ASTROPHYSICS 3; SEMESTER 1
TUTORIAL 1: Observational Astronomy

1. (a) At the earth, the flux of radiation from the sun is 1410 Wm^{-2} (assuming that the earth's atmosphere is non-absorbing). Calculate the luminosity of the sun in Watts, and hence calculate what the flux of sunlight would be if the sun was in fact 1 parsec distant from the earth (1AU = 1.496 $\times 10^{11}$m, 1pc = 3.09 $\times 10^{16}$m).

   (b) As seen from the earth, the Sun subtends a diameter of 30 arcminutes. Determine the solid angle subtended by the Sun and hence calculate the *intensity* of solar radiation as seen from the Earth, averaged over this solid angle ?

   (c) Given that the mean orbital distance of Mercury is 0.387AU, calculate the solar flux on the sunlit surface of Mercury. What linear angle (in degrees) and solid angle (in steradians) does the sun subtend when viewed from Mercury? What is the intensity of the solar radiation when measured from Mercury?

   (d) Assuming that Pluto (which has an orbital radius of 39.4 AU), behaves like a blackbody, calculate the temperature of Pluto if the only source of energy is the Sun, and Pluto is in thermal equilibrium ($\sigma_{SB} = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}).

2. (a) Observations using the V-filter of a star known to have a magnitude of $V = 10.7$ produce 1350 counts on a CCD detector in a 10 second exposure. What is the instrumental zero-point magnitude (ie. the magnitude of a star that will produce 1 count per second).

   (b) A second star is then observed and gives 75 counts in 300 seconds. What magnitude is it?

   (c) The star is observed in three filters, and is found to have the colours $B-V = 1.0$ and $B-R = 1.5$. In which filter does the object have the highest flux density, assuming that the flux density zeropoints for B, V, and R are 6.6×10^{-12}, 3.6×10^{-12}, and 1.7×10^{-12} W m^{-2} Å^{-1} respectively.

3. (a) A star, with an apparent magnitude of $m_V = 2.5$, is found to have a parallax of 0.002 arcsecond. What is its absolute magnitude in V? Given that the absolute magnitude of a main-sequence A0 star is typically $M_V = +0.6$, what type of star might have this value of M_V?

   (b) The star explodes and goes supernova, increasing in luminosity by a factor of 50,000. What are the new values of apparent and absolute magnitude?

   (c) The supernova remnant, in the shape of a ring, is expanding with a velocity of 10,000 km/sec. After a day, would it be possible to resolve the ring with a ground based optical telescope? [Ground-based optical telescopes have a resolution limited by atmospheric instabilities (known as *seeing*), with a typical limit of around 1 arcsec.]

4. Calculate the wavelength (in nanometres) at which the following stars emit their maximum energy. What colour will they appear to the human eye?

Betelgeuse	Effective Temp $T_e = 2500$ K	$M_V = -6.0$
Ross 128	Effective Temp $T_e = 2800$ K	$M_V = 13.5$
Sirius B	Effective Temp $T_e = 8000$ K	$M_V = 11.56$
Polaris	Effective Temp $T_e = 6200$ K	$M_V = -4.6$

5. The spectrum of a particular star is best described by a Planck curve of temperature $T = 6000$K. However, the flux density of the light received from this star is 1×10^{-17} times smaller than that predicted by the Planck function $B_\nu = 2h\nu^3c^{-2}/(e^{h\nu/kT} - 1)$ for this temperature.

   (a) Write down the defined relation between flux density and surface brightness, and thus express this in terms of the distance to the star and the star's radius.

   (b) Given that this star has a measured parallax of 0.2 arcsec, calculate its physical radius.

6. A binary star system has two stars, located at RA: 14 37 42.27, Dec: +39 15 24.0, and RA: 14 37 39.83, Dec: +39 14 56.3.

   (a) What time of year would be best to carry out long observations of this binary system?

   (b) Would it be better to use the Anglo-Australian Telescope in Australia, or the William Herschel Telescope on the Canary Islands?

   (c) What is the separation of the two stars on the sky? Draw a sketch of their relative positions.

Hand-in Question; modified from 2008 Astro-3 exam, B1.2

B1.2 (a) An astromer wishes to observe *Star A*, which is located at RA=$05^h32^m15.54^s$ Dec=$+56°13'19.2''$. To locate this faint star, the astronomer decides to first centre their telescope on *Star B* at RA=$05^h32^m16.23^s$ Dec=$+56°12'57.4''$, and then offset the telescope to *Star A*. How many arcseconds north/south and east/west does the telescope need to be offset? Sketch the relative positions of the two stars on the sky. **[6]**

(b) *Star A* has an apparent R-band magnitude of 18.03. *Star B* has $R = 16.47$. Is *Star B* brighter or fainter than *Star A*, and by what factor? **[5]**

(c) A spectrum of *Star A* indicates that it is an A0 star, like Vega. What does this imply about the intrinsic optical colours of the star? Define what is meant by the term *Absolute magnitude*. Given that the absolute V-band magnitude of Vega is +0.6, determine the distance to *Star A*. **[6]**

(d) The Gaia telescope will be able to measure parallaxes down to 10^{-5} arcsec – will it be able to measure the parallax of this star? **[3]**