

## Lecture Nineteen

### Pluto and the Definition of Planet

**Scope:** At the beginning of the 21<sup>st</sup> century, our solar system is best understood as six families of objects, each of which share similar characteristics of size, orbit, composition, moons, rings, and more. From this viewpoint, Pluto fits in as a member of the Kuiper Belt, and there are 8 planets. As our knowledge of the solar system has changed, the number of planets both grew and shrank, from 5 up to the teens and back down. These numbers reflect both new discoveries of planets as well as changing views of the definition of a planet. The discovery of Eris, a Kuiper Belt object larger than Pluto, brought the issue to the forefront. The 2006 formal definition ultimately embraced the modern view, but through an unnecessarily hasty process that produced some awkward compromises. As history has shown before, what matters after a couple of decades will not be the demoting of a planet but the gaining of new perspective on the solar system.

#### Outline

- I. The 21<sup>st</sup>-century view of the solar system is rooted in both history and data.
  - A. In this course, we have progressed through various perspectives on the solar system.
    - 1. The geocentric model of the ancients gave way to the heliocentric model of the Renaissance.
    - 2. The development of physics brought a gravitational perspective on solar system motions.
    - 3. The space age enabled us to study things in much greater detail.
  - B. The modern view now encompasses six families of objects: the Sun, the rocky planets, the asteroid belt, the giant planets, the Kuiper Belt, and the Oort Cloud.
  - C. The best way to convince oneself of this structure is to look at the data and organize it.
    - 1. Using the characteristics of objects without identifying them helps avoid preconceived ideas.

- 2. Graphs make it easy to spot trends. For example, only 4 objects have many moons.
    - 3. Correlation of characteristics reveals relationships. For example, those objects with more elliptical orbits also tend to have more tilted orbits.
    - 4. A plot of size versus distance from the Sun separates objects cleanly into four groups, and each group also shares several other similar characteristics.
    - 5. The data-derived groups are readily identifiable as the rocky planets, asteroid belt, giant planets, and Kuiper Belt.
    - 6. Pluto's characteristics are the same as those of other objects in the Kuiper Belt.
- II. Pluto is no longer a planet, but history shows that defining "planet" is not straightforward.
  - A. The number of planets has fluctuated much more than people generally recognize.
    - 1. In the geocentric model, the Sun, the Moon, and 5 planets circled Earth.
    - 2. The heliocentric model moved Earth to be the 6<sup>th</sup> planet.
    - 3. During the 1600s, moons of Jupiter and Saturn were considered planets for many decades and then relegated to secondary status.
    - 4. The discovery of Uranus in 1787 gave us 7 planets.
    - 5. The first asteroids discovered were counted as planets 9 through 12.
    - 6. When Neptune was discovered it was the 13<sup>th</sup> planet.
    - 7. Designating the family of the asteroid belt brought the number of planets from the teens down to 8.
    - 8. In the late 1800s, several mistaken discoveries were called planets for a decade or two before being discarded.
    - 9. Pluto was the 9<sup>th</sup> planet when discovered in 1930, but it was demoted in 2006.
  - B. The definition of "planet" has changed over the years.
    - 1. The original definition meant a wanderer on the night sky.
    - 2. In the heliocentric view, planets orbit the Sun.
    - 3. Kepler's laws came to define how planets should behave.
    - 4. For a time, the Titius-Bode rule specified where planets should be found.

5. Until 2006, the nonspecific definition was that planets were the major bodies orbiting the Sun.

### III. Now, we come to Pluto.

- A. Pluto's mass was predicted to be seven times the mass of Earth.
- B. After discovery, Pluto was quickly seen to be no larger than Earth.
- C. Over the decades, estimates of Pluto's mass shrank until the discovery of Charon helped measure its mass at only 2/1000 that of Earth.
- D. As discoveries in the Kuiper Belt grew, the justification for calling Pluto a planet shrank.
- E. The catalyst for change was the discovery of Eris, a Kuiper Belt object 10% larger than Pluto.
- F. Committees of the International Astronomical Union spent several years attempting to define "planet" and properly deal with Pluto and Eris.
  1. In defining planet, the upper limit is set by the notion that anything large enough to have nuclear fusion in its core is a star.
  2. The first proposal in 2006 defined a planet as an object orbiting the Sun that was large enough to be spherical. Twelve planets were counted, with possibly 40 others to be confirmed.
  3. The proposal was quickly revised to include the requirement that a planet must dominate its orbit and the definition of "dwarf planet" for spherical objects like Eris, Pluto, and Ceres that did not meet that criterion.
  4. The process was needlessly rushed, overly publicized, and not a proper representation of the scientific process.
  5. The result was a compromise that folks accept, but with which few are truly happy.

### IV. It is not even clear that a scientific definition of "planet" can or needs to be devised.

- A. How one might define the cutoffs based on physical criteria is not clear.
  1. Everyone agrees that lack of fusion works as an upper cutoff for size.
  2. The fact that Mercury is smaller than the moons Ganymede and Titan shows that size alone is not enough.

3. Shape is not necessarily definitive, as an icy object deforms to spherical at a lower mass than a rocky object does.
4. Orbital characteristics can be questioned, as they are dynamical properties and not intrinsic to the object itself.
5. The idea that a planet must dominate its orbit can be quantified, and this is effectively the same criteria used to separate out the asteroid belt.

- B. A general definition of "planet" raises many questions.
  1. Can a planet become a nonplanet if its orbit changes?
  2. What about planets that may have been ejected from the solar system by Jupiter?
  3. What if other solar systems don't follow our rules?
  4. One sure thing is that the definition of planet will be revisited as we discover more.
- C. Some, including me, feel that no strict definition is necessary.
  1. One can point out that there is no strict definition of other terms like "continent."
  2. The rocky planets and the giant planets are well defined, and arguing over other things just confuses the issue.
  3. The 21<sup>st</sup>-century perspective of families of the solar system provides the proper viewpoint that increases understanding and advances science.

### Suggested Readings:

Bennett, Donahue, Schneider, and Voit, *The Cosmic Perspective*, chap. 12.

Davies, *Beyond Pluto*.

Hoyt, *Planets X and Pluto*.

Jewitt, Morbidelli, and Rauer, *Trans-Neptunian Objects and Comets*.

Levy, *Clyde Tombaugh*.

Weintraub, *Is Pluto a Planet?*

### Questions to Consider:

1. Why are the short-period comets not generally considered as a seventh family of objects in the solar system?
2. Does Sedna, existing alone out beyond the Kuiper Belt, deserve to be called a planet?