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"ORBITAL BELT" AS PRECONDITION OF DEFINING "PLANET"

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Introduction

For several thousand years humans were aware of planets. While sitting by the fire, humans were observing the sky and the stars even since prehistory. They noticed that several sparks out of thousands of stars were oddly behaving, moving around the sky across irregular paths. They were named planets.

Definition of the planet at that time was simple and it could have been expressed by following sentence:

Sparkling dot in the sky whose relative position to the other stars is continuously changing following unpredictable paths.

During millenniums and especially upon telescope discovery, human understanding of celestial bodies became deeper and deeper. This also meant that people understood better the space and our Solar system and in this period we have accepted the following definition of the planet:

Round objects orbiting Sun.

Following Ceres and Asteroid Belt discoveries this definition was not suitable any longer, and as a result it was modified. Principally the new definition was:

Round object of substantial size orbiting Sun.

Acceptance of this definition represented the root of today planet definition problems since scientific definitions were not supposed to be consisted out of any arbitrary term that could be differently interpreted. Unfortunately words *substantial size object* are exactly that kind of term. For long time, the prevailing opinion was that Pluto size was an entry level for *substantial size object*.

Recent discoveries of several objects sized between Ceres and Pluto (Orcus, Quaoar, Sedna, 2003 EL_{61} «Santa» and 2005 FY_9 «Easterbunny») as well as one object larger then Pluto (Erida), have wiped out what was once clear border between sizes of round objects orbiting the Sun. Since existing planetary definition was not able to classify clearly weather new objects in the Sun orbit are planets or not, International Astronomical Union IAU[1] has tried to solve the situation by making new planetary definition.

[1] The International Astronomical Union (IAU) was founded in 1919. Its mission is to promote and safeguard the science of astronomy in all its aspects through international cooperation. Its individual members are professional astronomers all over the World, at the Ph.D. level or beyond and active in professional research and education in astronomy. The IAU is composed of 8,858 Individual Members in 85 different countries worldwide out of which 62 are National Members (according to statistics of August 2006). The IAU also serves as the internationally recognized authority for assigning designations to celestial bodies and any surface features on them.

Defining the problem

The IAU on his convention in Prague has just issued a new version of a definition of planets. Definition itself is saying:

A planet is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighborhood around its orbit.

Astronomers themselves are sharply divided on the topic. There are two sides of a problem for each of the confronted groups. Astronomers that voted for the new definition that has expelled Pluto from its planetary status are quoting that if Pluto status would remain intact we will end up with several tens of planets and chaotic understanding of our Solar system.

Astronomers that voted against the definition and for Pluto planetary status were focused on historical reasons but also on the fact that new definition is not applicable since there are only four bodies in Solar system that have really cleared the neighborhood around their orbits: Mercury, Venus, Saturn and Uranus. Besides that, adding new planets to our solar system would create excitement especially at school children and is therefore a source of inspiration for new generations to get involved in space exploration which would eventually one day enable human race to step out of home planet by inhabiting new worlds and thus secure the long time survival of our spieces.

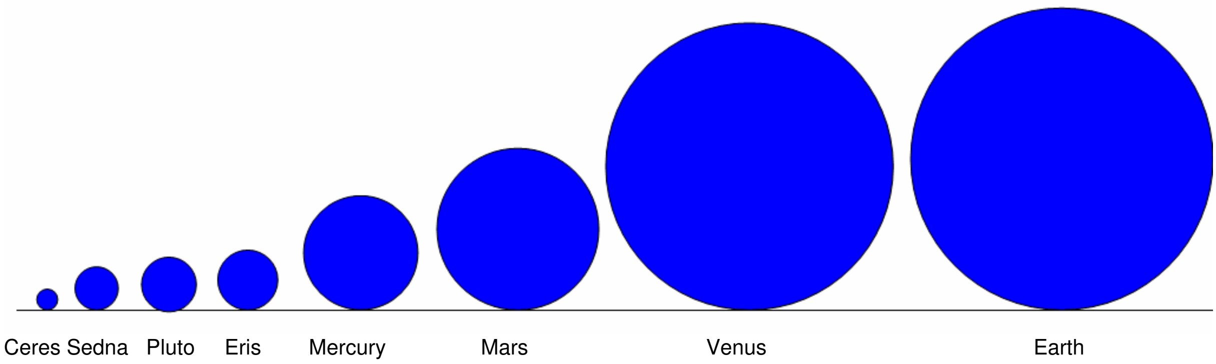
Trying to define planet we always tackle two main topics - size of the objects and their orbits.

Size factor

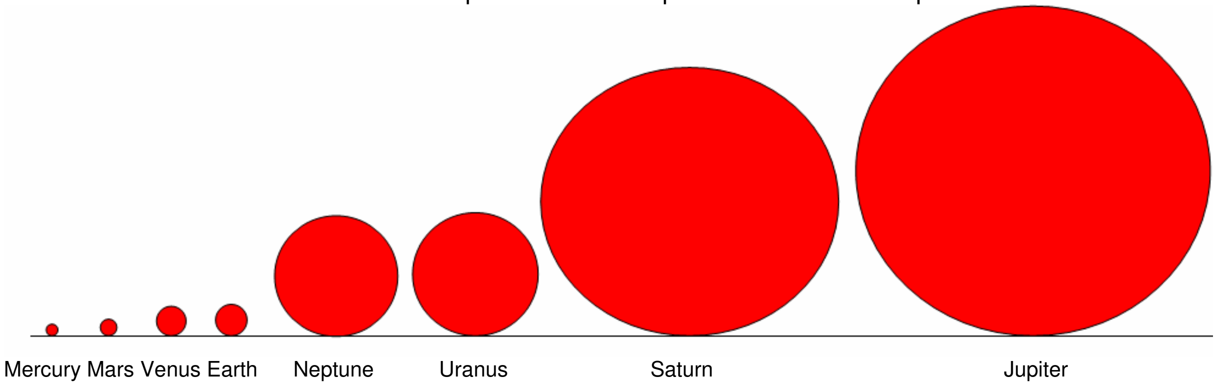
To understand if the size is a relevant planet definition factor we will conduct a comparative analysis of planets within our Solar system. One of the analyses will compare gas and terrestrial planets and the other will compare terrestrial and dwarf planets. It is necessary to note that by definition dwarf planets are not the real planets which mean that terrestrial and gas planets are one group of solar system objects and dwarf planets are the other.

