

# The **ASTERISM**

as' ter ism ~ a recognizable pattern of stars  
con stel la' tion ~ an internationally designated area of the sky

Volume XX No. 2

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## Is Pluto A Planet?

Opposing views by Mike Luciuk and Laurel Kornfeld

What's Inside...

[Luciuk's Pluto](#) Pg2  
(continued)

[Kornfeld's Pluto](#) Pg 5  
(continued)

[General Meeting](#) Pg 4

[Stewart's Skybox](#) Pg 8

[Contacts](#) Pg 11

[Theater in the Sky](#) Pg 12

Note: Use bookmark  
panel in Adobe Reader.



### Mike Luciuk's position

Here's the question before us, "**Should Pluto be classified as a planet without qualification?**" My answer is, "Yes, but." This article will discuss why Pluto is in a different astronomical class than the eight major planets.

### Some Historical Background

In the ancient era of geocentric astronomy, people saw seven bodies

Cont'd page 2 **Luciuk's Pluto**

### Laurel Kornfeld's Position

#### **Pluto—and the Dwarf Planets—Are Planets**

The 2005 discovery of Eris, the first Kuiper Belt Object larger than Pluto, set off a controversy in the astronomy community, with many scientists urging the need to define the term planet for the first time.

The urgency to quickly coin a definition and the subsequent demotion

Cont'd page 5 **Kornfeld's Pluto**

## Luciuk's Pluto (continued from page 1)

that moved in the sky, the Sun, Moon, and the five naked-eye planets. All **seven** were considered planets or "wanderers." Copernican heliocentrism and Galileo then established that Earth was also a planet but the Sun and Moon were not, for a total of **six** planets. Next, the telescope revealed Uranus to William Herschel in 1781, resulting in **seven** planets. Later, asteroids Vesta, Juno, Ceres, and Pallas, (listed by orbital distance rather than date of discovery, which ranged from 1801-1807) were called planets well into the middle of the 19<sup>th</sup> century. They were the 5<sup>th</sup>, 6<sup>th</sup>, 7<sup>th</sup>, and 8<sup>th</sup> with Jupiter, Saturn, and Uranus moving to the 9<sup>th</sup>, 10<sup>th</sup>, and 11<sup>th</sup> spots. Astronomy publications and textbooks for nearly half a century referred to "**eleven primary planets**" of the solar system. As more asteroids were found by mid-century, astronomers realized there was a zone of numerous small bodies residing between the orbits of Mars and Jupiter, of which Vesta, Juno, Ceres, and Pallas were members. Their planet designations were dropped and they were called asteroids. Finally, Adams and Le Verrier used perturbations in Uranus' orbit to predict Neptune's position and the **eighth** planet was sighted in 1846.

Percival Lowell predicted the existence of "Planet X" based on perceived but non-existent Neptune and Uranus residuals, resulting in Tombaugh's serendipitous discovery of Pluto in 1930. Its predicted mass was 6.6x that of Earth, an over-estimate by a factor of 3,000x. After its discovery, many astronomers expressed reservations of Pluto's planetary designation, especially as calculations revealed its true mass. These include solar system experts like Fred Whipple (1964, "a large comet"), Brian Marsden (1980, "[drop] the appellation of 'ninth planet'"), Julio Fernandez (1991, "large planetesimal") "and Dave Jewett (1996, "changes its status from that of 'smallest planet' to 'largest known Kuiper Belt object'"). Ever since its discovery, Pluto's 'ninth planet' designation never had total astronomer acceptance.

In 2000, S. Alan Stern, the pre-eminent Pluto expert, co-authored a paper with H. F. Levison addressing dynamical aspects of planets (see [http://www.boulder.swri.edu/~hal/planet\\_def.html](http://www.boulder.swri.edu/~hal/planet_def.html)):

- Because such smaller bodies [KBOs] clearly play a dynamically different role in the solar system than the large bodies that architecturally shape the system, *distinguishing between the bodies on some dynamical basis is both useful and desirable* [my italics].
- Hence, we define an *überplanet* [higher-planet] as a planetary body in orbit about a star that is dynamically important enough to have cleared its neighboring planetesimals in a Hubble time. And we define an *unterplanet* [under-planet] as one that has not been able to do so.
- From a dynamical standpoint, our solar system clearly contains 8 *überplanets* and a far larger number of *unterplanets*, the largest of which are Pluto and Ceres,

Dr. Stern's paper confirmed that dynamical factors place Pluto and Ceres in a different classification than the eight major planets, and that these factors are a "useful and desirable" distinguishing tool.

It was 62 years after Pluto's discovery that the next trans-Neptunian object, 1992QB<sub>1</sub> was found. Much effort has now gone into investigating the distant reaches beyond Neptune. Astronomers have learned that the zone where Pluto resides, the Kuiper Belt, is populated with thousands of planetesimals. In 2003 Mike Brown *et al* discovered Sedna, smaller than Pluto, and then found Eris, slightly larger. These two findings once again raised serious questions on the status of Pluto as a planet, since the Kuiper Belt contained a number of bodies with masses comparable to Pluto. The IAU met in 2006 and voted that Pluto no longer be classified as a planet.

