A Third-Millennium Nomenclature for Celestial Bodies: Dwarf-Moons and Moon-Planets

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ABSTRACT

The recent discovery of numerous small rocks orbiting planets and dwarf planets in our solar system has revealed a gap in celestial nomenclature. These objects, often less than 100 kilometers in diameter, challenge traditional definitions of "moons" due to their size, irregular shapes, and diverse origins. This presentation introduces "dwarf-moons" as a new classificatory term to address these unique celestial bodies, providing a framework that enhances clarity in planetary science and public communication.

Keywords: dwarf-moons, moon-planets, planetary taxonomy, oblateness, teleology

Una nomenclatura del tercer milenio para cuerpos celestes: lunas enanas y planetas-luna

RESUMEN

El reciente descubrimiento de numerosas rocas pequeñas que orbitan planetas y planetas enanos en nuestro sistema solar ha revelado una laguna en la nomenclatura celeste. Estos objetos, a menudo de menos de 100 kilómetros de diámetro, desafían las definiciones tradicionales de "lunas" debido a su tamaño, formas irregulares y diversos orígenes. Esta presentación introduce "lunas enanas" como un nuevo término clasificatorio para referirse a estos cuerpos celestes únicos, proporcionando un marco que mejora la claridad en la ciencia planetaria y la comunicación pública.

Palabras clave: lunas enanas, planetas-luna, taxonomía planetaria, achatamiento, teleología

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第三个千年天体命名法：矮卫星和卫星行星

摘要

近期在太阳系中发现的众多围绕行星和矮行星运行的小型岩石天体，揭示了天体命名法的一个空白。这些天体直径通常小于100公里，由于其体积小、形状不规则且成因多样，对传统的“卫星”定义提出了挑战。本次报告引入“矮卫星”这一新的分类术语，以描述这些独特的天体，并构建一个有助于提升行星科学和公众传播清晰度的框架。

关键词：矮卫星，卫星行星，行星分类，扁率，目的论

Acronyms/Abbreviations

International Astronomical Union (IAU)

Trans-Neptunian Object (TNO)

1. Objective

To discuss the current state of astronomic definitions and how atmospheric composition, along with spherical oblateness, should play a fundamental role in how we classify inter-solar objects.

2. Background

For millennia, humanity has looked to the night sky, captivated by the celestial tapestry of stars, planets, and constellations. Across cultures, from the Sumerians in ancient Mesopotamia to the Indigenous peoples of Australia, the act of naming celestial bodies was both a practical and spiritual endeavor, blending navigation, agriculture, and mythology. The brightest stars and constellations were given names tied to gods, heroes, and natural phenomena, reflecting their cultural significance (Hannah, 2015). The five “wandering stars”—Mercury, Venus, Mars, Jupiter, and Saturn—stood out due to their distinct motion relative to the fixed stars, earning names like “Nabu” (Mercury) in Babylonian astronomy or “Inanna” (Venus) in Sumerian culture. These early naming practices, rooted in observation and cultural narrative, established a foundation for astronomical nomenclature that persists in modern science.

The advent of telescopic astronomy in the 17th century marked a pivotal shift, expanding the catalog of known celestial bodies and challenging existing classifications. Galileo’s observations of Jupiter’s moons in 1610 revealed that celestial objects could orbit bodies other than Earth, prompting a rethinking of what constituted a “planet” or “star.” The 19th century brought further complexity with the discovery of the asteroid belt, which introduced a new class of objects that defied traditional categories. The rapid identification of hundreds of asteroids by the mid-1800s necessitated new naming conventions, often drawn from mythology but grounded in systematic observation. By the 20th century, the International Astronomical Union (IAU) emerged to standardize nomenclature, yet the discovery of numerous small, irregular satellites around planets and dwarf planets exposed gaps in the existing framework. This historical trajectory—from ancient storytelling to modern taxonomy—highlights the ongoing need for terms like dwarf-moons and moon-planets to address the diversity of solar system objects.

2.1 Planetary Differentiation

The word "planet" roots from the Greek word *planetes*, meaning wanderers. These heavenly bodies are unique because they move relative to the other stars in night sky, as noted by Ptolemy. Ancient observers noted that planets appeared distinct from stars, likely due to their brightness and motion, but lacked the tools to understand their internal structure. Modern studies confirm that differentiation produces spherical bodies, influencing why some moons achieve roundness while others remain irregular.

2.2 Copernican Revelation

The Copernican Revolution, initiated by Nicolaus Copernicus in his 1543 work *De revolutionibus orbium coelestium*, shifted the astronomical paradigm from an Earth-centered (geocentric) model to a Sun-centered (heliocentric) one.

This revelation simplified planetary motion explanations and laid the groundwork for the Scientific Revolution, influencing later astronomers like Galileo and Kepler. Galileo, whose telescopic observations of four of Jupiter's moons and the phases of Venus provided empirical evidence that celestial bodies could orbit something other than Earth, fundamentally undermining the Ptolemaic system.

2.3 Asteroid Belt Discovery

The main asteroid belt, located between Mars and Jupiter, was first revealed through the discovery of Ceres in 1801 by Giuseppe Piazzi, followed by Pallas in 1802.

Initially thought to be a "missing planet," these objects instead formed a belt of rocky remnants from the solar system's early accretion phase, prevented from coalescing by Jupiter's gravitational influence.

Over 100 asteroids were identified by the early 19th century, prompting the term "asteroid" and highlighting the diversity of non-planetary bodies.