In order to understand better the importance of this factor, relative sizes of the planets are shown on following pictures. *Picture 1* shows us the differences in size between four terrestrial planets and three dwarf planets accompanied by Sedna. *Picture 2* shows us the differences in size between four terrestrial planets and four gas planets.

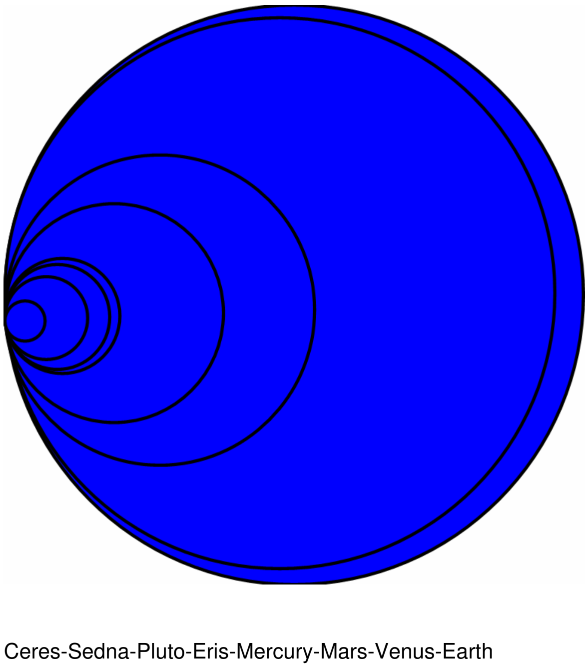
It is even easier to track the size relations between three different groups of Solar system objects on the graphic that is showing the diameters of terrestrial and dwarf planets (+ Sedna) within the diameter of Earth (*Picture 3*) and the diameters of gas and terrestrial planets within the diameter of Jupiter (*Picture 4*).



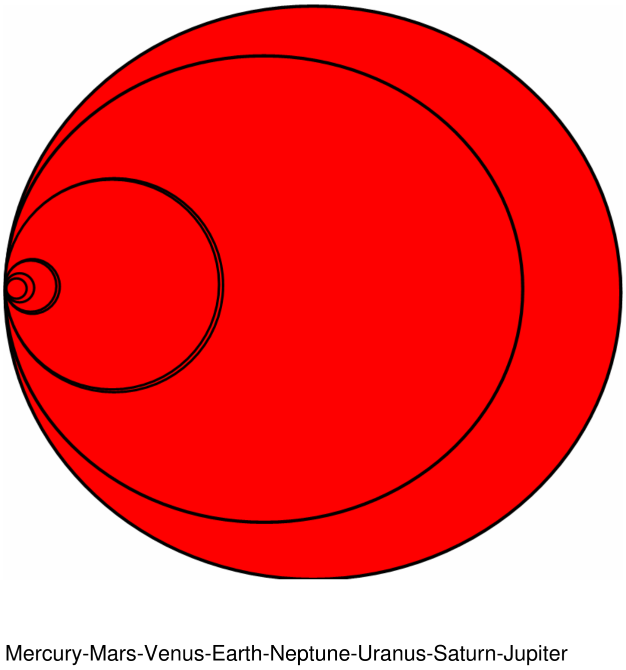
Picture 1: Size comparison of dwarf planets vs. terrestrial planets



Picture 2: Size comparison of terrestrial planets vs. gas planets



Picture 3: Size comparison of dwarf planets vs. terrestrial planets



Picture 4: Size comparison of terrestrial planets vs. gas planets

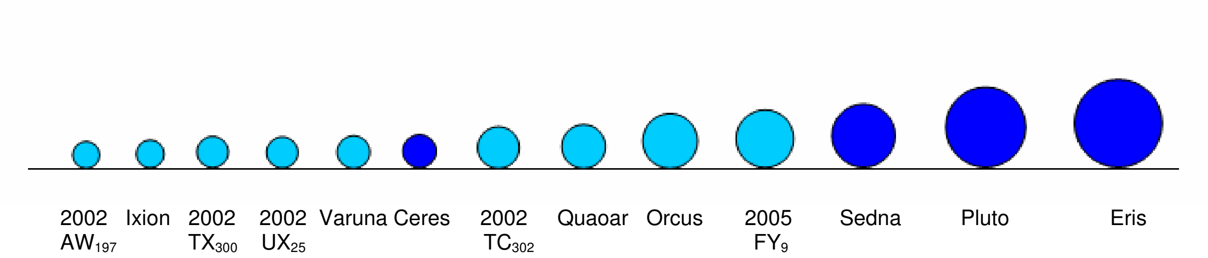
Looking at numbers we can see that size index between the largest dwarf (Eris) and the smallest terrestrial planet (Mercury) is 203 and size index between the largest terrestrial (Earth) and the smallest gas planet (Neptune) is 386.

According to this it is obvious that terrestrial planets are much more similar in size to dwarf planets then to gas planets.

