Can Pluto be a Planet? – Yes!

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TMATH 342: Applied Topology
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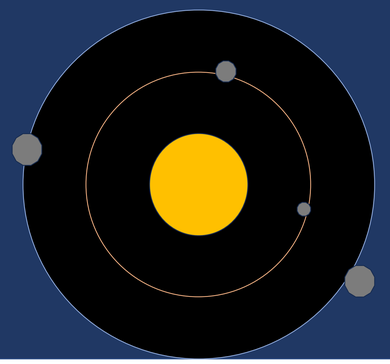


Abstract

What if Pluto was a planet? We reviewed Solar system data to find out whether Pluto and other Solar system objects could be considered planets, and to better categorize the minor objects in the solar system. Under NASA's definition, three main characteristics define planets: The object must orbit the sun, have sufficient mass to have a roughly spherical shape from gravity, and clear its orbital neighborhood. Under this definition, Pluto is not a planet since it is in the Kuiper Belt. However, we believe these objects should be defined based solely on their own physical characteristics: mass, size, shape, and density. After comparing these traits using scatter plots, a trend was discovered between size and mass of objects that could be used to build a new definition of planet. These traits were then compared using a Kepler Mapper algorithm to cluster together similar objects, and what other objects would also have to be considered planets if Pluto was considered a planet under this new definition, resulting in only Eris.

Definitions

> Solar Mass: A measure of mass relative to the sun. A mass of 1 would represent a mass equal to that of the sun.

> Axis Diameter: The diameter of an object as measured along one of three axes. Think length, width & height.

> Unroundness: Used here to measure sphericity. The ratio of the three axis diameters. A number between 0 and 1. Larger number represent less round shape. Not all of our objects had three-axis diameter data, meaning "unroundness" could not always be measured.

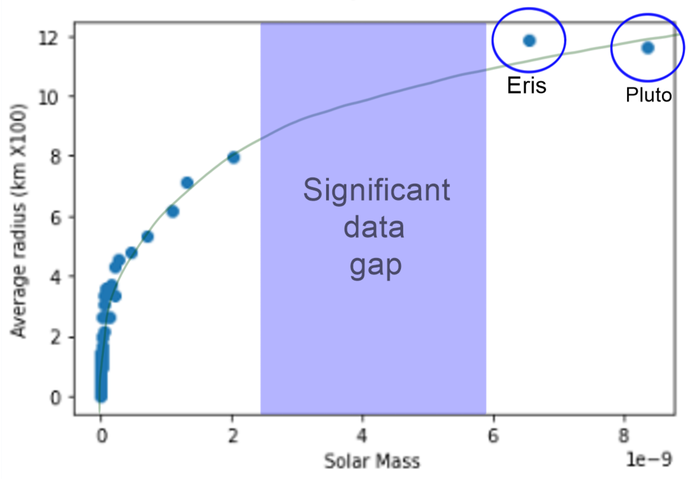
> Sphericity: How close an object is to being a perfect sphere.

> Orbital Neighborhood: A vague term referring to the general area around a planet and its orbital path. As described on the NASA website covering what defines a planet, the actual size of this neighborhood is undefined, making the definition vague.

> Trans-neptunian object: A term defining objects of interest beyond the orbit of Neptune. Includes objects in the Kuiper belt, a dense ring of comets orbiting the sun which contains Pluto and Eris.

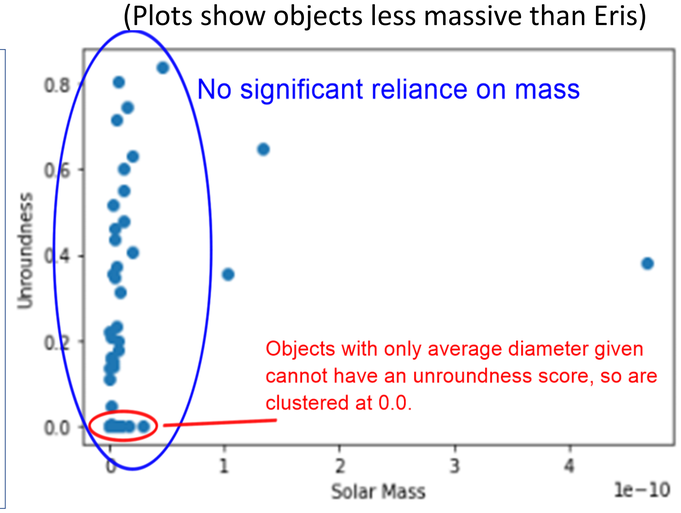
Explanation

Mass separates minor Solar system objects.