***Throughout history, as our knowledge of the solar system has increased, so have our definitions of planets changed. Pluto is surrounded by thousands of similar Kuiper Belt bodies, analogous to Ceres' position in the asteroid belt. The IAU astronomers recognizing that Pluto was very different from the eight major planets, created a new classification, "dwarf planet." However, the IAU decided that "dwarf planets were not planets.*** Later in this article, I'll question the IAU decision of dwarf planets not being planets.

## The International Astronomical Union (IAU) Decision

This body was formed in 1919 and is made up of almost 10,000 astronomers from 86 countries. One of its tasks is to assign designations of celestial bodies. The Working Group for Planetary System Nomenclature (WGPSN) has this mission for planets and the outer solar system. It's important in science to have an organization like the IAU to standardize definitions and naming conventions, otherwise, communication among astronomers and between the astronomical community and the public suffers.

On August 24, 2006 at IAU's XXVI General Assembly, a vote was taken on the definition of a *solar system* planet. The following was agreed upon by a very large majority of the participants

[http://www.iau.org/public\\_press/news/release/iau0603/](http://www.iau.org/public_press/news/release/iau0603/) :

The IAU members gathered at the 2006 General Assembly agreed that a "planet" is defined as 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 neighbourhood around its orbit.

It was agreed that "planets" and "dwarf planets" are two distinct classes of objects. The first members of the "dwarf planet" category are Ceres, Pluto and 2003 UB<sub>313</sub> (temporary name) [Eris].

This was a hurried, poorly organized voting session. Only 4% of total IAU members voted, but the 424 astronomers that did vote represented 17% of the Prague attendees. This demonstrated significant interest in the outcome of the decision, given that planet definition is a relatively minor area of astronomy. Since the "Planetary Systems Sciences" sessions were held the previous day, it was not inconvenient for planetary experts to participate in the voting. The attendees were not all planetary specialists, but they were all astronomers. The vote was overwhelmingly in favor of Pluto being designated a "dwarf planet" and not a "planet."

***Thus, Pluto was denied planetary status because its orbital neighborhood is surrounded by numerous "uncleared" KBOs. The lack of a "clearing" capability is an indication that Pluto wasn't a gravitationally dominant Kuiper Belt body, just one of many similar size objects which have been discovered comparatively recently.***

## Differences between Pluto and the Major Planets

- Pluto has less than 1/5 Moon's mass and only 4% of the smallest planet Mercury's mass. ***Without gravitational dominance, Pluto cannot clear its orbital zone, and hasn't differentiated itself from its Kuiper Belt neighbors.***
- Pluto's large 25.4% orbital eccentricity creates a 29.7 AU perihelion and a 49.9 AU aphelion. Pluto is closer to the Sun than Neptune for 20 of its 248-year orbit. ***No major planet's orbit intersects that of an adjacent planet; only lesser bodies do that.***
- Pluto's orbit is governed by Neptune's gravity forcing two solar orbits for three of Neptune. Hundreds of Pluto's neighboring KBOs participate in this 2:3 resonance. ***Their orbits are under Neptune's control.***
- Pluto's (2.05 g/cm<sup>3</sup>) density is almost half that of Mars (3.9 g/cm<sup>3</sup>), the least dense of the rocky planets. A significant percentage of Pluto's mass consists of N<sub>2</sub>, CH<sub>4</sub>, and CO ices, which explains the low density. ***Pluto would develop a tail from ice sublimation if it was at Mars' distance, and we would regard it as a spectacular comet.***

***So, except for having a round shape and solar orbit, Pluto is different from the eight planets. Its orbit intersects with and is controlled by Neptune. Since it has insufficient mass to gravitationally dominate its Kuiper Belt area, except for size, Pluto has no distinguishing features from its frozen neighbors.***

On the other hand, there are a number of similarities with planets. Pluto is in hydrostatic equilibrium, which means it has a differentiated structure. Pluto also has an atmosphere. Except for size, it has many attributes of the eight major planets.

## Future IAU Activity

The phrase, "has cleared the neighborhood around its orbit" should be replaced by "has achieved gravitational dominance". Some critics use this IAU's ill-chosen wording of planet definition to claim that a planet with Trojan asteroids like Jupiter has not cleared the neighborhood around its orbit. However, it's obvious that the eight major planets' gravitational forces dominate their orbital areas, so the IAU intent holds.

The IAU should change the word dwarf in “dwarf planet” from a noun to an adjective. Ceres, Pluto, Haumea, Makemake, and Eris are small, but real planets. The four trans-Neptunian dwarf planets, Pluto, Haumea, Makemake, and Eris are now called plutoids. Why this extra designation was created is unclear. The IAU should address these areas of confusion in upcoming sessions. Also, as our knowledge of other stellar systems grows, the IAU should develop an exo-planet definition.