Besides the size terrestrial and dwarf planets are much more alike regarding their constitution and material of which they are made – rocks and ice (water) instead of gas.

This comparative analysis brings us to the conclusion that terrestrial planets are much more alike in size and constitution to dwarf planets - which are not real planets, then to gas planets - that are real planets just like terrestrial planets.

To firther understand the importance of size *Picture 5* is showing relative sizes of dwarf planets and largest planetoids.



Picture 5: Size comparison of dwarf planets vs. large planetoids

We can draw the conclusion that there is no significant difference in size (but also in composition) between dwarf planets and large planetoids.

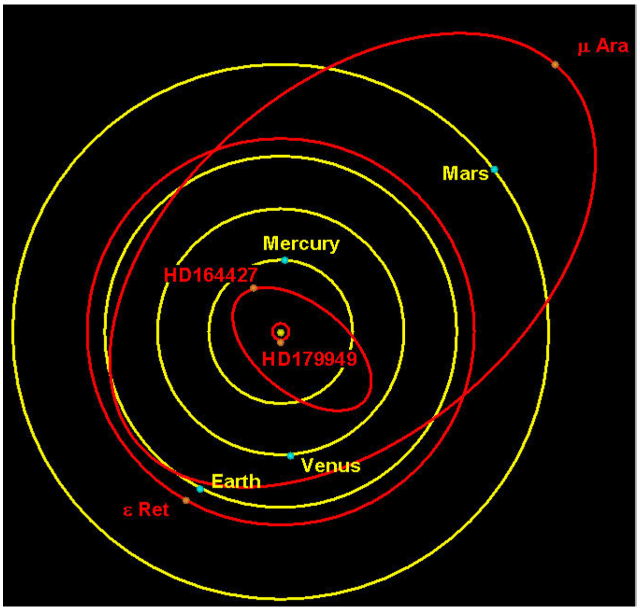
Consequently, the size can not be the planet definition factor.

Eccentricity issue

TNO dwarf planets Pluto and Eris have much more eccentric orbits then regular planets and this is one reason why some astronomers say they are different then other planets and due to this they shouldn't be treated as real planets.

However, although terrestrial and gas planets in Solar system have much less eccentric orbits it is often not the case with extra solar planets. From *Picture 6* we can easily understand that extra solar planets HD164427 and μ Ara have very eccentric orbits. Thus any planet definition that would apply only to Solar system would not be correct since it will not be applicable to the rest of the Universe level.

This also leads to the conclusion that orbit eccentricity can not be the planet definition factor as well.



Picture 6: Extra solar planet orbits vs. Solar system orbits

Planemos and fusors

Direction which can lead us to the solution has roots in the definition of words planemo and fusor. Definition was given by Gibor Basri, Professor of Astronomy at the University of California, Berkeley. Professor Basri is giving following definitions:

- *FUSOR - an object that achieves core fusion during its lifetime.*

- *PLANEMO (**plane**tary **m**ass **o**bject) - a round non fusor.*

These two definitions are very clear and self explaining.

Mr. Basri has proposed also a definition of planet, relaying on these definitions:

- *PLANET – a planemo orbiting a fusor.*

Due to relatively large number of fusor orbiting planemos in Solar system this definition would have brought the number of planets to 25 or even more and this was the main reason why one part of the astronomers was strongly opposing it.

Clear explanation of our Solar system

Due to ongoing discoveries we gather understanding that our Solar system is much more complex then we have realized it so far. We used to believe that Solar system was consisted of nine planets with satellites and an asteroid belt and number of comets. Meantime we have discovered the Kuiper Belt, Scattered Disc, Extended Scattered Disc, transitional area between the Extended Scattered Disc and Inner Oort Cloud, Inner Oort Cloud and an Oort Clod. It made a cacophony in how to present these discoveries to school kids but also to the public. We have lost a simple way how to explain our own Solar system.

Solution to the simple understanding of our Solar system but also to the definition of a planet is to understand that Solar system is made of layers. These layers are:

- terrestrial planets layer,
- Asteroid Belt layer,
- gas (jovian) planets layer,
- Kuiper Belt layer,
- Scattered Disc layer,
- Oort cloud layer

As we try to explain the “new Solar system” more clearly we can further split layers into orbital belts.

Orbital belts are: Asteroid Belt, Kuiper Belt, Scattered Disc and Extended Scattered Disc, Inner Oort Cloud and Oort cloud and planetary belts (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune).

This actually means that the Solar system is consisted of following orbital belts:

- Mercury orbital belt,
- Venus orbital belt,
- Earth orbital belt,
- Mars orbital belt,

- Asteroid Belt,

- Jupiter orbital belt,
- Saturn orbital belt,
- Uranus orbital belt,
- Neptune orbital belt,

- Kuiper Belt,
- Scattered Disc,
- Extended Scattered Disc,
- Inner Oort Cloud,
- Oort Cloud.

