

A GEOPHYSICAL PLANET DEFINITION. K.D. Runyon¹, S.A. Stern², T.R. Lauer³, W. Grundy⁴, M.E. Summers⁵, K.N. Singer², ¹Johns Hopkins University, Dept. of Earth and Planetary Sciences, Baltimore, MD, USA (kirby.runyon@gmail.com), ²Southwest Research Institute, Boulder, CO, USA, ³National Optical Astronomy Observatory, Tucson, AZ, USA, ⁴Lowell Observatory, Flagstaff, AZ, USA ⁵George Mason University, Dept. of Physics and Astronomy, Fairfax, VA, USA.

Introduction: In the mind of the public, the word “planet” carries a significance lacking in other words used to describe planetary bodies. In the decade following the supposed “demotion” of Pluto by the International Astronomical Union (IAU) [1], many members of the public, in our experience, assume that alleged “non-planets” cease to be interesting enough to warrant scientific exploration, though the IAU did not intend this consequence [1]. To wit: a common question we receive is, “Why did you send *New Horizons* to Pluto if it’s not a planet anymore?” To mitigate this unfortunate perception, we propose a new definition of planet, which has historical precedence [e.g., 2,3]. In keeping with both sound scientific classification and peoples’ intuition, we propose a geophysically-based definition of “planet” that importantly emphasizes a body’s *intrinsic* physical properties over its *extrinsic* orbital properties.

Planet: A Geophysical Definition: We propose the following *geophysical* definition of a planet for use by educators, scientists, students, and the public:

A planet is a sub-stellar mass body that has never undergone nuclear fusion and that has sufficient self-gravitation to assume a spheroidal shape adequately described by a triaxial ellipsoid regardless of its orbital parameters.

A simple paraphrase of our planet definition—especially suitable for elementary school students—could be, “round objects in space that are smaller than stars” (Figure 1). Our definition clearly excludes stars or stellar objects such as white dwarfs, neutron stars, and black holes. We leave for the future the issue of brown dwarfs’ stellar versus planetary status so as to not force a premature definition on the larger end of planetary scales. In keeping with emphasizing intrinsic properties, our geophysical definition is directly based on the physics of the world itself rather than the physics of its interactions with external objects.

Common Usage: Our definition captures the common usage already present in the planetary science community. In peer-reviewed planetary science publications and talks, the word “planet” often substitutes

for the given name of the world, even if the world is a moon or dwarf planet. An instance of this usage of “planet” when referring to the moon-planet Titan is, “A planet-wide detached haze layer occurs between 300-350 km above the surface; the visible limb of the planet, where the vertical haze optical depth is 0.1, is about 220 km above the surface” [4]. Another instance in the literature refers to Eris, Makemake, and Haumea as “small planets of the Kuiper Belt” [5].

The IAU Definition: The planet definition adopted by the IAU in 2006 [1] is technically flawed, for several reasons. First, it recognizes as planets only those objects orbiting our Sun, not those orbiting other stars or orbiting freely in the galaxy as “rogue planets.” Second, it requires zone clearing, which no planet in our solar system can satisfy since new small bodies are constantly injected into planet-crossing orbits, like NEOs near Earth. Finally, and most severely, by requiring zone clearing the mathematics of the definition are distance-dependent, requiring progressively larger objects in each successive zone. For example, even an Earth sized object in the Kuiper Belt would not clear its zone.

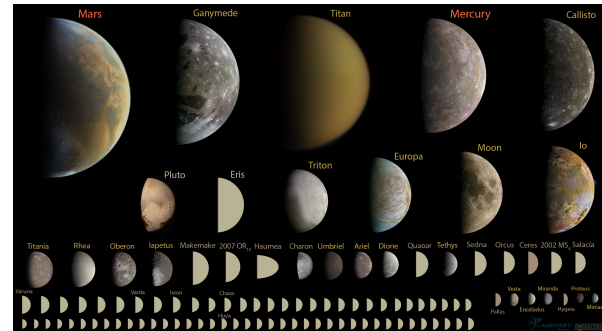


Figure 1. Every discovered planet in our Solar System under 10,000 km in diameter, to scale. The geophysical definition of planet includes ~110 known planets in our solar system.

Modified from Emily Lakdawalla, *The Planetary Society*: <http://www.planetary.org/multimedia/space-images/charts/every-round-object-under-10k.html>.

The eight planets recognized by the IAU [1] are often modified by the adjectives “terrestrial,” “giant,” and “ice giant,” yet no one would state that a giant planet is not a planet. Yet, the IAU does not consider dwarf planets to be planets [1]. We eschew this inconsistency. Thus, dwarf planets and moon planets such as Ceres, Pluto, Charon, and Earth’s Moon are “full-fledged” planets. This seems especially true in light of these planets’ complex geology and geophysics [e.g.,

6]. While the degree of internal differentiation of a given world is geologically interesting, we do not use it as a criterion for planethood in the spirit of having an expansive rather than a narrow definition.

Astronomers with research interests in dynamics may find the IAU definition perfectly useful. However, many planetary scientists are closely aligned with the geosciences. Accordingly, our geophysical definition is more useful for planetary geoscience practitioners, educators, and students.

Planetary Pedagogy: With the above definition of a planet, we count at least 110 known planets in our Solar System (Figure 1). This number continues to grow as astronomers discover more planets in the Kuiper Belt [e.g., 7]. Certainly 110 planets is more than students should be expected to memorize, and indeed they ought not. Instead, students should learn only a few (9? 12? 25?) planets of interest. For an analogy, there are 88 official constellations and ~94 naturally occurring elements, yet most people are content to learn only a few. So it should be with planets.

Understanding the natural organization of the Solar System is much more informative than rote memorization. Teaching the zones of the Solar System from the Sun outward and the types of planets and small bodies in each is perhaps the best approach: The zone closest to the Sun consists of rocky planets; the middle zone consists of gaseous, rocky, and icy planets; and the third zone consists of icy planets. All zones also have small, non-round, asteroidal/cometary bodies.

Implicitly using the geophysical planet definition in context is easy. Teachers may introduce new moon planets to their students with phrases such as, “In the 2020s, NASA will send a spacecraft to study the planet Europa, which orbits around Jupiter as one of its many moons.”

Conclusion: In our numerous talks with the public, we find they resonate happily with the geophysical definition we offer, especially as it is a definition reflecting a body’s intrinsic physical properties, not its location, and is a definition that leverages their intuition. This definition highlights to the general public and policymakers the many fascinating worlds in our Solar System that remain unexplored and are worthy of our exploration, along with the necessary budgets.

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