Astronomy 101U Skylab #2 – "Now Where Was I?"

Introduction: One might think that the Sun and the stars move across the sky at the same speed since their motions result primarily from the same cause–the rotation of the Earth. The Sun's apparent motion, however, is also affected by the orbit of the Earth. Because we travel around the Sun, we must complete a little more than one rotation for the Sun to appear in the same place on two successive days. On the other hand, the Earth is so far from the stars that its motion among them is negligible, and a given star will appear in the same place for every rotation of the Earth. The time required for this rotation is called a siderial (star) day.

Equipment: One good eye, a tall building and a watch (must have a "seconds" hand or a digital display).

Time Required: A few minutes on each of several nights over a week or two.

What to Do: To find the difference between a solar day and a sidereal day, you will measure the intervals between the times when a star returns to a given spot over successive evenings. This requires knowing both the position of the star and the solar time when it is in that position. The latter is easy–you can read it off your watch, although you should carefully check your watch before each observation to make sure it isn't gaining or losing time each day.

Finding the position is somewhat trickier. Note that you don't really need to know the coordinates of the position; you need only to pick a "spot" which can be reliably identified each night as the star returns. A good way to do this is to time when a star passes behind (is occulted by) a tall building (or perhaps a nearby mountain). The edge of the building defines the spot. This would be fine if you could remain at the same location for several nights. But if you must leave during the 24 hours and you then return to a slightly different location, the edge will be in front of a different place in the sky, resulting in a poor measurement.

To minimize this problem, move as far away from the building as possible. For example, if you think you can from night to night reproduce your observing location (position of your eye) to within 1 meter, the building should be at least 100 meters away from your spot. For 1/2 meter, the building should be 50 meters away, etc. A good way to mark your position and sight-line would be with a stick, but this is not necessary if you are careful.

Pick a bright star low enough in the sky that it will soon be occulted by your chosen building from your vantage point. It's simplest if the star is roughly in the southerly direction; if it is not, you will have to think carefully about the star's path across the sky. The best thing to do is to monitor the motions of a few candidate stars over an hour or so, and thus better pick a suitable star, building and observing location.

Having chosen those, record the instant at which the star is occulted by the building. If you want to improve accuracy, you can repeat this for a second star, which wouldn't have to be using the same building or even the same observing location. On the next clear evening, return to exactly the same observing location, find your star, and again record the time of occultation, down to an accuracy of at least a second. Repeat this on at least three nights, but 4-6 nights and a longer interval between nights yields better accuracy.

Questions:

(1) Calculate your values for the length of the sidereal day for each of the night-to-night intervals for which you observed.

(2) Determine at least four sources of error in this experiment and for each, list a way, if one exists, for that error to be minimized. Also, estimate the size of each error (in time) as best you can (I'm not expecting a full-blown statistical analysis or anything...just a best guess).

(3) Compare your average measured value and an estimate of its error (take the square root of the sum of the squares of your numeric estimates from (2) as an estimate) with the accepted value. Don't work backwards here! In other words, give me your honest opinion of your error bars, whether they turn out to be unreasonably large or small...what counts here is that you do the science "honestly" without letting yourself by biased by trying to get just the right numbers. That's the whole point of this process! State whether the actual value falls within your error bars, and state whether you think your error bars were satisfactory.

(4) Usually, your longest intervals between measurements will give you the most accurate results. Why is this?

(5) Why does standing further away from your occulting object reduce the error? Explain with a diagram if that will make your case clearer.

(6) Make a sketch showing your "set-up" with approximate measurements of distances. Also, identify which star(s) you used using a star chart. Just the name(s) and rough coordinates will be fine.

(7) Should your measurement differ from star to star? Why or why not?