The definition of an orbital belt would be:

- *ORBITAL BELT – area around the fusor defined by the orbit of a single planemo or by the orbits of planemo group that are orbiting it.*

- *PLANEMO GROUP – group of planemos with similar orbit.*

Clear examples of a planemo group orbiting Sun are round KBOs. Besides, planemo groups can be found also around some planets:

Jupiter planemo group:	Saturn planemo group:	Uranus planemo group:
- Jupiter	- Saturn	- Uranus
- Io	- Mimas	- Miranda
- Europa	- Enceladus	- Ariel
- Ganymede	- Tethys	- Umbriel
- Callisto	- Dione	- Titania
	- Rhea	- Oberon
	- Titan	
	- Iapetus	

Earth planemo group:	Neptune planemo group:	Pluto planemo group:
- Earth	- Neptune	- Pluto
- Moon	- Triton	- Charon

Here is how specific belts are usually defined:

1. Asteroid belt is region from 2,1 - 3,3 AU;
2. Kuiper Belt is consisted of objects with Perihelion not less then 30 AU and Aphelion not larger then 50 AU (semi major axis ranging from 35 to 50 AU);

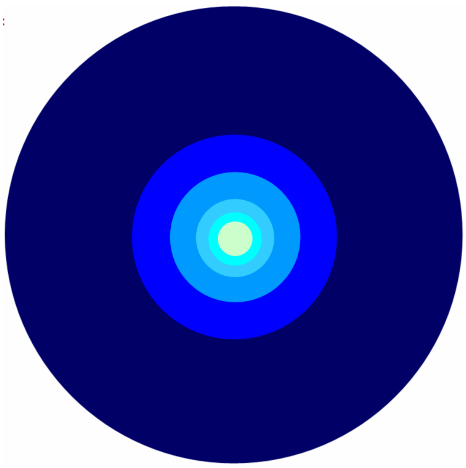
3. Scattered Disc is consisted of objects with Perihelion not less then 35 AU and Aphelion not larger then 100 AU (semi major axis ranging from 50 to 100 AU);
4. Extended Scattered disk object is consisted of objects with Perihelion not less then 45 AU (like 2000 CR_{105}) and Aphelion not larger then 1000 AU (semi major axis ranging from 100 to 1000 AU);
5. Inner Oort Cloud is region from 1.000 AU to 50.000 AU;
6. Oort Cloud is region from 50.000 AU to 100.000 AU.

Border between single planemo orbital belts can be defined as an arithmetic middle of neighboring planets semi major axis.

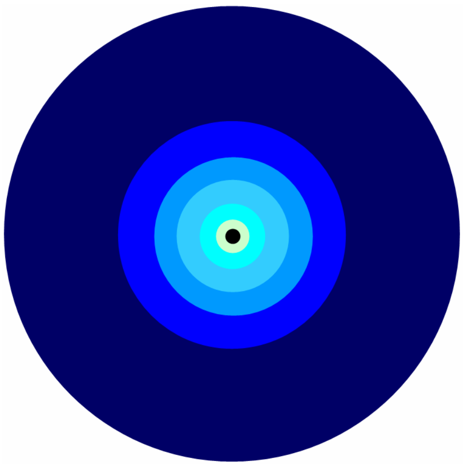
Regarding this orbital belt borders would be:

Mercury and Venus	= (0,39 AU + 0,72 AU) / 2 = 1,11 AU / 2	**= 0,56 AU**
Venus and Earth	= (0,72 AU + 1,0 AU) / 2 = 1,72 AU / 2	**= 0,86 AU**
Earth and Mars	= (1,0 AU +1,52 AU) / 2 = 2,52 AU / 2	**= 1,26 AU**
Mars and Asteroid Belt	= Asteroid Belt inner border	**= 2,10 AU**
Asteroid Belt and Jupiter	= Asteroid Belt outer border	**= 3,30 AU**
Jupiter and Saturn	= (5,20 AU + 9,54 AU) / 2 = 14,74 AU / 2	**= 7,37 AU**
Saturn and Uranus	= (9,54 AU + 19,19 AU) / 2 = 28,73 AU / 2	**= 14,37 AU**
Uranus and Neptune	= (19,19 AU + 30,07 AU) / 2 = 49,26 AU / 2	**= 24,63 AU**
Neptune and Kuiper Belt	= KBOs semi major axis inner border	**= 35,00 AU**
Kuiper Belt and Scattered Disc	= Kuiper belt outer border	**= 50,00 AU**
Scattered Disc and Extended Scattered Disc	= Scattered Disc outer border	**= 100 AU**
Extended Scattered Disc and Inner Oort Cloud	= Extended Scattered Disc outer border	**=1.000 AU**
Inner Oort Cloud and Oort Cloud	= Oort Cloud inner border	**= 50.000 AU**
Oort Cloud	= Oort Cloud outer border	**= 100.000 AU**

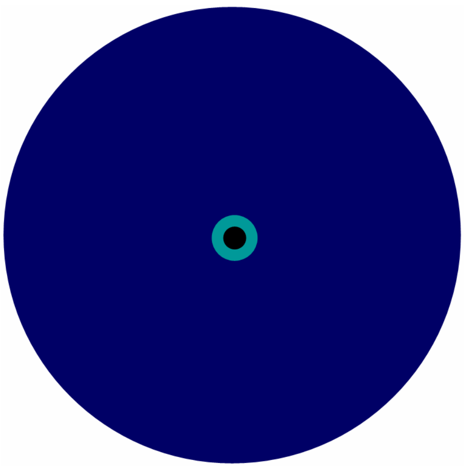
Solar system orbital belts are visible on Pictures 7, 8 and 9.



Picture 7: Orbital belts: Mercury, Venus, Earth, Mars, Asteroid Belt, Jupiter



Picture 8: Orbital belts: Jupiter, Saturn, Uranus, Neptune Kuiper Belt, Scattered Disc



Picture 9: Orbital belts: Scattered Disc, Extended Scattered Disc

Planet definition

Understanding solar system as a set of layers and belts enables us to achieve the definition of a planet.

- *PLANET – a planemo orbiting a fusor and representing a dominant – largest object of the respective orbital belt.*

This definition enables us to have more planets then today but is also controlling their maximum number. This makes Solar system easier to explain and understand but also very exciting to learn by the school kids.