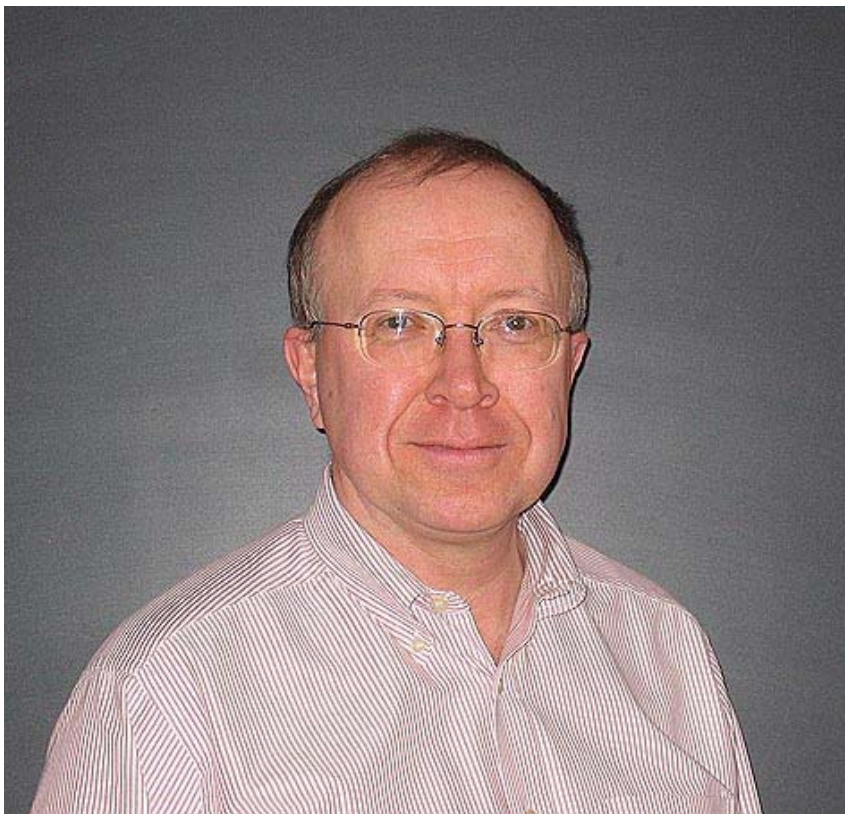
It’s difficult to accept IAU’s implied position that a planet like Mars, located near the Sun, should not be considered a planet if it was located beyond Neptune. It’s the same physical body, even though it no longer would have gravitational dominance. ***The solar system has two planet classes, eight major planets with gravitational dominance of their orbital zones and five dwarf (small) planets that do not. All thirteen are in hydrostatic equilibrium and are structurally differentiated. They are all planets, in two different dynamical classes.***

***Clyde Tombaugh did something very important. He discovered Pluto, the first Kuiper Belt object. It’s also the second dwarf (small) planet, the tenth planet from the Sun. He added significantly to our knowledge of the solar system.***



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## GENERAL MEMBERSHIP MEETING OCTOBER 17, 2008



**Dr. Scott Tremaine, Princeton University**

### **“New Worlds: The Search for Planets Outside the Solar System”**

For thousands of years, humankind has speculated on the existence of planets and life beyond the solar system, but, until recently, astronomers have had only our own planetary system to study. Everything changed in 1995, with the announcement of the first convincing evidence for another planet. Since then, over 300 extrasolar planets have been found, and many more are likely to be discovered. Dr. Tremaine will review what we know so far and hope to learn about planets around other stars. Raised in Toronto, he has held faculty positions at MIT, the University of Toronto, and Princeton University. He is currently the Richard Black Professor of Astrophysics at the Institute for Advanced Study in Princeton.

**8 pm In The MAIN LECTURE HALL**

## Kornfeld's Pluto (continued from page 1)

of Pluto to “dwarf planet” by four percent of the International Astronomical Union (IAU) led to the exact opposite result as that intended by those seeking a concise planet definition. Instead of clarifying what makes an object a planet, the IAU decision muddied the waters with a vague and unusable definition that confused the public and caused a serious rift among astronomers.

The first mistake was the attempt to define the term “planet” in an overly narrow way. “Planet” never was a scientific term. Meaning “wanderer,” it was originally used by the ancient Greeks to refer to those objects that appeared to move randomly in the sky in contrast to the “fixed” stars. The Sun and Moon were among the seven objects labeled planets.

With the 17<sup>th</sup> century acceptance that the Sun rather than the Earth is the center of the solar system, the definition of planet was changed to mean an object orbiting the Sun.

Ceres and several other objects in the asteroid belt were discovered in the early 19<sup>th</sup> century and were originally considered planets until astronomers discovered they orbited in a belt of many objects. They were then demoted to a new category, the asteroids.

However, what 19<sup>th</sup> century astronomers did not realize is that Ceres, unlike its companions in the asteroid belt, has a significant characteristic that other asteroids don't have. Unlike those objects, Ceres is in hydrostatic equilibrium, meaning it has enough self-gravity to have pulled itself into a round shape.

Roundness is a central quality the average person thinks of when considering the concept of planet. It turns out that the state of hydrostatic equilibrium, which makes an object round or oblate, is the one and only feature that unites a very diverse number of objects, both in this solar system and others, under the umbrella of “planets.”

Objects in hydrostatic equilibrium have geological and geophysical activity such as plate tectonics and volcanism, which inert, shapeless asteroids do not have. This is why Ceres and Pluto, both of which are known to be in hydrostatic equilibrium, cannot accurately be classified in the same category as asteroids and non-round Kuiper Belt Objects.

