Astronomy 10, Fall 2006
Worksheet 5

Constructing a Temperature-Luminosity Diagram[1]

In this exercise, your group will calculate the temperature, luminosity, and radius of a number of stars, and add these values to the temperature-luminosity diagram on the board.

The accompanying handout gives recipes for calculating, in physical units, the properties of any star based only on its spectrum, apparent brightness, and parallax. However, we'd rather not have to deal with loads of constants, so first of all, divide out the constants using known values for the Sun so we can do our calculation using ratios.

	Absolute formulas	Ratio formulas
Parallax:	$\mathbf{d = 1 / p}$	*Sun does not have a parallax*
Inverse-square law:	$L = b \times 4\pi d^2$ →	$\mathbf{(L/L_{Sun}) = (b/b_{Sun}) \times (d/d_{Sun})^2}$
Wien's law:	$\mathbf{T = 3 \times 10^7\ \text{Å}\cdot K\ /\ \lambda_{peak}}$	$(T/T_{Sun}) = \lambda_{peakSun} / \lambda_{peak}$
Stefan-Boltzmann law:	$R = (L / (4\pi\ \sigma\ T^4))^{1/2}$	$\mathbf{(R/R_{Sun}) = (L/L_{Sun})^{1/2} / (T/T_{Sun})^2}$

Fill in the missing values on the table below and plot the temperature and luminosities on the class diagram when you're finished. (Make sure you give the temperature in Kelvin, not T_{Sun}.) Try to distribute the work so each group member is responsible for one or two stars. The values for the Sun are given in the first row for reference.

Summer Stars – If you've been to any of the star parties this semester, you're probably familiar with some of these stars – Vega, Deneb, and Altair form the "summer triangle"; the two stars of Albireo (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** (erg / cm^2)	λ_{peak} (Å)	**distance** (parsec)	**luminosity** (L_{sun})	**temp.** (K)	**radius** (R_{sun})
(Sun)	N/A	1.37×10^6	5000	4.84×10^{-6}	1	5800	1
Vega	0.130	2.88×10^{-5}	3000				
Deneb	*0.001?*	9.9×10^{-6}	3400				
Altair	0.194	1.3×10^{-5}	3800				
Albireo A	0.008	2.2×10^{-7}	7100				
Albireo B	0.008	1.5×10^{-5}	*1500?*				

Use this space to copy down the class diagram. No need to label each individual star, but definitely label the axes (also their direction), the major groupings, and the evolutionary track of the Sun.

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	Absolute formulas		Ratio formulas
			Sun does not have a parallax
Parallax:	$\mathbf{d = 1 / p}$		
Inverse-square law:	$L = b \times 4\pi d^2$	→	$\mathbf{(L/L_{Sun}) = (b/b_{Sun})\times(d/d_{Sun})^2}$
Wien's law:	$\mathbf{T = 3 \times 10^7\ \text{Å}\cdot K\ /\ \lambda_{peak}}$		$(T/T_{Sun}) = \lambda_{peakSun} / \lambda_{peak}$
Stefan-Boltzmann law:	$R = (L / (4\pi\, \sigma\, T^4))^{1/2}$		$\mathbf{(R/R_{Sun}) = (L/L_{Sun})^{1/2} / (T/T_{Sun})^2}$

Fill in the missing values on the table below and plot the temperature and luminosities on the class diagram when you're finished. (Make sure you give the temperature in Kelvin, not T_{Sun}.) Try to distribute the work so each group member is responsible for one or two stars. The values for the Sun are given in the first row for reference.

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 the star with an extrasolar planet orbiting it that we discussed last section.