We can therefore define new class of planets:

- *BELT PLANET – planet with mass not larger then sum of all other belt objects masses.*

Belt planet is usually part of the belt that contains other smaller planemos or large asteroids (+ 100 km) and this is also the reason for its name.
Belt planets can also be called **proto planets** since they represent the undeveloped nucleuses of terrestrial planets. Other name that can be used is the existing term of a **dwarf planet** but in a different meaning.

This actually means that we would have three equally important planet groups: terrestrial planets, gas or jovian planets and belt or proto or dwarf planets.
Another two definitions that are necessary to describe our solar system are:

- *PLANETOID – non dominant planemo orbiting a fusor.*

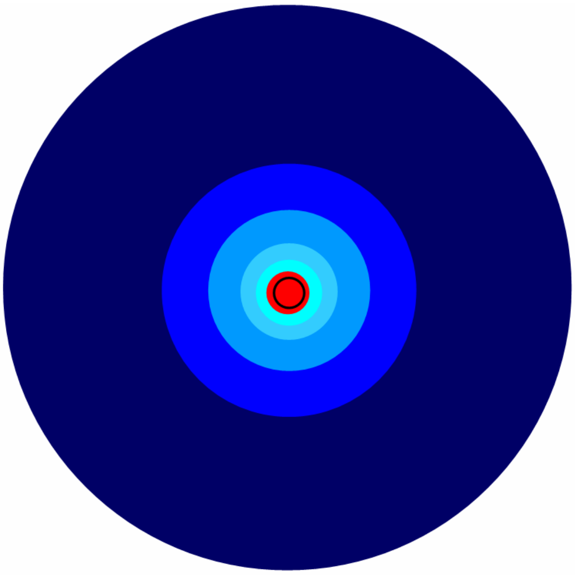
- *ASTEROID – irregular non fusor orbiting a fusor.*

As a consequence to this definition our Solar system would have following planets:

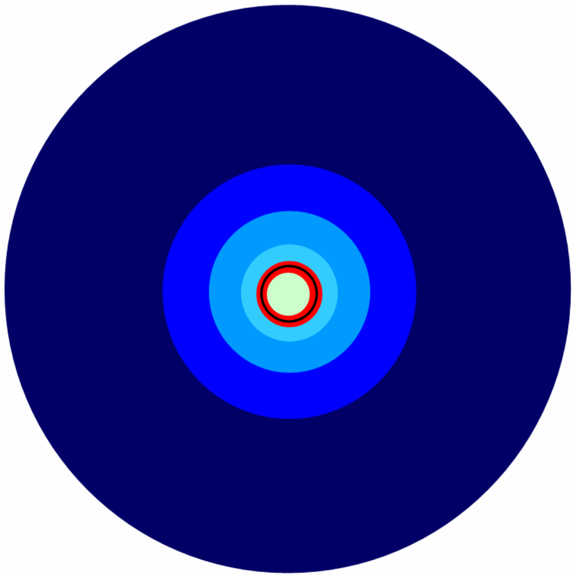
Mercury		Terrestrial planet
Venus		Terrestrial planet
Earth		Terrestrial planet
Mars		Terrestrial planet
Ceres	Asteroid Belt dominant object	Belt planet, proto planet, dwarf planet
Jupiter		Gas planet
Saturn		Gas planet
Uranus		Gas planet
Neptune		Gas planet
Pluto	Kuiper Belt dominant object	Belt planet, proto planet, dwarf planet
Eris	Scattered Disc dominant object	Belt planet, proto planet, dwarf planet
Sedna	Extended Scattered Disc dominant object	Belt planet, proto planet, dwarf planet

Once the relevant discoveries will occur also the Inner Oort Cloud and Oort Cloud could provide planets. In case that larger objects would be discovered within their relevant orbital belts status of Eris and Sedna could be changed from Planet to Planetoid.

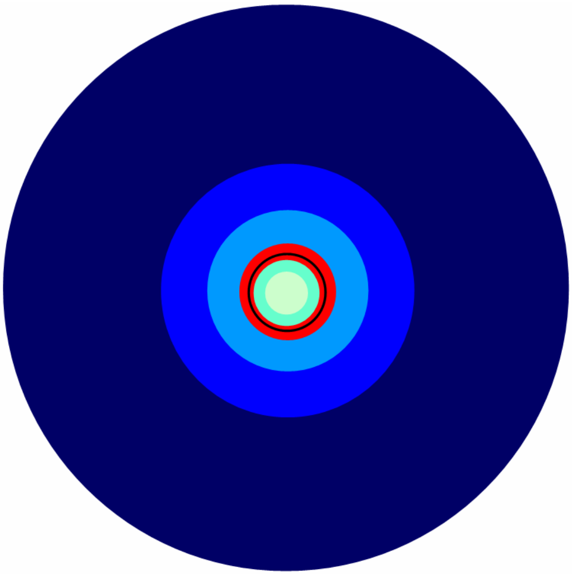
Pictures 10 to *21* are showing the planetary orbits within their respective orbital belts



