PHYS-3301 Homework 11 Due 28 Nov 2012

This homework is due in the dropbox outside 2L26 by 11:59PM on the due date. If you wish to turn it in ahead of time, you may email a PDF or give a hardcopy to Dr. Frey.

1. **Doppler Broadening** *based on Barton 13.4*

   The sun emits a spectral line of wavelength λ. When we observe the sun, this line is broadened because some parts of the sun rotate toward the earth and some rotate away. What is the ratio of the difference in wavelengths observed from opposite points on the sun's equator to the line's emitted wavelength? The circumference of the solar equator is 4.4×10^6 km, and the sun's equator rotates once every 25 days. You may make any appropriate approximations and work to 2 significant figures.

2. **The Cosmic Microwave Background**

   The universe is filled with left-over radiation from the Big Bang called the Cosmic Microwave Background, which has a typical frequency of $\bar{\omega} = 160$ GHz averaged over the sky. There is a smooth variation of frequency at different points on the sky. The maximum observed frequency is 200 MHz higher than average in one particular spot on the sky; the minimum frequency is 200 MHz lower than average at the diametrically opposite point.

   (a) What is the relative speed of the earth and the source of the Cosmic Microwave Background in km/s? Remember that $c \approx 3 \times 10^8$ m/s.

   (b) Suppose we measure the frequency at an angle θ on the sky from the maximum frequency point. Show that the frequency is

   $$\omega(\theta) = \bar{\omega} + (200 \text{ MHz}) \cos\theta \ . \tag{1}$$