

## Solar System Bodies from the dynamical point of view

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In August 2006 at the General Assembly of International Astronomical Union, Pluto was decided to be not the planet but 'Dwarf Planet.' A planet or a dwarf planet is a celestial body that is in orbit around the Sun (not satellite), and it has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape. The difference between a planet and a dwarf planet is whether it has cleared the neighbourhood around its orbit or not.

There are two points that related to the dynamics of the solar system bodies. One is the definition of satellite. Simply speaking, satellites are celestial bodies that move around an solar system body, which is not the sun. But, of course, it is true that they are also moving around the sun. So the definition of satellite is not as simple as imagined first. We may compare the gravitational force from the sun and the central body of the satellite. But for example, as for our Moon, the gravitational force from the sun is stronger than that from the earth. In this sense, the Moon is under the control of the sun. Then we should say that the Moon is not the satellite of the earth, but this is against to our intuition. On the other hand, there are some asteroids whose orbits are similar to that of the earth (they are sometimes called 'companion asteroids'), and sometimes we can consider that they are moving around the earth. But we do not say that they are the satellites of the earth. Thus the distinction between satellites and non-satellites is ambiguous.

The second point is that 'it has cleared the neighbourhood around its orbit.' This is somewhat misleading because there are such objects like Trojans of Jupiter, which are existing near the orbit of Jupiter. Also as for Neptune, there is the orbit of Pluto near the orbit of Neptune. Here we must take notice of the fact that Trojans or Pluto are in the state of resonance with Jupiter or Neptune, respectively. This indicates that if orbits of celestial bodies are not in special relations such as resonance with planets, they cannot exist stably near the planets. On the contrary, there are a lot of celestial bodies around the orbits of dwarf planets, even though they are not in a special relations with the planets. However, it is true that there are many small objects near the orbits of planets even if they are not in the resonance states. Such objects are unstable in generally and they will change their orbits soon. But we also can say that even for the objects in resonances, they will go out of resonance and change their orbits in future. Thus, it is also a matter of degree.

In summary, we do not have clear distinction between the planet and the dwarf planet from the dynamical point of view. To begin with, there are not clear difference among planets, dwarf planets, asteroids, comets, and satellites. We just call them from the point of principal features. But when we consider such distinction, it is helpful to know their dynamical characteristics.