Name	**parallax** (arcsec)	**apparent brightness** (erg / cm^2 s)	λ_{peak} (Å)	**distance** (parsec)	**luminosity** (L_{sun})	**temp.** (K)	**radius** (R_{sun})
(Sun)	N/A	1.37×10^{6}	5000	4.84×10^{-6}	1	5800	1
Fomalhaut	0.130	8.6×10^{-6}	3400				
Aldebaran	0.054	3.3×10^{-5}	7300				
Alpheratz	0.033	7.0×10^{-6}	2200				
Eps. Eridani	0.311	8.5×10^{-7}	5700				
Capella A	0.078	1.5×10^{-5}	5300				
Capella B	0.078	1.0×10^{-5}	5300				

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Parallax:	$\mathbf{d = 1 / p}$		*Sun does not have a parallax*
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Wien's law:	$\mathbf{T = 3 \times 10^7\ Å{\cdot}K\ /\ \lambda_{peak}}$		$(T/T_{Sun}) = \lambda_{peakSun} / \lambda_{peak}$
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Fill in the missing values on the table below and plot the temperature and luminosities on the class diagram when you're finished. (Make sure you give the temperature in Kelvin, not T_{Sun}.) Try to distribute the work so each group member is responsible for one or two stars. The values for the Sun are given in the first row for reference.

Winter Stars – The brightest and most spectacular stars in the sky belong to the winter. Betelgeuse, a ridiculously huge red supergiant; Meissa, the only O-star that can be easily seen with the unaided eye; and the "dog star" Sirius, the brightest of all stars in the night sky – 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** (erg / cm^2)	λ_{peak} (Å)	**distance** (parsec)	**luminosity** (L_{sun})	**temp.** (K)	**radius** (R_{sun})
(Sun)	N/A	1.37×10^6	5000	4.84×10^{-6}	1	5800	1
Rigel	0.004	3.72×10^{-5}	2600				
Betelgeuse	0.008	1.12×10^{-4}	9400				
Procyon A	0.290	1.86×10^{-5}	4460				
Procyon B	0.290	1.46×10^{-9}	3300				
Sirius A	0.379	1.05×10^{-4}	3100				
Sirius B	0.379	3.61×10^{-8}	1080				
Meissa	0.003	2.29×10^{-5}	800				
Castor C-a	0.064	6.51×10^{-9}	8840				

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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** (erg / cm²)	λ_{peak} (Å)	**distance** (parsec)	**luminosity** (L_{sun})	**temp.** (K)	**radius** (R_{sun})
(Sun)	N/A	1.37×10^{6}	5000	4.84×10^{-6}	1	5800	1
Barnard's Star	0.549	9.6×10^{-9}	9100				
Antares	0.005	3.7×10^{-5}	8500				
Arcturus	0.088	5.3×10^{-5}	6800				
Spica A	0.013	6.6×10^{-5}	1300				
Regulus	0.043	1.4×10^{-5}	2400				

Use this space to copy down the class diagram. No need to label each individual star, but definitely label the axes (also their direction), the major groupings, and the evolutionary track of the Sun.

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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 also appears to be bound to the system. One of these stars is an absolute monster – for comparison, the radius of Saturn's orbit is about 2000 R_{sun}.

Name	**parallax** (arcsec)	**apparent brightness** (erg / cm^2)	λ_{peak} (Å)	**distance** (parsec)	**luminosity** (L_{sun})	**temp.** (K)	**radius** (R_{sun})
(Sun)	N/A	1.37×10^{6}	5000	4.84×10^{-6}	1	5800	1
Polaris	0.008	4.1×10^{-6} *	4800 *				
Mizar A	0.042	1.7×10^{-6}	3200				
Alcor	0.040	6.2×10^{-7}	3600				
Mu Cephei	*0.001?*	1.1×10^{-5}	8500				
Algol	0.036	8.1×10^{-6}	2400				

* variable

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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), the Sun's "twin" (Alpha Centauri A), and the second brightest star in the night sky (Canopus).

Name	**parallax** (arcsec)	**apparent brightness** (erg / cm^2)	λ_{peak} (Å)	**distance** (parsec)	**luminosity** (L_{sun})	**temp.** (K)	**radius** (R_{sun})
Sun	N/A	1.37×10^6	5000	4.84×10^{-6}	1	5800	1
Proxima Cen.	0.772	3.5×10^{-8}	9400				
Alpha Cen. A	0.742	2.6×10^{-5}	5000				
Alpha Cen. B	0.742	8.9×10^{-6}	5500				
Canopus	0.010	4.75×10^{-5}	3700				
Achernar	0.023	5.7×10^{-5}	1900				
Acrux B	0.010	5×10^{-5}	1100				

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