### The IAU definition

The IAU definition sets three requirements for an object to be considered a planet. It must be round and not a star itself, must be in hydrostatic equilibrium, and must “clear the neighborhood of its orbit”. That last requirement excludes Ceres, Pluto, and any other round objects that orbit in belts since these smaller objects do not clear out the other objects in their belts by capturing them as moons or flinging them away by force of gravity.

But the IAU definition is problematic for multiple reasons. The concept of “clearing the neighborhood of its orbit” is extremely vague. Jupiter and Earth do not clear their orbits of nearby asteroids, and Neptune does not clear its orbit of Pluto. If this provision is applied strictly, it could potentially exclude all the “classical planets,” leaving our solar system with a planet count of zero!

In all likelihood, the IAU intended its definition to mean that the objects in question dominate their orbits. Such a requirement works, but only in distinguishing between gravitationally dominant bodies and a second subclass of smaller planets whose physical composition makes them akin to the “big eight” but whose small size means they orbit alongside a belt of smaller asteroids.

Unlike its eight larger companions, Pluto does not have sufficient mass to dominate the region in which it is located. This is why, like Ceres, it orbits among a belt of objects. The IAU likely intended in its definition to distinguish between those objects that dominate their orbits and those that do not. Dr. Alan Stern and Dr. Hal Levison proposed exactly such a distinction in an article they published in 2000.

However, Stern and Levison, in distinguishing between two classes of planets, one type gravitationally dominant and the other not, never intended for the latter to be precluded from being considered planets at all. This is where the IAU erred. By specifically stating that dwarf planets are not planets, the IAU definition is flawed because it classifies objects solely by where they are while ignoring what they are.

Notably, the IAU decision was made by a vote of four percent of the group's 10,000 members. No absentee or electronic voting was allowed, meaning anyone not in the room in Prague on the day of the vote had no say in the matter. That excluded some of the world's most prominent planetary scientists, such as Dr. Alan Stern, Principal Investigator of New Horizons and a leading authority in the world on Pluto and the Kuiper Belt. It also excluded many planetary scientists who are not members of the IAU.

The vote reflected a sharp division between two camps of astronomers—dynamicists, who study orbits, and planetary scientists, who study objects' physical properties. Dynamicists succeeded in promoting a solely dynamical definition in Prague, a definition that is scientifically untenable because it takes into account only **where** an object is and not **what** an object is. This creates potentially absurd situations. For example, if a Mars-sized object is discovered in the Kuiper Belt, it would not be considered a planet while the real Mars is considered to be one.

Defining dwarf planets as not being planets at all is the equivalent of stating that a grizzly bear is not a bear. It also goes against traditional classifications in astronomy. Dwarf stars are still considered to be stars, and dwarf galaxies are still considered to be galaxies.

Also, requiring an object to clear its orbit automatically precludes any objects in binary systems from being considered planets since two objects in orbit around one another by definition do not “clear their orbits”.

Even more problematic, **the IAU definition applies only to our solar system** and takes no account of exoplanets, a curious decision at a time when approximately 300 very diverse planets have been discovered orbiting other stars.

Supporters of the IAU definition argue that Pluto is clearly different from the eight classical planets designated by the IAU and, therefore, never belonged in the planet category. They also claim that objection to the IAU definition is due largely to sentimental attachment to Pluto and that keeping Pluto as a planet would “open the floodgates” to many small objects in the Kuiper Belt, leaving us with “too many planets” for children to memorize.

None of these arguments holds merit. The first, Pluto's obvious difference from the “big eight,” is based on an artificially narrow conception of what makes an object a planet. For nearly eighty years, Pluto was the “odd-ball” in the solar system because the other planets in the Kuiper Belt most like it had not yet been found. Ceres had not yet been confirmed as spherical and therefore different than its asteroid companions. That does not mean Pluto and Ceres are not planets. It means there are many more types of planets than we have accounted for, and we need to create new subclasses of the term planet to accurately categorize them.

We don't have any problem using the term “star” to apply to the very diverse numbers and types of objects that are self-luminous through nuclear fusion. Why should planets be any different?

Every one of the eight major planets is significantly different from every other one, meaning any criterion chosen as the one necessary for planethood will be arbitrary. If we choose size as the criterion, the four gas giants would stand out as the solar system's only planets. If we choose having moons as the criterion, Mercury and Venus would be excluded. If we choose the presence of an atmosphere, Mercury is out.

Neither does Pluto's 17-degree orbital inclination preclude it from being considered a planet. Astronomers know that many exoplanets have inclined, eccentric orbits. We could require all objects to orbit within five degrees of the ecliptic, thereby excluding Mercury, which has a seven-degree orbital inclination. Or we could require objects to orbit within 20 degrees of the ecliptic, which would include Mercury and Pluto but exclude Eris, whose orbital inclination is 42 degrees. Who decides the boundary, and what is the rationale for that particular choice?

