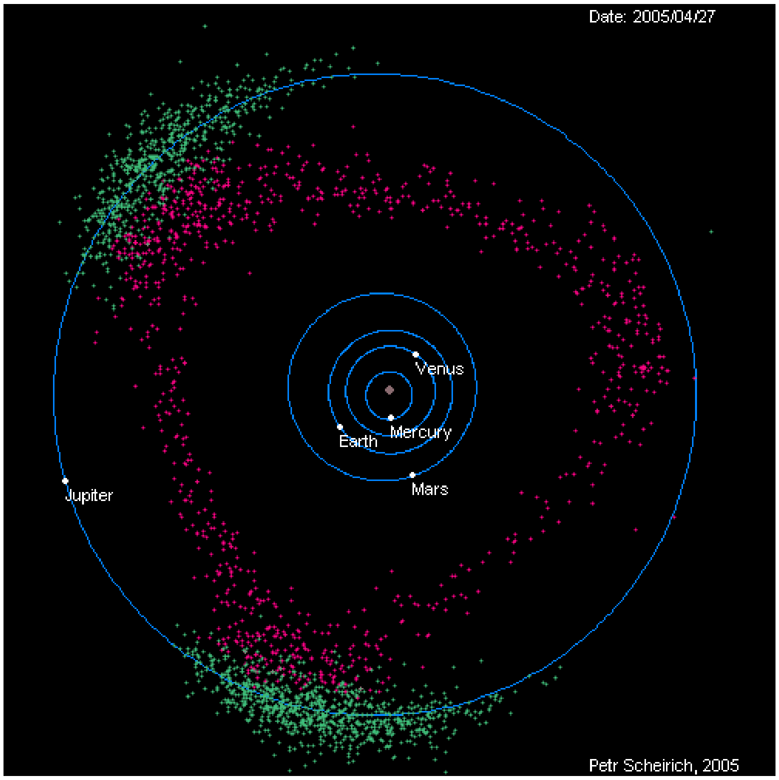
LEARN - What is Asteroid Orbital Resonance?



Learning Objective:
Learn what asteroid orbital resonance is and what effects it has on celestial objects in our solar system.

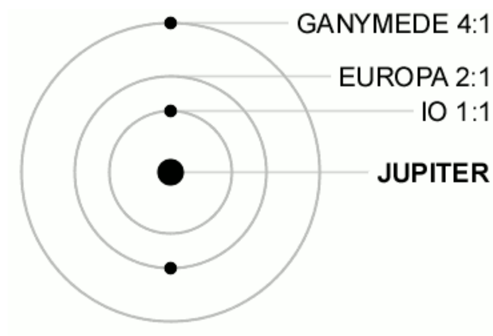
Overview:
Orbital resonance is when the periods of two celestial bodies around a third are in a simple ratio, e.g. 2:1.

Specifics:
Our solar system is home to three general types of resonance phenomena:

- Spin-orbit resonance, which is the connection between the period of rotation of a smaller object with the period of its orbital revolution due to the gravitational tidal torque from a larger body.

- Secular resonance, which is the connection between the precession (the gravity-induced, slow but continuous changes in the body's rotational axis or orbital path) frequencies of the orbital inclination (the tilt of the orbit).

- Mean motion resonance is when the orbital periods of two bodies are the exact multiples of each other. This is the case for three of Jupiter's moons: Europa's orbital period is twice that of Io, while Ganymede's is twice Europa's.

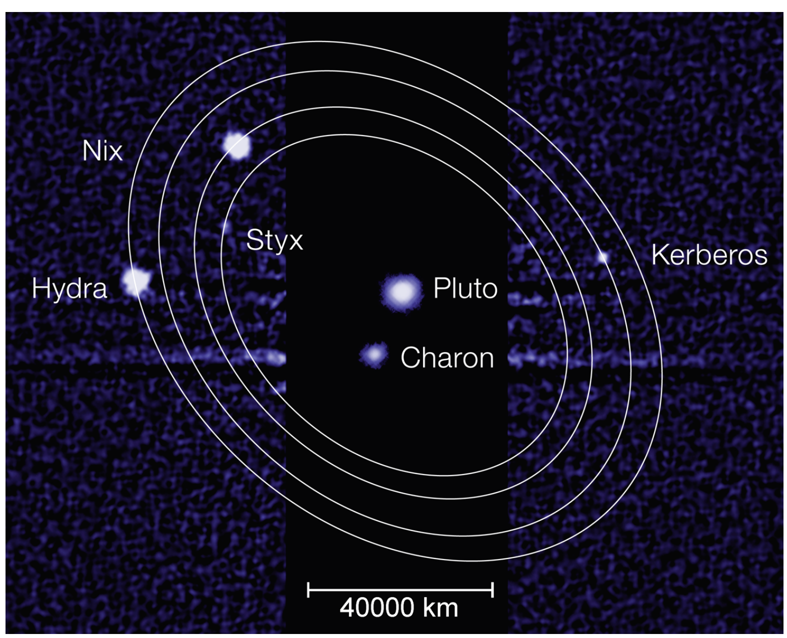


In our solar system, when a body orbiting the Sun is in orbital resonance with a larger body, usually two things can happen. The smaller body will sometimes be accelerated and at other times it will be slowed down by the gravitational pull of the larger body. This “tug and pull” distorts the orbit of the smaller body until it is not in orbital resonance with the larger one anymore. Its orbit changes and thus the previous orbit remains unoccupied.

This is the process that causes the Kirkwood Gaps, which are spaces in the asteroid main belt (the region between Mars and Jupiter, where most of the asteroids exist in our solar system), where only very few asteroids are present due to Jupiter’s dominant gravitational influence on main belt asteroids.

Orbital evolution is when a celestial body’s orbital parameters change. Orbital evolution explains the distribution of smaller bodies in our solar system and it is especially critical in the case of Near Earth Asteroids (NEAs). The orbits of NEAs come near or even cross the orbit of Earth and therefore could potentially collide with our planet in the future, which makes them Potentially Hazardous Asteroids (PHAs).

The NEA population is continuously replenished due to the constant orbital evolution of smaller bodies in the main asteroid belt. The gravitational effects of both Mars and Jupiter deliver some of these minor bodies to the inner solar system, but the opposite can happen as well: some objects in the inner solar system can evolve outwards.



The other possible outcome is the exact opposite: the smaller body can get locked into its orbit as the larger body holds the smaller one there. These are called stable resonances. An example of stable resonance is the orbits of Pluto and the plutinos (trans-Neptunian objects), despite crossing that of Neptune.

In summary, the gravitational influence of larger bodies in our solar system plays a critical role in shaping the orbits of asteroids. This influence can lead to either stable, long-term orbits or create potential collision risks. Understanding these dynamics is essential for comprehending the workings of our solar system and for mitigating potential threats to Earth from these celestial bodies. By studying these interactions, we gain valuable insights into the behaviour of asteroids and their impact, both now and in the future.

Learn more about this subject by visiting these websites:
Orbital Resonances of the Galilean Moons of Jupiter
Orbital Resonances in the Solar System
Orbital Resonances and Chaos in the Solar System