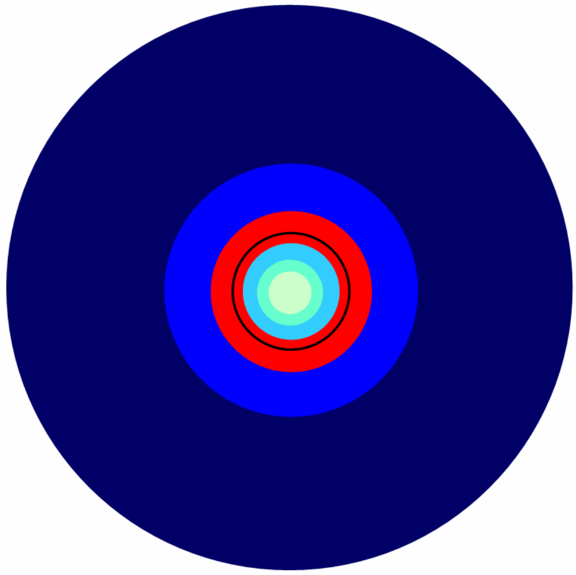
Picture 10: Mercury belt and orbit



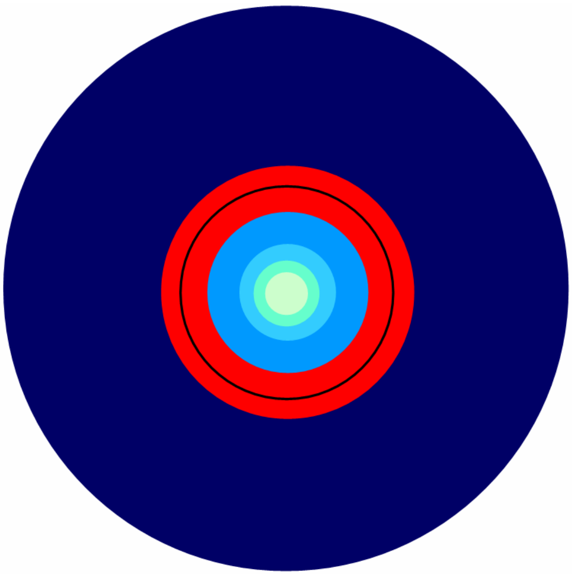
Picture 11: Venus belt and orbit



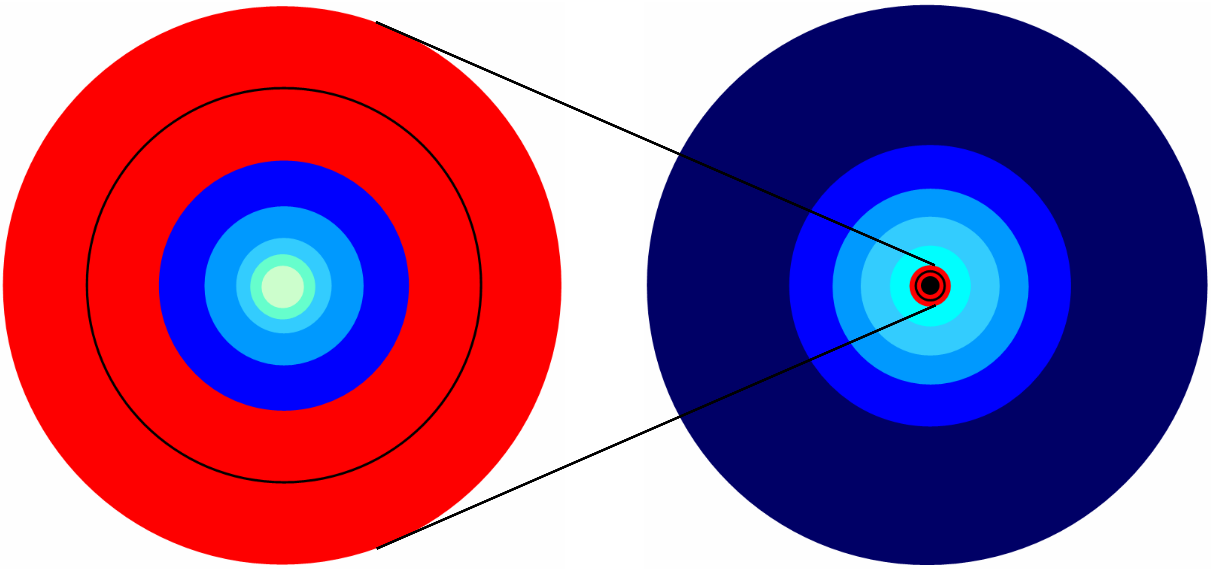
Picture 12: Earth belt and orbit



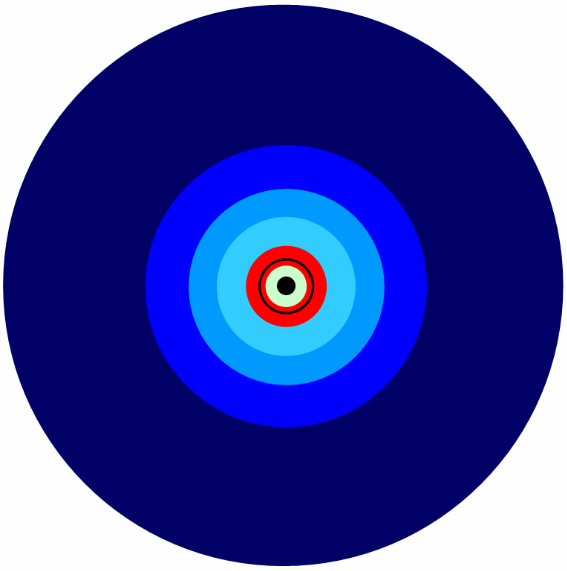
Picture 13: Mars belt and orbit



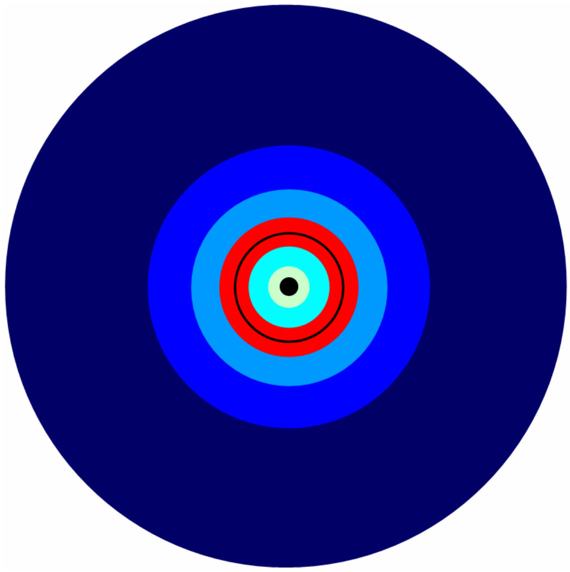
Picture 14: Ceres orbit and Asteroid Belt



