worksheet by D. Perley

Constructing a Temperature-Luminosity Diagram

In this exercise, we will use the observed properties (parallax, apparent brightness, and spectrum peak) of some of the well-known stars to calculate, using the formulas and methods discussed in class, their intrinsic properties (temperature, luminosity, and radius.) We will then look for patterns in these properties by way of the H-R (temperature-luminosity) diagram.

Your group will be in charge of a particular region of the sky (north, south, or one of four seasonal groups). Each student in the group should choose, and perform the calculations for, one particular star, but please help each other out and check each other's answers.

To help speed the calculations along, you are highly encouraged to **round all numbers to one significant digit** – for example, to round the Sun's apparent brightness of $1.37\times10^{+3}$ W/m^2 to simply $1\times10^{+3}$ W/m^2. You can go for more careful precision if you have a calculator and really want to, but for the purposes of this exercise a rough estimate is sufficient.

Once you have determined the luminosity and temperature of each star, please go to the board and plot that star on the class temperature-luminosity diagram. Calculating the radius and spectral type is optional, but strongly encouraged.

Northern Stars – These stars are visible all year round! Polaris, the famous North Star, is a "Cepheid variable" that pulsates slowly, changing its luminosity slowly and predictably. Mizar is a quadruple system; only one of its stars is represented here, though the nearby star Alcor may also be bound to the system. Massive Mu Cephei is one of the largest stars that can be seen without a telescope.

Name	**parallax** (arcsec)	**apparent brightness** (W / m^2)	**λ_{peak}** (Å)	**distance** (parsec)	**luminosity** (L_{sun})	**temp.** (K)	**radius** (R_{sun})	**class**
Sun	N/A	$1.37\times10^{+3}$	5000	4.84×10^{-6}	1	5800	1 R_{sun}	G (MS)
Polaris	0.008	4.1×10^{-9}	4800					
Mizar A	0.042	1.7×10^{-9}	3200					
Alcor	0.040	6.2×10^{-10}	3600					
Mu Cephei	*0.001?*	1.1×10^{-8}	8500					
Algol	0.036	8.1×10^{-9}	2400					

Minor caveat: The apparent brightnesses quoted here are integrated brightnesses at all wavelengths, including IR and UV. These values have also been corrected for absorption due to interstellar dust, which can be extremely significant for distant, blue stars.

Original worksheet by D. Perley