Some claim that if Pluto were placed in Earth's orbit, it would grow a tail like a comet. This is a “red herring” because again, it addresses solely where an object is. The growth of a tail is due to rapid escape of the heated atmosphere from an object's gravity. Every planet in our solar system, if brought sufficiently close to the sun, would experience this. Earth would grow a tail in Mercury's orbit, and even Jupiter would grow a tail if it were placed in the close orbits of exoplanets known as “hot Jupiters”.

The portrayal of those rejecting the IAU decision as being motivated by sentimental attachment to Pluto amounts to a logical fallacy known as a “straw man” because the real reason for the rejection is the desire for a clearer and more encompassing planet definition that makes room for the diversity of objects that fall under this category.

How many of us learned about Ceres in grade school? The real world result of its demotion was that knowledge of this body disappeared into obscurity. Many opponents of the IAU decision are justifiably concerned that the same will happen regarding Pluto and all dwarf planets.

As for the argument that we cannot have too many planets because children will be unable to memorize them, that is also unscientific. We do not limit the number of elements in the periodic table for children's convenience. If the solar system has 200 planets, then that is what it has, and educators will have to find a way to

teach this. Anything less would be a disservice to children. Memorization is not even that important. Instead, it would be better to emphasize the differences among planets and the characteristics of each type.

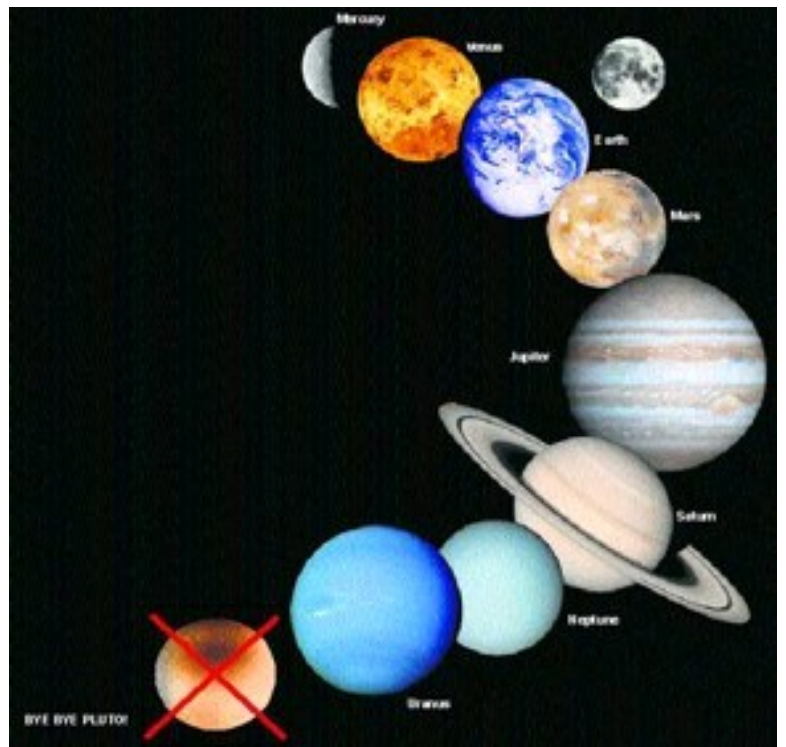
Neither is it important to have a specific number of planets. With new discoveries occurring rapidly, there is no reason why children and students of all ages cannot be taught that the number of planets in our solar system is not fixed but is constantly changing as new objects are found and understood.

### In Conclusion

The word "planet" is also a cultural term. The planets are arguably the most accessible area of astronomy. Many are visible to the naked eye, and they are observable in detail with telescopes. People enjoy hearing and reading about the discovery of new planets. They are alienated when, for seemingly obscure reasons, astronomers "take planets away" especially when nothing has happened "out there" to change those planets. Instead of looking down on people for resisting a definition that makes little sense to them, we should welcome their interest in astronomy, and adopt definitions that encourage rather than discourage public interest in the field.

**"Planet" should remain a broad, umbrella term** that can encompass a wide range of astronomical objects, including some types that have yet to be discovered. Pluto is a planet, as are Ceres, Makemake, Haumea, Eris, and very likely a host of other round objects in the Kuiper Belt. Round moons of planets can also fall under the umbrella as secondary planets, meaning they orbit other planets rather than stars, even if we colloquially continue to refer to them as satellites or moons.

The best planet definition can be credited to AAI's own Al Witzgall. **"A planet is a non-self-luminous spheroidal object orbiting a star"**. "This includes rogue and pulsar planets which, at one time, orbited stars". The IAU, the astronomy community, and the general public would be best served by adoption of this inclusive definition.



# Stewart's Skybox

by Stewart Meyers

**T**his past January, the MESSENGER spacecraft had its first flyby of the planet Mercury. It was a resounding success and everything worked well. This month, on October 6<sup>th</sup>, MESSENGER will make another flyby, the second of three planned before the spacecraft settles into orbit around Mercury and officially begins its mission. So, now is a good time to look over what was found during the earlier flyby.



Mercury as seen from MESSENGER while on approach for the January flyby.

