EYH Solar Astronomy Workshop, 3/13/04

Sentences in regular font are instructions to us, the workshop leaders.
Sentences in italics are things we will say to the class.

Setup:

turn on computers (and plasma screens?)
log in
load SOHO page, find sample images
write on board
check for all supplies (scissors, tape, extra pencils, exacto knives)
locate bathrooms and good outside location for sun viewing

I. Intro (10 minutes)

1. Welcome the girls, introduce ourselves. JH: *background, EYH experience, current research, how to become an astronomer, outside interests.* Others: *name, major, research, outside interests.*

2. Have girls introduce themselves to others at their table: names, where they live/what school they attend, interests. Write names on board.

3. *Please respect the equipment in the computer lab: no food or drink, be careful with the monitors. You're invited to eat lunch with us to talk further about studying physics/astro.*

II. Background (10 minutes)

1. *Astronomy is different from other sciences: can't do experiments, so have to rely on observations of light we receive from stars and galaxies. In this workshop we'll study the sun using satellite pictures and pinhole cameras we make ourselves. Note: don't look directly at the sun!*

2. *Sun is closest star, easiest to study in detail. Very normal star, lots of others like it – so learning about the sun tells us about what other stars are like.*

3. *SOHO is a satellite launched by NASA in 1995 to study the Sun. Why is it better to study the sun using a satellite than using a telescope on earth?* Show pictures of SOHO and its orbit. *SOHO is orbiting the sun but stays close to the earth. It takes pictures of the sun with several different cameras with several different kinds of filters to reduce the brightness of the sun and see different kinds of light, including some we can't see with our eyes.* Show examples on the overhead screens and/or girls' screens. *We can use these pictures to learn about the sun's characteristics and behavior.*

II. Rotation calculation (25 minutes)

1. *Click on a month; you'll see a list of dates (year, month, day, time). Choose one and click on it. You'll see a picture of the sun's surface taken by the SOHO satellite.* Have a few people describe what they see. *The dark spots are sunspots, cooler areas of the sun's surface. (They are still very hot! Surface ~10,000° F , spots ~7600° F!) They are caused by the sun's magnetic field (remember the strange appearance of some of the other pictures we looked at). This is a visible-light image; what you would see if you could look at the sun.* If some people don't see spots, have them try another day.

2. *Go back and choose another image several days later. Now what do you see? Hey, the sunspots are moving! Why, do you think? … Most celestial bodies rotate: planets, stars, galaxies. No surprise that the sun does too. Note that the spots are also changing slightly in appearance.*

3. (Illustrate the following on the board and with volleyballs.) *Let's figure out how long it takes the sun to rotate once around. Here's how we can do it. You have 2 grids labeled in degrees: halfway around the sun is 180 degrees. Tape your transparent grid to the top of your screen. Pick a spot and mark its location on your paper grid along with the date. Then choose other nearby dates and mark its location again. After doing this a few times, you can figure out how long it will take to go all the way around (360 degrees). It's OK to talk to the other people at your table, and we will help you too.*

4. Help the girls find good spots, choose dates not too close or far apart, and do the math. Try to avoid telling them the answers, but rather ask them questions about what they're doing, and make friendly suggestions about other things to try. Use the volleyballs to help illustrate what's happening. As the girls come up with answers, write them on the board beside their names. When they're finished, they can print out one of their images. While waiting for the rest of the class, you might have them look at another spot and see if they get the same answer, or help their neighbors, or look at other SOHO images.

5. When all are done: *How come we got so many different answers? Are some wrong and some right? If we wanted to come up with a class answer, how could we decide on one?* Someone calculate the average so they can write down the class answer. True values are ~25 days at equator, ~30 at poles (but we won't bother discussing the differential rotation).

6. Briefly: *So the sun takes about [class answer] days to spin around once. How long does the earth take? Why do you think the sun takes so much longer? Interestingly, some stars rotate lots more quickly than the sun – even hundreds or thousands of times per second!* Play pulsar tape if time permits.

III. Break (15 minutes)

One or two people take girls to the bathroom and back.
One or two people go outside with them to time the break, talk with the girls, and help them find the room again. It's okay if some want to stay in.
Others shut down and fold up computers, put supplies on desks, write/draw on board, talk to girls who stayed in.

IV. Camera construction (20 minutes)

1. *Now we're going to build tools that will let us look at the sun ourselves. Remember, NEVER look directly at the sun! We're going to make pinhole cameras that will project an image of the sun we can look at. You can take these home. They won't be good enough to see sunspots like in the SOHO images, but they are very good for solar eclipses. [What's a solar eclipse?]*

2. Draw and explain ray diagram of the camera. *Because light travels in straight lines, the sun distance times the image distance equals the sun size times the image size. Since the sun is 93 million miles away (we know this from earth's orbit), we can calculate how big it is.*

3. Give overview of what we'll do to make the cameras (draw picture on board, show example of one that's already built). *In any order:*

- *Put foil over one end, tape it down, poke a small hole in the middle*
- *Ask a helper to cut a window in the side*
- *Cut out graph paper and tape it to the cap*
- *Thread a long piece of string through the tube and tie it.*

Then you can decorate it as you like until everyone is done.

4. Help cut holes in tubes and provide any other assistance necessary. Try to keep the mess somewhat under control. Don't let them start decorating until the camera is completed. When we feel it's time, give them a 2-minute warning to finish up. Then have them clean up their desks and put things away.

5. *In a minute we'll go outside to test the cameras and measure the sun's size. Here's how to do it. Point the foil end at the sun, look into the hole. Make the tube's shadow as small as possible.* Show how to do this, and show that it may help to work in pairs. *Count how many squares big the image is and write this down. The helpers will use this measurement to calculate the size of the sun for you.*

6. Have them gather their things so they don't have to come back. Keep everyone together as we go outside. One or two people lag behind to make sure nothing gets left in the room.

V. Camera testing (rest of time)

One or two people set up the solar viewer and show it to the girls. Others, help them find the sun and measure the image size in squares of graph paper. Have them write down what they measure. Calculate solar size for them, and have them write that down too.

Tubes are 37 1/8” long = 94.3 cm
10 sq = 1 cm => 1 sq = 0.1 cm

Image size/image distance = Sun size/Sun distance
If X = image size in squares,
=> Sun size = 1.5e13 cm * 0.1 cm * X / 94.3 cm
= 1.6e10 * X cm
= 1.6e5 * X km
= 9.9e4 * X miles. (1 mile = 1.6093 km)

So X should be 9-10 squares for ~1.5e6 km ~ 900,000 miles.

The earth is ~1.3e4 km = 8000 miles across, so the sun is over 100 times bigger!
The earth is about the size of a small sunspot in the images we looked at.

Say goodbye and thanks, remind them about lunch, and make sure they take the cameras with them!

Before lunch:
make “Physics & Astronomy” poster
lock computer lab

After lunch:
Set up for afternoon session

After second session:
Clean up lab
Load supplies back in cars
Return EYH materials
Return keys to Kathy