Student guide

Erasmus+

Title IO

Jupiter moon orbit resonance

Norwegian translation

Material List:

Split pins

Hole maker for paper

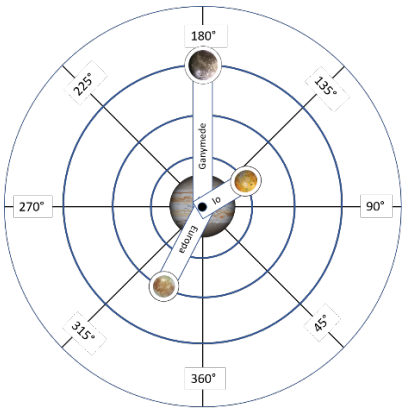
Scissors

Outline

All the planets and moons affect each other with their gravity, it is not just the large objects in the centre. And through this “mini gravity” pull, we get a fascinating resonance between the orbits of all the planets as they orbit the sun, and the moons of the larger planets like Jupiter and Saturn. Here we investigate the resonance in the orbits of Jupiters moons.

Procedure

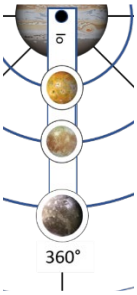
1 Make an orrery



We will not make an orrery, with the three biggest Jovian moons (moons of Jupiter). Start by printing the attached document (on thick paper if you have), to get the dial, the arms and the pictures of the moons and Jupiter. If you do not have thick paper, it can be smart to put plastic foil on the papers after cutting them out, so they are stiff and more easy to work with. Cut holes in the middle of the dial, and in the white end of the arms for each of the moon. Put them together with a split pin.

The online observatory collaboration consists of the following partners: Baldone Observatory, Brorfelde Observatory, Cardiff University, Harestua Solar Observatory, Helsinki Observatory. See onlineobservatory.eu for more activities and information.

2 Getting ready



When the Jovian moons orbit Jupiter, they will have a slightly larger pull on each other when they are close. This slightly larger pull will not cause any of them to dramatically change orbits, but with time, their orbits starts to resonate, which means the start going in a specific pattern.

The Jovian moons Ganymede, Europe and Io have a ratio 1:2:4, which means that in the same time Ganymede completes 1 orbit, Europe does 2 orbits and Io does 4. Position the moons like in the picture to your left.

We are now ready to start!

3 The first steps

Start by moving Ganymede one step. Use the lines in the dial, and let Ganymedes first step be 45 degrees to your right. The Europe shall move two steps, i.e. 90 degrees, and Io shall move four steps, i.e. 180 degrees.

Continue this way of stepping the moons forward: Ganymede does one step, Europe two steps and Io four steps.

4 Find the equation

We will now try to find of there is a way of calculating when they all align at a later stage. Use the numbers given for Ganymede in the table below, and the ratio 1:2:4 calculate how many orbits Europe and Io does in the same time.

If either of these values of Ganymede results in answers for Europa and Io, without any decimals in the answer, you have found a time when all the planets are in the starting point.

Are you able to guess any other value for orbits of Ganymede, that will result in complete orbits of the other two? Write your best guess in the line below “132”.

Number of orbits for Ganymede	Ganymede	Europa	Io
1	1		
43	43		
99	99		
132	132		

5

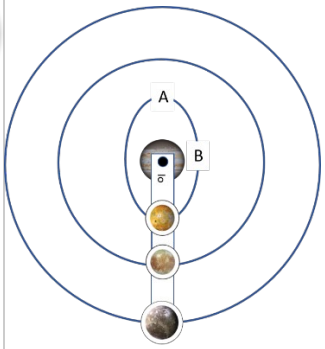
Orbit time

The time of each orbit can also be calculated from the ratio 1:2:4. We hav given in the table below, that it takes 7.15 earth days (24h) for Ganymede to orbit Jupiter once. How long do you then think it takes Europe and Io to orbit.

Verify your answers with arguments like “is it bigger than” or “smaller than” Ganymede, and check your arguments with the orrery you made.

	Ganymede	Europa	Io
Time of one orbit	7.15		

6



Gravity stretching the orbit of Io

When all the moons are aligned, the gravity of the outer moons tend to stretch the orbit of IO slightly, making it more an ellipse then a circle. This causes Io to be further away from Jupiter in points A, and closer to Jupiter in points B. This enhances the geological activity on Io through the tidal forces of Jupiter, which in turn causes large volcano eruptions and Io-quakes.

Fun fact: Io is the most geologically active object in our solar system today, with 400 active volcanoes. Some of these volcanoes are even higher than Mount Everest.

Further Resources/Activities:

Video:

Io - Jupiter's Volcanic Moon - YouTube
Jupiter's Moons: Crash Course Astronomy #17 - YouTube