2.4 Classification of Dwarf-Planets

In 2006, the IAU formalized the dwarf planet category to distinguish bodies like Pluto that orbit the Sun. According to the new definition put forth, a planet must: orbit around the sun, have sufficient mass for its self-gravity to overcome rigid body forces to achieve hydrostatic equilibrium (nearly round shape), and clear their orbital neighborhoods of debris (Kumar, 2008).

This classification addresses small, spherical objects but leaves gaps for irregular satellites, motivating terms like dwarf-moons.

3. Methods

The solar system has proven to be far richer and more complex than early astronomers imagined. As of 2025, there are over 891 confirmed moons in the solar system, with 421 officially recognized as orbiting planets and hundreds more orbiting dwarf planets, asteroids, and trans-Neptunian objects (TNOs). The diversity of moons—ranging from the massive Ganymede and Titan to tiny satellites only a few kilometers wide—highlights the need for updated nomenclature. Recent discoveries, such as 128 new moons around Saturn and an additional moon around Uranus in 2025, demonstrate this complexity and the gaps in traditional definitions.

The primary rational for this new nomenclature is to highlight the importance of objects in the solar system that could support life, or could have supported life at some point in their distant past. These celestial objects stand out as points of interest to be studied. Additionally, as human civilization expands out into the solar system, there is likely to be a strong desire to settle to the larger, more spherical bodies that have non-negligible gravity.

3.1 Moon-Planets

Under this new paradigm, a planet is defined as a celestial body that has achieved hydrostatic equilibrium and possesses a substantial atmosphere, potentially with complex chemistry and distinct layers like a stratosphere or a subsurface ocean. It does not have to orbit the sun. This definition prioritizes a body's intrinsic, observable properties over its orbital dynamics. Consequently, several large moons and a dwarf planet are elevated to full planetary status. Under then new paradigm, Titan, Ganymede, Io, Europa, Triton, and Enceladus are given full planetary classification. Pluto, which has a stratosphere, also regains full planetary status.

3.2 Dwarf Planets

Mercury, although it is one of the original planets, is given dwarf planet standing under the new regime. It does not have an atmosphere. Notwithstanding, is also smaller than both Titan and Ganymede.

Under the new paradigm, a celestial body can be both a moon and a planet. This concept is not new. Luna, Callisto, Rhea, Ariel, and Proteus, among others, are given dwarf planet status. Ceres maintains its dwarf-planet status in additional to other bodies such as Eris, Charon, Makemake.

The debate over "moon-planets" is not new. During the Copernican era, the distinction between planets and moons was not as rigid, and satellites were often regarded as secondary or "subordinate" planets. In recent years, leading scientists (like Alan Stern of the New Horizons mission) have argued for a geophysical definition of planethood, which would elevate several moons—such as Ganymede, Titan, Callisto, and Europa—to planetary status based purely on their intrinsic characteristics (Metzger et. al., 2021).

3.3 Dwarf-Moons (Non-Spherical)

A Dwarf-Moon is any natural satellite

whose self-gravity is insufficient to overcome its material strength, resulting in a non-spherical, irregular shape and is also non-heliocentric. These objects are often captured asteroids or remnants from collisions and are typically less than a few hundred kilometers in diameter. Both moons of Mars, Phobos and Deimos, are considered dwarf-moons because neither is spherical, appearing more like potatoes than round worlds.

Additional dwarf-moons include irregular moons like Pan, Nix, Nereid, Hyperion, Phoebe, and Himalia, which all have an oblateness greater than .1.

4. Results

Many astronomers and planetary scientists have expressed support for taxonomy that emphasizes intrinsic properties—size, shape, geology, and atmosphere—rather than solely relying on orbital mechanics. This paradigm provides clearer guidance for classifying newly discovered exomoons and other bodies with planet-like features.

Adoption of the schema in educational tools and public resources offers improved clarity, helping learners and researchers reliably distinguish between objects of scientific interest. Currently, Intergalactic Education has a solar system simulator using the Unity3d physics engine.

5. Discussion

5.1 Determining Oblateness of Sphere

The community should look closer at how spherical a moon is before determining if it is a dwarf-moon or a moon-planet. For this classification system to be effective, the community should look closer at how spherical a moon is before determining if it is a dwarf-moon or a dwarf-planet. Oblateness is a measure of a shape's compression along its axis of rotation. Characteristically, the objects this paper defines as dwarf-planets have an oblateness of less than .1, but should be discussed.

5.2 Determining Thickness of Atmosphere

This proposal highlights the need for a more granular atmosphere classification system based on pressure (density) and/or chemical composition. Simply noting the presence of an atmosphere is insufficient. A meaningful distinction could be made using surface pressure.

Such a system would provide a quantitative basis for distinguishing between a planet, a dwarf planet, and a dwarf-moon in this new framework. The introduction of a more granular atmosphere classification system, based on pressure (density) or chemical composition, could also be used.

6. Conclusion

The current system of celestial nomenclature, while historically significant, is a product of an era before the full diversity of our solar system was known. This paper proposes a new framework centered on physical, observable characteristics—hydrostatic equilibrium and the presence of a substantial atmosphere—that are directly relevant to the search for life. By introducing categories like dwarf-moons and reclassifying bodies with teleology in mind, we can create a more intuitive and scientifically functional taxonomy. There is a clear need to promote more discussion and promotion of these ideas within the broader astronomical community, including the IAU, to build a consensus for a 21st-century classification system.

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