Week 9 Notes
Astro 1 (Discussion Sections 101 & 102)

Department of Physics: University of California, Santa Barbara

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Administrative Tasks

Stargazing Event If you are interested in signing up for the stargazing events on March 7 (and possibly March 8), e-mail me with the words "Astro 1 Stargazing" in the subject line and indicate that you wish to attend. This is a first come, first serve system, and many have already signed up. There is a limit of 50 students per night.

Tests Hand back any remaining test results. The free response question has also been graded and will be handed back shortly. The average for the multiple choice section was around 12/20 and the average for the free response section was about 1.5. The renormalization will likely be

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PERCENT SCORE=(.7*MC RAW SCORE/19+.3*FR RAW SCORE/3)*110%
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Evaluations We will end class about ten minutes early for evaluations today.

Free Response Question Solution (If Desired)

Questions on Last Week's Homework

Concept Review

Energy Mass Equivalence

Relevant Equation We finally get to use Einstein's famous equation,

$$E = Mc^2$$

where E is the intrinsic energy contained in a chunk of mass M with c being the speed of light, as always. Typically mass will need to be in kg and energy in Joules to make units agree.

When to use this equation This equation (at least in this class) is most useful when determining the energy output of a nuclear reaction. If we start a reaction with some matter that has a mass M_0 and end with a final mass $M \neq M_0$, then we can determine the amount of energy absorbed or emitted by invoking the mass-energy equivalence equation:

$$E = (M_0 - M)c^2$$

If $M_0 > M$, there is less mass after the reaction, so the missing mass (the difference) had to be converted to energy. Otherwise, if $M > M_0$, that is, we *gained* mass in the reaction, the same equation tells us how much energy was *absorbed* by the reaction. This would have a cooling effect, and isn't often seen in the cores of stars.

Example: Intrinsic Energy in your textbook If we were able to completely convert your Astronomy textbook into energy, (perhaps by having it come into contact with an antimatter textbook?) What energy would be liberated, assuming the book has a mass of about 1kg?

We simply apply the equation at hand. In our case, M_0 is the initial mass, which we have taken to be about 1 kg. If the book is completely converted to energy, the final mass M must necessarily be zero (none of the book is leftover and it hasn't been converted to other forms of matter). Then the energy liberated would be

$$E = (1\,\mathrm{kg})\left(3.0 \times 10^{8}\,\mathrm{m/s}\right)^2 = 9 \times 10^{16}\,\mathrm{J}$$

Note: the energy released in detonating 1 megaton of TNT is about 4×10^{15} Joules, so this is about 20 times more powerful than that!

Parallax and the Distance to Stars

Relevant Equation We mentioned this briefly after the first test, but here it is again

$$d = \frac{1}{p}$$

Here d is playing the same role it did in the small angle formula; it is the distance from the viewer to the object being viewed. However, in this case d *must* be expressed in parsecs. p is the parallax angle of the object, measured in arcseconds. For an image of what parallax angle is, see figure 17-2 in the text.

When to use this equation: This equation is only useful when computing distances to stars when you can find their parallax angle or for finding the parallax angle given a distance. Typically it is only valid for close stars since closer stars have more noticeable parallax angles.

Example: Wolf 359 The star Wolf 359 has a measured parallax angle of .419 arcseconds. How far away is it?

This is another straightforward application of the equation at hand. We simply plug .419 in for p and compute d:

$$d = \frac{1}{.419} = 2.39\,\text{parsec}$$

This is relatively close to our sun, but still not accessible in a human lifetime with our current technology.

The Motions of the Stars

Stars are not fixed points in space. Thus, the constellations we see today were not the one our ancestors saw thousands of years ago, nor will they be the formations our descendants will see long from now. We can learn a lot about a star just by observing its motion though the sky during our own liftimes.

Relevant Equation

$$v_t = 4.74\mu d$$

Here v_t is the **tangential velocity** in **km/s** (see figure in box 17-1). This is the velocity a star is moving that is not directly towards or away from the us. μ is the "proper motion" measured in arcseconds per year. This is the angular distance a star moves through the night sky over the course of the year *with respect to background stars*. Thus, this motion has nothing to do with the rotation of the earth and everything to do with the star actually careening through space at a rate which we can actually detect. Finally, d is again the distance from earth to the star *in parsecs*. Be *very* careful with your units on this equation, as you have no room for flexibility. The other portion of the velocity is the **radial velocity** which we studied earlier: it is ascertained through the doppler effect:

$$\frac{\lambda - \lambda_0}{\lambda} = \frac{v_r}{c}$$

The total velocity of a star is then given by the pythagorean theorem as

$$v = \sqrt{v_t^2 + v_r^2}$$

Be sure that you use the same units for v_r as you do for v_t or else your results will be erroneous.

Example: Box 17-1 *See textbook; only done if time permits*

Other Questions