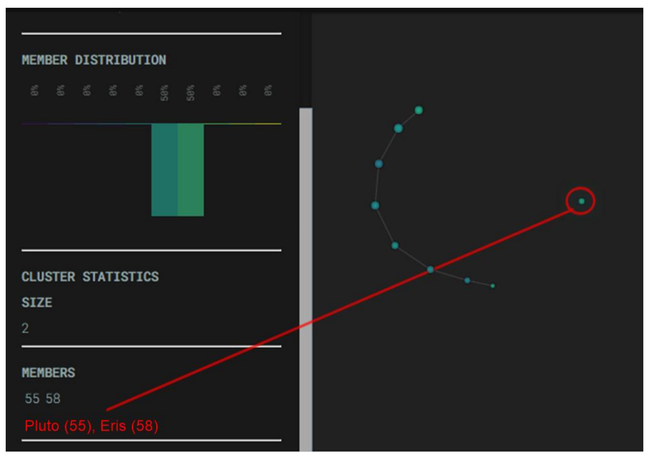
Radius vs. Mass
Among the largest objects in the asteroid belt and Kuiper belt, there exists a very large gap in mass between the smaller objects, and the two largest: Pluto and Eris. This would validate separating the objects into separate categories.

At low mass, other traits become random.
(Plots show objects less massive than Eris)

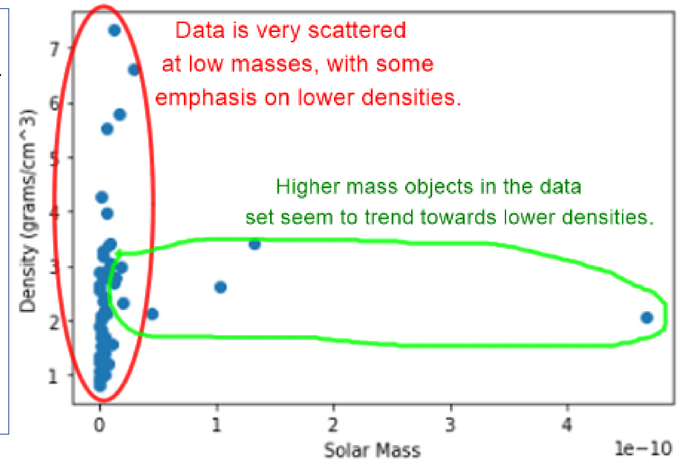


Other characteristics
Both the sphericity and the density of the objects become wild and far more unpredictable for the low mass objects, meaning just because an object is round does not mean it is a planet; it could be too small, meaning it is not round due to its own gravity. Additionally, the density of objects is wilder at low mass, meaning even the larger objects at this mass could have low gravity, and thus not be rounded.

The roundness of an object will be dependent on gravity, and so will the clearness of its neighborhood. Thus, it makes the most sense that out of all the traits, mass would be the single most important to analyze.



Kepler Mapper
The algorithm Kepler Mapper agrees with our visuals, clustering Pluto and Eris together separately from all other objects. This is not only based on mass, but based on density, roundness and size as well.



<u>Mass is the most significant defining trait in the data set.</u>

Conclusions

Making Pluto a planet could only cause one other object to be a planet as well: Eris. Eris and Pluto have very similar characteristics and can reasonably be clustered together, the Kepler Mapper algorithm supports this. Regarding NASA's definition of planet, shape due to "sufficient gravity" and "neighborhood clearing" are dependent on gravity, which is dependent on mass. Thus, it should be possible to define the line between planet and dwarf planet based solely on mass. Based on our analysis, it would be reasonable for the difference between planets and dwarf planets to occur between 3e-9 and 6e-9 solar masses. The line will be drawn depending how you define neighborhood, and how clear you want it to be, but based on physical characteristics, Pluto could be a planet.

Citations

Baer, J., Chesley, S., and Britt, D., Eds. (2020). Asteroid Masses V1.0. urn:nasa:pds:compil.ast.masses::1.0. NASA Planetary Data System; https://doi.org/10.26033/xt8p-wc59.
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