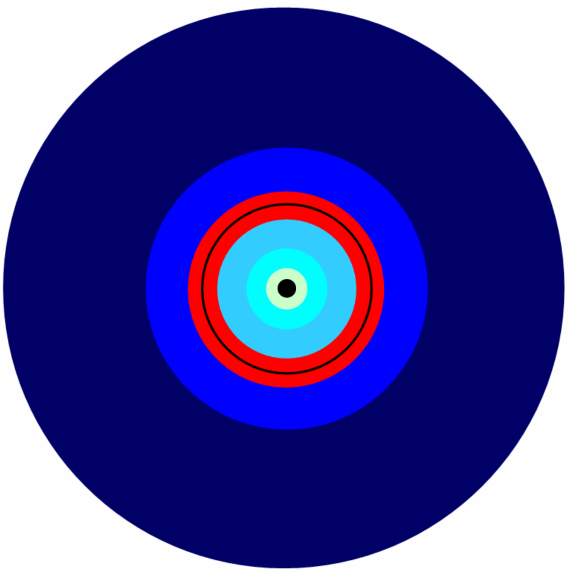
Picture 15: Jupiter belt and orbit compared to inner and to outer Solar system orbital belts



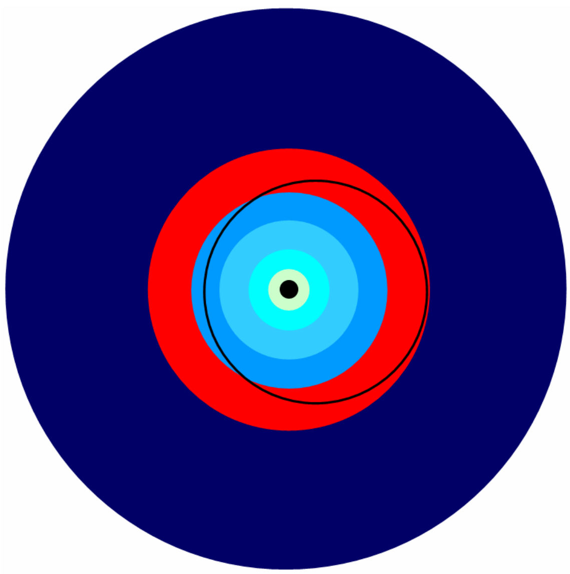
Picture 16: Saturn belt and orbit



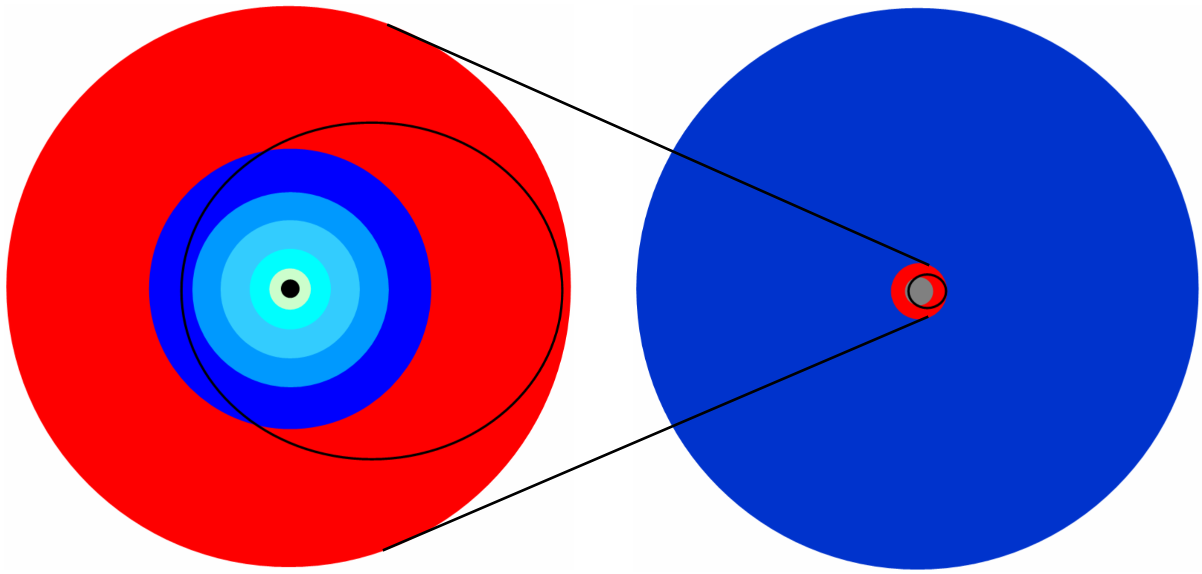
Picture 17: Uranus belt and orbit



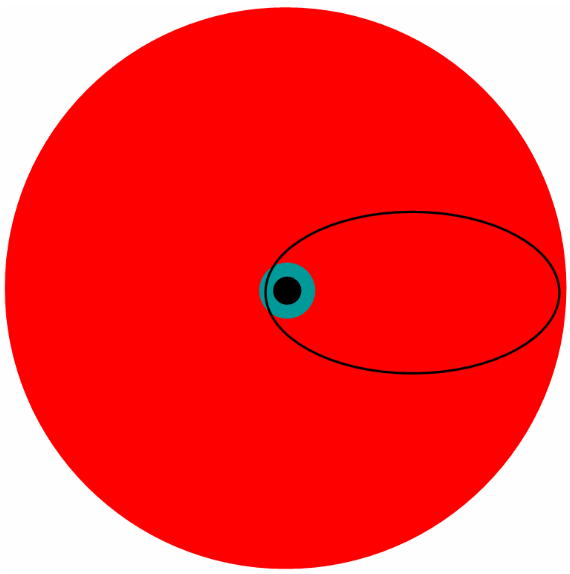
Picture 18: Neptune belt and orbit



Picture 19: Pluto orbit and Kuiper Belt



Picture 20: Eris orbit and Scattered Disc compared to Kuiper Belt and to Extended Scattered Disc



