Exercise set eight

1 Outdoor: Observing Saturn

Materials

telescope

Instructions

You will be observing Saturn and its rings and moons, tonight.

Pre-Observation

1. Can you think of any ways to tell moons from stars during your observations tonight?
2. Imagine you are facing South and looking at the sky with your naked eye. North will be "up" (i.e. farther from the horizon in front of you) from this perspective. Draw two arrows at right angles to each other, one pointing North and one East as you would see it on the sky and label them. Label the set of arrows "looking South". Also make sets of arrows for "Looking East", and "Looking North".
3. Some telescope setups will flip the image of the telescope either "left-right", or "up-down", or both. Draw the same sets of arrows as in the previous question, but this time as seen through a telescope that flips the image both ways.
4. Think of a way to tell which way is North and which way is East in the telescope. Remember that the telescope may flip the image one or both ways. Hint: you can move the telescope and you can also watch how things move in the telescope due to the Earth's rotation.
5. Saturn is currently 8.85 au from the Earth (1 au $= 1.5 \times 10^8$ km). Saturn's diameter is 1.2×10^5 km. Calculate the Saturn's angular diameter.
6. Show me your answers to these questions before you go out.

Observation

Observe Saturn with the telescope. You may try out different eyepieces.

1. Is the image in the telescope flipped one or both ways?
2. Draw a circle representing the field of view of the telescope. Label the North and East edges of the circle.
3. Draw Saturn, its rings, and anything you think might be a moon of Saturn within the circle.
4. Record approximately how far each moon is from Saturn on the sky (in Saturn diameters).
5. Record the focal length and type of the eyepieces you use.
6. Record the focal length and diameter of the telescope.

Post-Observation

1. The "field of view" of a particular telescope-eyepiece combination is the angular width of the region of the sky visible through the telescope. From your previous calculations and your observations, estimate the field of view of the setup you used.
2. Calculate the projected distances between Saturn and each potential moon.
3. Magnification measures how much larger, in angular extent, objects appear when viewed through a particular optical setup. The magnification of a telescope-eyepiece combination is just the focal length of the telescope divided by the focal length of the eyepiece $m = f_{\text{tele}}/f_{\text{eyep}}$. Calculate the magnification of the setup you used.

2 Outdoor: Measuring the Field of View

Materials

telescope, watch which indicates seconds

Instructions

Pre-Observation

The "field of view" of a particular telescope-eyepiece combination is the angular width of the region of the sky visible through the telescope.

1. How could you measure the field of view of a telescope using the rotation of the Earth (you will need a watch)?
2. Where would you need to point in the sky (it *does* matter)?
3. Show me your observing plan before you go out.

Observation

Use the same telescope setup you used for the Saturn observations, if you've done them.

Take the necessary observations to measure the field of view. Make sure to repeat your measurements at least 3 times. Record what eyepiece you are using (focal length and type), and the focal length and diameter of the telescope.

Post-Observation

Calculate the field of view of your telescope setup.

3 On paper: The Mass of Saturn

1. If you had more time to observe (i.e. many nights), how would you determine what was one of Saturn's moons and what was a star?
2. Using the same observations you would use for the previous question, how could you determine the mass of Saturn (assuming you know the distance to it)? Hint: from your observations you could measure the apparent angular separation between Saturn and each moon as a function of time.

3. Use the information below to find the orbital period for each moon listed (in days). It may help to count the number of periods that occur over a certain span of days.

4. Find the orbital radius for each of the moons listed (in km).

5. Use this information (and Kepler's 3rd law) to estimate the mass of Saturn (in solar masses). It may help to convert your periods to years.

The projected displacement, in Saturn radii, East and South of Saturn every 24 hours for two of Saturn's moons. Saturn's diameter is 1.2×10^5 km.

Date	Titan South	Titan East	Enceladus South	Enceladus East
2006/04/12	-15.104	6.246	3.950	-0.352
2006/04/13	-8.957	7.280	-0.638	1.432
2006/04/14	-1.514	7.250	-3.753	0.001
2006/04/15	6.150	6.176	1.659	-1.425
2006/04/16	12.942	4.234	3.364	0.371
2006/04/17	17.915	1.698	-2.449	1.339
2006/04/18	20.344	-1.076	-2.704	-0.705
2006/04/19	19.821	-3.690	3.201	-1.147
2006/04/20	16.337	-5.747	1.932	1.000
2006/04/21	10.334	-6.912	-3.637	0.906
2006/04/22	2.693	-6.973	-0.952	-1.227
2006/04/23	-5.379	-5.896	3.928	-0.578
2006/04/24	-12.558	-3.845	0.011	1.375
2006/04/25	-17.661	-1.157	-3.889	0.241
2006/04/26	-19.872	1.722	1.049	-1.432
2006/04/27	-18.893	4.327	3.659	0.135
2006/04/28	-14.967	6.259	-1.913	1.401
2006/04/29	-8.781	7.245	-3.133	-0.484
2006/04/30	-1.314	7.170	2.783	-1.268
2006/05/01	6.333	6.073	2.464	0.811
2006/05/02	13.086	4.125	-3.348	1.070
2006/05/03	18.002	1.600	-1.559	-1.080
2006/05/04	20.364	-1.147	3.804	-0.781
2006/05/05	19.771	-3.724	0.645	1.278
2006/05/06	16.223	-5.737	-3.920	0.466
2006/05/07	10.173	-6.857	0.426	-1.394
2006/05/08	2.511	-6.881	3.855	-0.098
2006/05/09	-5.551	-5.782	-1.340	1.420
2006/05/10	-12.694	-3.730	-3.471	-0.255
2006/05/11	-17.740	-1.063	2.304	-1.347