[http://www.nasa.gov/images/content/209135main1\\_color\\_mercury\\_350.jpg](http://www.nasa.gov/images/content/209135main1_color_mercury_350.jpg)

## Don't Eat the Iron Snow

Since Mariner 10's mission back in 1973, it has been known that Mercury has a weak magnetic field. This was quite unexpected since Mercury rotates very slowly, and was thought to be solid to its core. Just this year, it was shown via detailed radar observations of Mercury over time that the planet rotates slightly differently than it would if it were completely solid. This evidence shows that Mercury possesses at least a molten outer core. That finding still left a question as to what could cause a dynamo effect, since Mercury does not rotate anywhere near fast enough. Now, it seems that this mystery has been solved, and the answer is snow, but not the kind we are familiar with.

Based on modeling the properties of the iron compounds likely to compose the core of Mercury, Jie Li of the University of Illinois has found that the molten iron compounds are rising from the hotter inner core to the cooler upper layers. Once there, the compounds cool and form solid iron crystals, in essence -- iron snow. These crystals then sink back to the deeper, hotter parts of the core. This convective motion is just enough to generate the weak dynamo effect needed to generate the observed field.

## A Dirty Magnetosphere

In addition to taking pictures of the surface of Mercury, MESSENGER also studied the magnetic field. Aside from its weakness and the unusual way in which it is generated, the field is rather normal, and Mercury even sports a small magnetotail (the part of the magnetic field that is blown behind and away from the planet by the solar wind). However it has some different effects from what are seen with fields on other planets. On Earth, the charged particles in the field come from the solar wind and from Earth's upper atmosphere. In the case of Jupiter, the volcanic eruptions of the Galilean moon, Io, contribute sulfur and other substances to the particle mix. Since Mercury has no real atmosphere, the surface is exposed to space, therefore, some charged particles and cosmic rays make it through the weak magnetic field. These knock atoms off the surface, and they find their way into the magnetic field. Hence, some of the particles in the Mercurian magnetic field are composed of calcium, sodium, and other elements found in the surface minerals.

## An Iron Deficiency?

From the time of the Mariner 10 mission up to last January's MESSENGER flyby, it was thought that Mercury's surface was shaped only by cosmic impact with the only major internal geologic activity being the cooling of Mercury's interior which caused the enormous scarps seen on many areas of the surface. MESSENGER's cameras and other instruments revealed that Mercury's geology was bit more complex than previously thought.

The higher resolution images of MESSENGER reveal that the Caloris Basin impact feature has been filled by lava, somewhat like the lunar mare. The images also show possible lava vents in the area that supplied the material that filled the crater. Some evidence is also seen for actual, but long-dead, volcanoes on the surface. This indicates an active geological history on Mercury.

The three basic rock units (areas of a given mix of minerals) on Mercury are bright, but smooth plains, heavily cratered terrain, and smooth, dark, plains. While the first two types are not too much out of the ordinary, the third was a surprise. Visually, the smooth dark plains bear a resemblance to the basaltic material found in the lunar mare, but they contain an oddly low abundance of iron. There are a few possible explanations. The simplest is probably that iron is indeed present in considerable amounts, but it is in the form of a mineral such as ilmenite, which could not be detected with the spectrometer aboard MESSENGER. Or, it could mean that the process of differentiation (the process early in planet formation where heavier elements sink towards the core and lighter silicates rise to the surface) was very efficient in concentrating iron in the core. Some scientists have even suggested that Mercury may have had less iron to begin with.

A possible clue concerning this dark material might eventually be found in some unusual craters discovered by MESSENGER. Unlike impact craters everywhere else in the solar system which have rims that are either brighter or the same color as their surroundings, a small number of craters on Mercury (mainly near the Caloris Basin, but in a few other areas as well) have very dark rims. This could be caused either by the impacts ejecting dark material from beneath the surface or by the melting of surface ejecta during the impact which hardened into a much darker rock.

## Spider-Cracks

No, this isn't something Peter Parker might have smoked when he was the evil Spiderman. This is the nickname of a Mercurian surface feature discovered by MESSENGER. It is more formally known as Pantheon Fossae, a series of cracks centered on the Apollodorus crater (Apollodorus was the architect of the Pantheon in Rome, hence the name for the cracks) located in the Caloris Basin.

Since evidence for past volcanism had been found on Mercury, it was thought that Pantheon Fossae was formed by pressure caused by the upwelling of lava that filled the Caloris Basin. However, this theory, while plausible, could not explain the observed cracks. Sometimes appearances are *not* deceiving. The cracks and the way they are centered on Apollodorus crater look very similar to what you see when something shoots through a piece of glass. And that is what is thought to have happened. The crust was indeed stressed by the upwelling of lava, but it was the impact that formed Apollodorus that formed the cracks.

This is not the only evidence that shows Mercury had a rather active interior in its early days. Since the Mariner 10 mission, it has been known that the surface of Mercury sports unique geological features called scarps. They are not found on the Moon or on any other cratered body in the solar system. Conventional wisdom maintained that these were formed early in Mercurian history when the interior of Mercury cooled and contracted. The crust then collapsed slightly to conform to the interior and the results were the scarps, which were thought of as wrinkles. This picture turns out to be in need of revision.

