

Astronomy 4 Observing Project

Determining the Periods of Jupiter's Four Galilean Moons

Project Write-Ups due on Wednesday, 4 May, by 5 p.m.

Introduction: When on 7 January 1610 Galileo turned his telescope toward Jupiter, he observed several small points of light close the planet, lined up on a straight line through Jupiter's center. Writing a friend later that evening he noted:

And besides the observations of the Moon I have observed the following in the other stars. First, that many fixed stars are seen with the spyglass that are not discerned without it; and only this evening I have seen Jupiter accompanied by three fixed stars, totally invisible because of their smallness; and the configuration was in this form:



After viewing Jupiter over the next few nights, Galileo concluded that the tiny “fixed stars” were not stars at all, but rather that Jupiter is surrounded by four objects that move back and forth near the planet, always on a straight line. By 15 January, he decided that the Jupiter is circled by four moons. In March of 1610, Galileo announced his telescopic discoveries in a little book called the *Sidereus Nuncius* (Starry Messenger), a work that instantly catapulted him into fame and controversy across Europe (see *Sidereus Nuncius*, transl. Albert van Helden, 1989, pp. 12-16, on reserve in Kresge Library for Astro 4). For a facsimile of parts of the original Latin 1610 edition, see <http://www.octavo.com/researchfacsimiles/galsid/index.html>. For Galileo's original observational sketches of Jupiter and its moons, see <http://www.hao.ucar.edu/public/education/sp/images/galileo.4.html>.

Task: Your goal is to use a 4.5-inch Orion SkyQuest reflecting telescope to observe Jupiter's four brightest moons (Io, Ganymede, Callisto, Europa) several times over the course of an evening and on several subsequent evenings. By estimating the moons' relative distances from the planet, and by recording the times and dates of your observations, you will be able to estimate the orbital period for each of the four moons (i.e., the time required for a given moon to return to the same point on its orbit around Jupiter). You will then evaluate your results by repeating the exercise using the SkyChart III software provided with Chaisson/McMillan, *Astronomy Today*, 5th ed. (Accelerator CD, in the envelope at the back of the textbook). You may work in pairs, and should submit either a jointly authored (same grade for both authors) or individually authored observational project write-up by Wednesday, 4 May.

Observing Procedures: Pick up an Orion telescope and a pair of eyepieces in Room 200 in Wilder Laboratory (door key code 73715). Please sign out the telescope when you remove it and sign it back in when returned. Wilder Lab is open every weekday night until 11 p.m. If you miss that deadline, you'll have to schlep the telescope to your room and return it the next morning. Set up the scope and practice using it in daylight before you turn to Jupiter, which will be visible as the brightest object in the nighttime sky (except for the Moon) from sunset until sunrise throughout the month of April. Feel free to look at other objects in the night sky, but NEVER look at the Sun through the telescope. Note that the optics of the telescope inverts the image. Contact one of the

Astro 4 TAs immediately if you have any problems in securing or using a telescope. One of the TAs will be available in Room 200 on all the clear evenings during the first two weeks of April, standing ready to provide assistance if you need it.

Document ALL of your observations thoroughly, recording the date, time, weather/seeing conditions, and eyepiece employed for each observation, and sketching the relative positions of the moons and Jupiter. As a unit of length on your sketches, you might use the apparent diameter of the planet. See *Sidereus Nuncius*, pp. 64-83, for Galileo's sketches of his 1610 observations.

Computational Procedures: To determine the four moons' periods (number of days, to the nearest hundredth of a day, required for one complete revolution around Jupiter), you will need to:

- i) identify each of the moons in each of your observations;
- ii) extract the radius of each moon's orbit (its maximal elongation, or greatest apparent distance, from Jupiter) from your observations;
- iii) figure out how to plot an orbit and hence determine a period, from the information contained in your observational sketches.

To give you a sense of how the four moons move in sped-up time and to compute their periods by means of "computer observations," use the software package, SkyChart III, available on the CD-ROM that accompanies the Chaisson/McMillan textbook. After installing SkyChart III on your hard-drive, start the package and make the following settings:

- i) Under *View*, set *Center Planet* to Jupiter
- ii) Under *Draw*, click on *Object Labels*.
- iii) Under *View*, set to $1/2^\circ$ *Field*.
- iv) Under *Animation*, set to *10 Minutes*.
- v) Under *Animation*, click *Animation Forward* to start the moons moving.
- vi) Observe the time and date when a given moon eclipses Jupiter and then returns to eclipse it again, after completing one revolution. The difference between those times is the period of the given moon.

For modern values of the four moons' periods, see Chaisson/McMillan, p. 291.

Write-Up: Write a brief description of your procedures. Compare the results for the periods of the four moons that you obtain from the telescopic observations with those obtained with SkyChart III and with the modern values. If your telescopically derived results differ significantly for the latter two cases, discuss why such discrepancies might arise. Discuss any problems you encountered during this project, and compare your procedures and results with Galileo's. Include all your original observational notes, sketches and computations with the write-up, firmly fastening all the sheets so that nothing goes amiss. Write your name on each sheet.

The observation project write-up is due by 5 p.m. on Wednesday, 4 May. Write-ups submitted after that date will be accepted but penalized for lateness.