

The Utility of the Dynamical-Based (IAU) Definition

Steven Soter

Department of Astrophysics, American Museum of Natural History, New York

The IAU defined a planet as "a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass . . . so that it assumes a . . . nearly round shape, and (c) has cleared the neighborhood around its orbit."

The heart of the definition is part (c), which has the right general idea, but its lack of precision has led to confusion. A planet never completely "clears" its orbital neighborhood, because small objects continue to stray into its vicinity from the leaky reservoirs of asteroids and comets.

We can remedy this problem by defining a planet as a body that *dynamically dominates* its orbital neighborhood. A body is dynamically dominant if it sweeps up or scatters other objects from its neighborhood in a time much less than the age of the system (theoretical criterion), or if its mass is much greater than the total mass of all other objects in its neighborhood (observational criterion).

The dynamical definition derives from our knowledge of how the solar system formed. The final stage of accretion from the disk of gas and dust in orbit around the young Sun produced eight dominant planets in non-intersecting orbits, and swarms of leftover debris. By any measure, the dynamical power of a planet is orders of magnitude greater than that of the other objects orbiting the Sun. When nature produces such a large gap in a distribution that might have been continuous, it is telling us something fundamental. The IAU used this gap for its definition.

The mass and "roundness" criterion (b) is unnecessary, because dynamical dominance already distinguishes asteroids and comets from planets.

Computer simulations suggest that our solar system is dynamically full, with no room left to insert another planet in a stable orbit between the existing ones. Dynamical studies of other planetary systems suggest that this may be a general rule. This hypothesis recently led to the successful prediction of a planet, the first since the discovery of Neptune in 1846. It suggests that other systems also contain a distinct set of planets that dynamically dominate swarms of smaller objects. If that turns out to be the case, then the criterion (a), which limits the definition of a planet to our own solar system, would also be unnecessary.