Examining the images sent back by MESSENGER, Scott King of Virginia Tech noticed that the pattern and frequency of the scarps could not be explained by mere contraction of the crust. Another force had to be involved. King felt that the scarps could be best explained as a result of convective motions in the mantle of Mercury pushing on parts of the crust early in the history of the planet, when its crust was thinner than it is today. Eventually, the crust of Mercury thickened as the planet cooled and became too thick to be affected by motions in the interior of the planet.

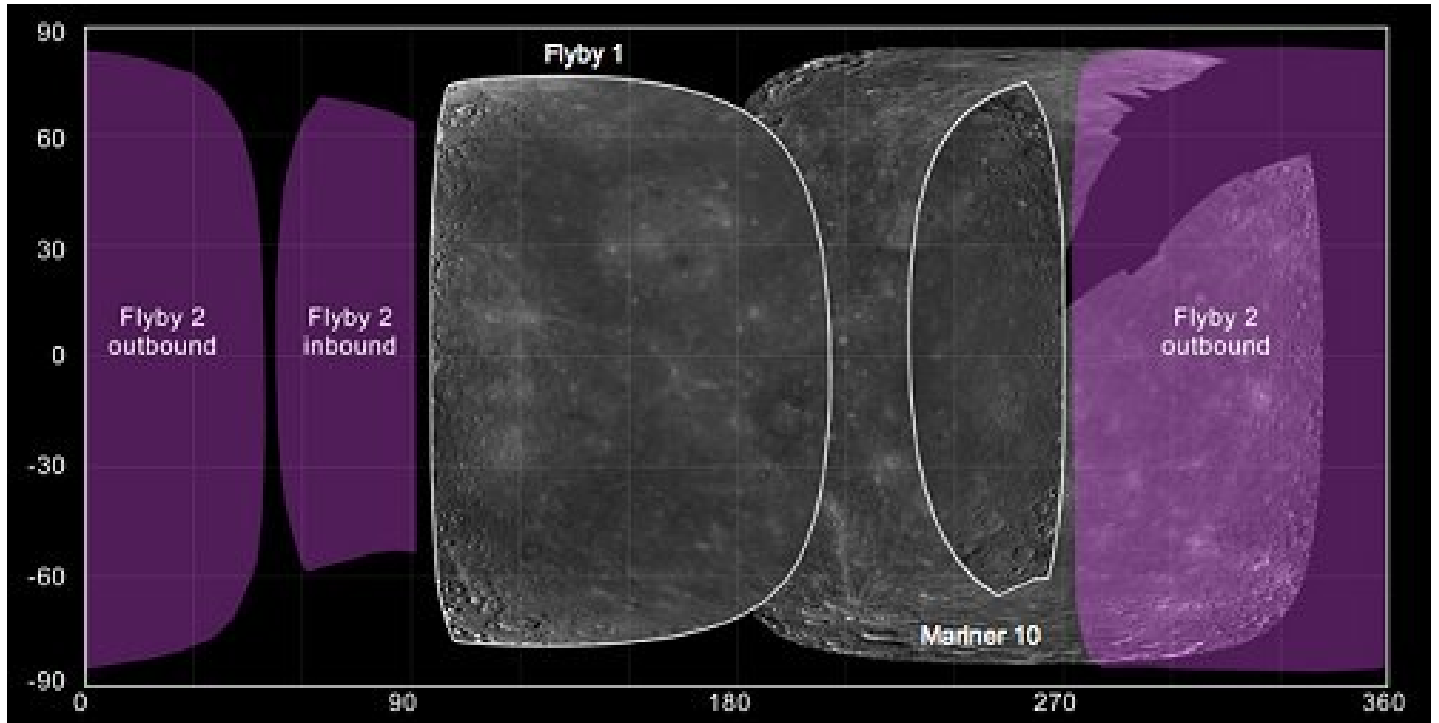
## Fuel Economy

The high price of gas has gotten everybody concerned about fuel. There are undoubtedly some amateurs who carefully consider how much gas their trips to observing sites and other astronomical functions will take and then act accordingly. Spacecraft have even worse fuel problems since they cannot stop and refuel at a gas

station. The limited supply of fuel for rockets and thrusters on a spacecraft often set the limit on how long a mission can last.

The controllers of the MESSENGER mission have hit upon a way to save fuel on the mission, and make some course corrections for free by using an effect of the Sun. Back in 1973, during the Mariner 10 mission, NASA scientists found that the pressure of light and other electromagnetic radiations of the Sun were affecting the spacecraft. This was a small effect, but, by exploiting it, the controllers were able to control the attitude of the probe without using much of the increasingly scarce thruster fuel. This works in the vicinity of Mercury because Mercury is extremely close to the Sun, and is exposed to much more solar energy than other planets.

During January's flyby, this radiation pressure was used to correct a 9.5 kilometer deviation from the optimum path. This bold move made a later planned correction unnecessary. This tactic will undoubtedly be used when possible for future flybys. The fuel savings will certainly prolong the useful life of the spacecraft.



Areas of Mercury already imaged by Mariner 10 in 1973 and MESSENGER's first flyby in January of this year.

Additional areas to be recorded during second flyby are also shown.