Picture 21: Sedna orbit and Extended Scattered Disc belt

It is visible from the pictures that outer planets like Pluto, Eris and Sedna tend to partially enter inner neighboring belt area. However since majority of their orbit as well as their semi major axis lies within their home belt they are classified as Kuiper Belt, Scattered Disc and Extended Scattered Disc objects.

Free floating planets

Another issue is represented through free floating planets that are not in the orbit of any star.

However even free floating planets are orbiting the centre of galaxy - just like the stars are doing. Since the galaxy center is the location of a massive black hole it actually means that the free floating planet is orbiting huge massive black hole in the center of the galaxy.

Possible explanations for the galaxy center black hole creation include the merger of stars to form a hyperstar that collapsed, or growth of a black hole through mergers with other nearby black holes and neutron stars.[2]

In both cases it means that even a free floating planet is a planemo orbiting a fusor.

Thus the issue of how to define free floating planet vs. star orbiting planet does not exist. It is enough to consider free floating planets as galactic planets in comparison to ordinary planets orbiting the stars.

According to this galactic planet definition is:

Planemo orbiting fusor that is centre of its galaxy.

This means that joint definition “planemo orbiting fusor” can describe:

1. Planetoids *(nondominant planemo orbiting fusor)*;
2. Planets *(dominant planemo orbiting fusor)*;
3. Galactic planets *(planemo orbiting fusor that is centre of its galaxy)*.

[2] http://chandra.harvard.edu/press/00_releases/press_091200.html

Conclusion

According to this paper we can make the conclusion that Solar system is consisted out of orbital belts and out of objects such as planets and planetoids with moons, asteroids and comets. (Although in this paper we have not tackled the comet definition, due to the long tail it creates while passing near the Sun, its definition is simple. Besides, since comets' orbits are passing through more then two orbital belts we can accept them as a sort of transbelts objects).

Orbital belt term introduction enables clarification by defining a planet as dominant object within its respective orbital belt, as a sort of its orbital belt guardian.

Acceptance of the new definition of planetary belt, planet and planetoid will again provide a clear planetary nomenclature since current practice of deciding on planetary status of Solar system objects by vote is not only scientific but also a sort of political act.

The new perspective on Solar system is at the same time

- a foundation for defining and understanding of planetary systems around other stars but Sun;
- a ground on which to relay our understanding of discoveries yet to come.

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- NASA: Orbit Diagrams: Asteroid (2003 UB313) (http://neo.jpl.nasa.gov/cgi-bin/db_shm?sstr=2003+UB313&group=all&search=Search)
- NASA: Orbit Diagrams: Asteroid 90377 Sedna (2003 VB12) (http://neo.jpl.nasa.gov/cgi-bin/db_shm?sstr=Sedna)
- IAU: The IAU draft definition of "planet" and "plutons" (http://www.iau2006.org/mirror/www.iau.org/iau0601/iau0601_release.html)

Curriculum Vitae

DoB: January 7th, 1968

Education:

1986: "Ćiro Gamulin" High School, Split – “Mathematics and information technologies”
1992. University of Economics Zagreb – Bachelors degree in "Foreign Trade"
1998. - 2002. various specialized courses sponsored by Procter & Gamble
1998. - present – University of Economics Zagreb
– post graduate study in "Organization and Management"

Work experience:

1992. - 1993. Paškić Trade, Split, Croatia, *Owner*
1994. - 1995. Bradek, Padova, Italy, *Consultant*
1996. - 1997. Impala, Split, Croatia, *Director*
1998. - 2001. Procter & Gamble Croatia, Zagreb, Croatia,
Area account manager, Key account manager
2001. - 2002. Procter & Gamble Hungary, Budapest, Hungary,
Key account manager, Unit sales manager
2002. - 2003. Zagrebačke pekarne Klara, Zagreb, Croatia,
General Manager (www.klara.hr)
2003. - 2005. Croatia baterije, Zagreb, Croatia
President of the Management Bord (www.croatia-baterije.hr)
2005. - 2006. Orca technologies, Samobor, Croatia
CEO and founder (www.orca-technologies.com)

Languages:

Native:	Croatian
Fluent:	English, Italian, Macedonian
Proficient:	French

Other:

1985 - “The shortest SF Story in the World” (Najkraća SF priča na svijetu) published in the best selling Yugoslavian SF magazine Sirius: - “They are coming...” (Dolaze...)

1997: - Solution against the snow freezing in tyre notches was offered as an example for creative thinking and problem solving during recruitment process for P&G

2002: - Solution against major A1 Croatian highway bridge (Maslenica) often closing due to strong winds presented directly to the Croatian prime minister competing with Governmental institute project

2003: - Patent application of the Mobile phone with simplified calling procedure targeting kids in the age from 6 to 9.

2004. – 2005:
- Supersonic transport status and its potential development study
- Ekranoplans (wing-in-ground) opportunities study
- Space tourism: alternative approach study