# A Quantitative Criterion for Defining Planets

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## Official Definition of "Planet" is Inadequate

Applies only to solar system bodies

Leaves thousands of exoplanets unclassified

Is vague (e.g., "clear its orbit", "nearly round")

How clear is clear? How round is round?

## Desirable Features of Planet Taxonomy

Rigorous (quantitative) and general

Easy to implement

Independent of ideas about formation

Follows spirit of existing IAU definition

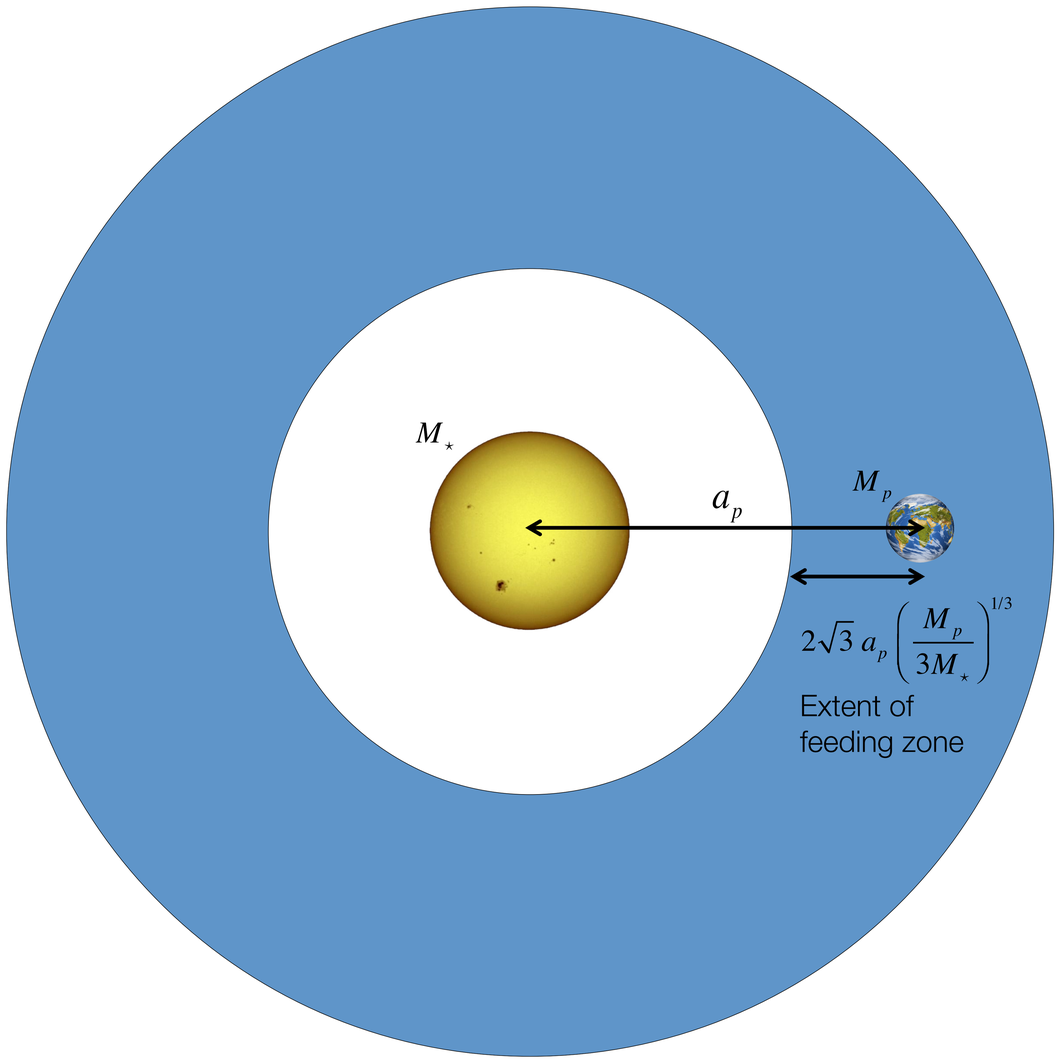
## Proposed Criterion

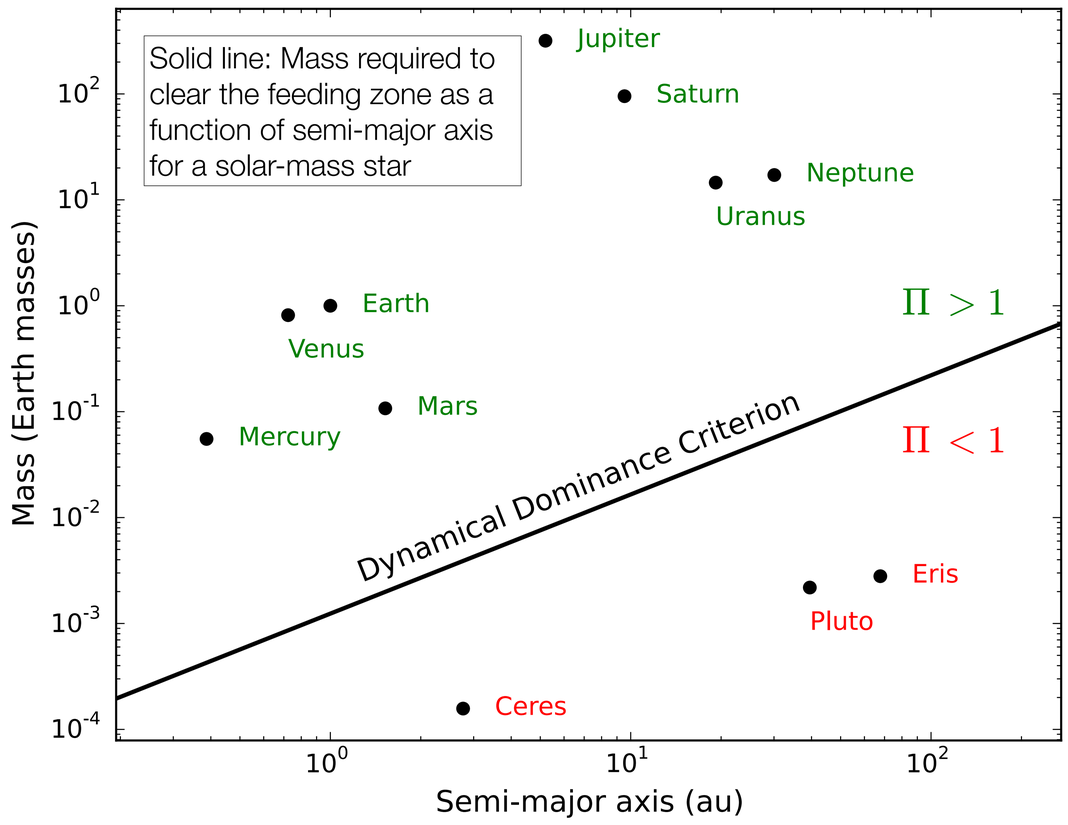
Define orbit-clearing mass $M_{clear}$ and compute $\Pi = M_{planet} / M_{clear}$

Requires only estimates of star mass, planet mass, and orbital period

Can immediately classify 99% of known exoplanets

Can be used to extend and simplify IAU planet definition




## Results

All 8 solar system planets are confirmed as planets.

All classifiable exoplanets are confirmed as planets.

All pulsar planets are confirmed as planets.

Striking disparity between planets and non-planets.

Classification based on 3 observable quantities.

Existing telescopes enable classification.

Newly discovered bodies can be easily classified.

Roundness is not observable nor easily quantifiable.

Roundness is problematic for classification.

All bodies with $\Pi \geq 1$ are round.

Roundness criterion can be discarded.

## Planet Test

Verify whether $\Pi = \dfrac{M_p}{M_{clear}} \geq 1$

## Reference

Margot, J. L.,

Astronomical Journal,

**150**, 2015.

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## Proposed Definition

A planet is a celestial body that

(a) is in orbit around one or more stars or stellar remnants,

(b) has sufficient mass to clear [or dynamically dominate] the neighborhood around its orbit, i.e., $\Pi \geq 1$,

(c) has a mass below 13 Jupiter masses, a nominal value close to the limiting mass for thermonuclear fusion of deuterium.

For single-star systems,

$$\Pi = 807 \left(\frac{M_p}{M_\oplus}\right) \left(\frac{M_\star}{M_\odot}\right)^{-5/2} \left(\frac{a_p}{1\,\mathrm{au}}\right)^{-9/8}$$

where $M$ is mass, $a$ is semi-major axis, and subscripts $p$, ★, ⊕, ⊙, refer to the planet, star, Earth, and Sun, respectively.