[http://messenger.jhuapl.edu/gallery/sciencePhotos/view.php?gallery\\_id=2](http://messenger.jhuapl.edu/gallery/sciencePhotos/view.php?gallery_id=2)

### October Surprise(s)?

When MESSENGER makes its second flyby this month, it will study the remainder of the hemisphere that was unseen by Mariner 10. This could reveal even more unusual features or at least offer more insight into the kinds of features seen on Mercury already. This time around, MESSENGER will use its laser altimeter. This instrument will provide very precise elevation measurements for the surface and should offer clues to the geology and possibly even the interior of Mercury.

After this October, the next and final flyby will take place in 2009. In 2011, MESSENGER will arrive at Mercury to stay and go into orbit around the planet. Then, it can use all of its instruments and it should make even more discoveries.

☆☆☆

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*Deadline for submissions to each month's newsletter is the first Friday of that month.*

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## MEMBERSHIP DUES

Regular Membership:	\$21
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Sponsoring Membership:	\$46
Family Membership:	\$5
First Time Application Fee:	\$3

*Sky & Telescope:* \$32.95

*Astronomy* subscription: \$34

(Subscription renewals to *S&T* can be done directly. See "Membership-Dues" on website for details.)

*AAI Dues can be paid in person to Membership Chair or Treasurer, or by mail to: AAI, PO Box 111, Garwood, NJ 07027-0111*

## DOMESTIC DUTY

October 24	Team E
October 31	Team A
November 7	Team B
November 14	Team C
November 21	Team D

## FRIDAYS AT SPERRY

**October 24, 2008**

"Making Time For Mars"

Bonnie Witzgall

**October 31, 2008**

"Ask Dr. Lew" Dr. Lew

**November 7, 2008**

"What's Up? A Down to Earth Sky Guide" Kathy Vaccari

**November 14, 2008**

"Is Pluto a Planet?" Laurel Kornfeld and Mike Luciuk

*All schedules above were accurate at time of publication. Please check [www.asterism.org](http://www.asterism.org) for latest information (click on "Club Activities")*

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## DR. LEW'S SEMINARS

See Dr. Lew Thomas for possible upcoming seminar topics.

*(Choice of topic at Dr. Lew's seminars is determined by participants' interest)*

Special thanks to Gordon Bond for the "Theater in the Sky" page design.

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Special thanks to Justin Shapp for the design of the masthead and other graphics.

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# Theater<sup>in</sup><sub>the</sub> Sky

by Ron Ruemmler

November 2008 hosts the magnificent, month-long convergence of the two brightest planets in our sky. Venus is finally far enough from the setting Sun to be an easy object to find at the end of twilight. **Jupiter** starts the month 30 degrees to the upper left of **Venus**. The two planets move toward each other at the rate of one degree per day until Jupiter passes just two degrees above Venus on the last evening of the month. This final rendezvous is further enhanced by the presence of the new-born crescent Moon.

The other naked eye planets offer little competition to the main event. **Mercury** is concluding its magnificent morning appearance of October and rapidly fades before passing behind the Sun near the end of November. **Mars** is hopelessly close to the Sun as it, too, prepares for its conjunction with the Sun in December. Even **Saturn**, rising a few hours after midnight, barely reaches first magnitude brightness as it turns its rings edgewise to the Earth.

November always features the **Leonid meteor shower**, but it will be very poor this year, largely because the just-past-full Moon will be in Gemini, only sixty degrees away from the shower radiant in Leo.

However, the **Taurid meteor showers**, both Southern and Northern, also occur in November, and they are centered around the first week of the month when the Moon is below the horizon. Averaging just five meteors per hour, the Taurids are seldom mentioned, but, when they happen, they tend to be spectacular fireballs. Also they peak when the radiant is high in the south around midnight, unlike the pre-dawn Leonids. Any spectacular "shooting star" from the middle of October through the end of November is likely to be a Taurid.

Finally, the single morning of Daylight Saving Time this month produces a sunrise that is a full six minutes later than the latest that winter has to offer. This "event" has no astronomical significance whatsoever.

## November Sky Calendar

- 1 Sat 7:27am Latest sunrise of the year
- 1 Sat 6:40pm Thin crescent Moon to left of Venus
- 1 Sat 6:40pm Jupiter 30 degrees upper left of Venus
- 2 Sun 2:00am Standard Time returns; move clocks one hour back
- 2 Sun 5:30pm Crescent Moon midway between Venus and Jupiter
- 3 Mon 5:30pm Jupiter upper right of crescent Moon
- 5 Wed 11:03pm First Quarter Moon
- 11 Tue 6:20pm Jupiter 20 degrees upper left of Venus
- 13 Thu 1:18am Full Moon
- 17 Mon 5:00am Leonid meteor shower; very unfavorable this year
- 19 Wed 4:32pm Last Quarter Moon
- 21 Fri 5:00am Saturn left of fat crescent Moon
- 21 Fri 6:00pm Jupiter 10 degrees upper left of Venus
- 25 Tue noon Mercury passes behind the Sun into the evening sky
- 27 Thu 11:55am New Moon
- 30 Sun 6:00pm Jupiter 2 degrees above Venus
- 30 Sun 6:00pm Thin crescent Moon lower right of Venus and Jupiter

