The Discovery of Neptune

THE LAW OF UNIVERSAL GRAVITATION has been used by mathematicians and astronomers to predict and find other bodies in the universe. With the discovery of a perturbation in a solar system, we can assume another body is causing it and look for this new unknown body. The law of universal gravitation makes such planetary discoveries possible. The law states that all bodies have a gravitational force in direct relationship to their size and proximity to other bodies.



Objectives:

- 1. Explain how the study of perturbations has led to important discoveries in astronomy.
 - 2. Describe the law of universal gravitation.

Key Terms:

law of universal gravitation perturbation

Perturbations

A **perturbation** is a disturbance in the regular elliptic motion of a heavenly body. It is produced by a force additional to that which causes a regular rotational motion (orbit). For example, perturbations of planets are caused by their attraction to each other. Yet their regular rotation is around the sun. Therefore, any perturbation in their rotation would be caused by some other body.



THE DISCOVERY OF NEPTUNE

The planet Neptune was discovered in 1846. Its existence and position were predicted by two mathematicians who noticed that Uranus was not moving in a perfectly elliptical path around the sun. They concluded that for this to happen there must be another gravitational force from a planet that rotated near it.

The mathematicians calculated the gravitational tug necessary to pull Uranus out of its orbit and determined where the source would need to be. With this information, they were able to tell the astronomers where to point their telescopes to discover the new planet. Once astronomers took the predictions seriously, they found Neptune within hours. They simply turned their telescopes onto the region implied by the calculations. The new planet and its location were done with precise prediction, which was striking confirmation of the power of Newton's theory of gravitation.



FIGURE 1. Mathematicians predicted that another planet's force of gravity was causing the perturbation in the orbit of Uranus, thereby deducing that another planet was nearby.



FIGURE 2. The discovery of Neptune was possible with knowledge of how Newton's theory of gravitation worked.

THE DISCOVERY OF PLUTO

In 1930, Pluto was discovered because of supposed perturbations of the orbits of Uranus and Neptune. It is now believed that these apparent deviations in the orbits of Uranus and Neptune were errors because the actual properties of Pluto would not have accounted for the supposed perturbations in their measurements. The size of Pluto and its gravitational force is too small. As a result, Pluto could not have caused those, believed to be, perturbations. Therefore, the discovery of Pluto was more or less an accident.



FURTHER EXPLORATION...

ONLINE CONNECTION: Chronology of Solar System Discovery

Our knowledge of our solar system and the universe is constantly changing. This is primarily because of new technology and our ability to see deeper and with more detail into space. All the objects (major bodies) in our solar system are documented and described—at least the ones we know of so far. You can learn when, and by whom, all the bodies in our solar system were discovered. You can also see images and statistics.

The following is a Web link where you can find this information:

http://www.nineplanets.org

Beyond the confines of our solar system, perturbations have been observed in the orbits of stars. These, caused by the gravitational forces of orbiting bodies, have led to the discovery of a number of solar planetary systems.

Law of Universal Gravitation

Newton's **law of universal gravitation** states that every object in the universe attracts every other object. The attraction is from the gravitational force directed along the center line of the objects. This force is proportional to the product of their masses and is inversely proportional to the square of the separation between them. The actual formula for Newton's law of universal gravitation is Fg = G (m1m2/r2). Fg is the gravitational force; m1 and m2 are the masses of the two objects. The r is the separation between the objects, and G is the universal gravitational constraint.

MASS AND FORCE

The larger the mass of the object, the greater its force. As the distance increases between the objects, the force decreases in increasing amounts. Therefore, we can account for all the perturbations that exist on each planet from one another and from the sun. We can calculate and predict exactly how and where each planet should orbit around the sun. Then, if we physically observe the planets and they deviate from the prediction, there are two options: Newton's law of universal gravitation requires modification, or there is obviously an undetected mass causing an alternate perturbation in the orbits of the planets observed. In the assumption that the law is correct, this process has been used to detect and find many bodies in the universe.



Summary:



Perturbations are caused by forces acting on a body. These forces are in addition to the main gravitational force that causes the body to rotate in orbit. The planet Neptune was discovered with this knowledge. Similarly, in 1930, Pluto was discovered because of supposed perturbations of the orbits of Uranus and Neptune.

Newton's law of universal gravitation states that every object in the universe attracts every other object. This force of attraction is proportional to the product of their masses. The actual formula shows that the larger the mass of the object, the greater the force. As the distance increases between the objects, the force decreases in increasing amounts.

Checking Your Knowledge:



- 1. What are perturbations?
- 2. Why was Neptune discovered?
- 3. How do perturbations help astronomers?
- 4. What does Newton's law of universal gravitation state?
- 5. As the mass increases in a body, what happens to its gravitational force?

Expanding Your Knowledge:

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Most cities and many universities have a planetarium. Plan a visit to the planetarium nearest to you. There you can see many images of objects and distant planetary systems while learning about the history and recent discoveries in space.

Web Links:



Galaxies

http://library.thinkquest.org/28327/html/astronomy/galaxies.html

Space Science

http://www.esa.int/esaSC/SEMZVI5V9ED_index_0.html

