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PLUTO: A HUMAN COMEDY

On 24th August 2006, at a meeting of its General Assembly in Prague, members of the International Astronomical Union (IAU) -- the largest body of professional astronomers -- voted to define a planet. In sharp focus was the status of Pluto, which was demoted from its erstwhile position of being the ninth (and outermost) planet of our solar system, to that of a “dwarf planet”. This led to sharp outcry from a section of astronomers. Within a few months, O. Gingerich (Harvard University), chair of IAU's Planet Definition Committee, wrote a retrospective (Ref. 1), calling this voting “...the raucous process by which the world's astronomers defined the word “planet”. “ Gingerich had had enough: if matters could not be settled amicably within the astronomical community, he (and some others) felt it was their responsibility to take the battle into the streets. A few months later, S. Soter (American Museum of Natural History), defending the IAU's position, wrote (Ref. 2) that “the controversial new official definition of “planet”, which banished Pluto, has its flaws but by and large captures essential scientific principles.” A scientific debate had not only spilled over into something of a public spat, but had many non-scientists wondering why a group of scientists *voted* to arrive at a decision, on an issue that most of us would expect to be settled by scientific arguments. To appreciate the scientific and human dimensions of the problem, it is perhaps best to begin with the text (including footnotes) of the “Definition of a `Planet' in the Solar System”, adopted by the IAU in Prague:

Contemporary observations are changing our understanding of planetary systems, and it is important that our nomenclature for objects reflect our current understanding. This applies, in particular, to the designation “planets”. The word "planet" originally described "wanderers" that were known only as moving lights in the sky. Recent discoveries lead us to create a new definition, which we can make using currently available scientific information.

The IAU therefore resolves that “planets” and other bodies in our solar system be defined into three distinct categories in the following way:

A “planet”[1] 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[2], and (c) has cleared the neighborhood around its orbit.

A “dwarf planet” is a celestial body that (a) is in orbit around the Sun, (b) has

1 The eight planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

2 An IAU process will be established to assign objects into dwarf planet and other categories.

sufficient mass for its self-gravity to overcome rigid-body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) has not cleared the neighborhood around its orbit, and (d) is not a satellite.

All other objects[3] except satellites orbiting the Sun shall be referred to collectively as "small solar-system bodies."

The IAU further resolves that Pluto is a "dwarf planet" by the above definition and is recognized as the prototype of a new category of trans-Neptunian objects.

The lay reader might require clarification of some of the terminology in the above (italicized) statements of the IAU. However, the brevity of the note and the simplicity – or vagueness, to some -- of its wording suggest that the IAU had taken pains to ensure that its position is understood, not only by the astronomical or the larger scientific community but, by the public at large. One goal of this essay is to offer the reader a broad – and necessarily simplistic -- account of the development of planetary science: this will, hopefully, enable the reader to appreciate the reasons behind the current divide among planetary scientists.

Modern science and astronomy

The origins of modern science are closely associated with the origins of modern astronomy in 16th century Europe, and the origins of modern astronomy are rooted in the study of our solar system. This revolution in our perception of natural phenomena rested on a combination of earlier discoveries, made by many cultures across the world. Centuries-old questions were sharpened and new speculations were subjected to empirical tests that, in principle, could be repeated anywhere by any competent person. The discoveries that followed and the changes in our perception of the nature of celestial bodies are largely associated with the names of N. Copernicus, T. Brahe, J. Kepler, and Galileo G. To get an idea of their contributions, it is useful to have a broad picture of the notions that they inherited from their predecessors. Since prehistoric times, many cultures have noted certain regularities in the motions of the heavenly bodies: some of the observations were so acute that quite accurate calendars, predicting eclipses of the Sun or Moon, were constructed. Imagination cannot be restricted to the construction of empirical charts, without stimulating theorizing about possible causes. Consequently, many different astrologies and mythologies flourished; however, it is not the purpose of this essay to explore this rich cultural heritage.

Many cultures of the northern hemisphere had observed that the star called Polaris (the "pole-star") occupied a nearly fixed position in the night sky, whereas the innumerable other "fixed" stars seemed to rotate about Polaris with a period of one day. Moreover, the apparent positions of the stars varied with the latitude of the

3 These currently include most of the solar-system asteroids, most trans-Neptunian objects, comets, and other small bodies.

place from which they were observed. These facts could be organised into a workable model, if one imagined a round Earth which rotated with a period of one day, about an axis which pointed in a direction very close to the position of the Polaris. This model is, of course, consistent with the notion that the Sun – whose presence/absence in the sky defines day/night, in the first place -- also seemed to rotate about Polaris, with the same period of one day. Over and above this daily cycle, the apparent motion of the Sun also has an annual cycle, marked by the seasons. This detail can be accommodated if the Sun happened to be much closer to the Earth than the stars, and the Sun was in orbit round the Earth with a period of one year. A few other objects were also known to exhibit more complicated motions than the stars. These included the Moon, Mercury, Venus, Mars, Jupiter, and Saturn. Together with the Sun, these wandering lights in the sky comprised 7 planets, according to ancient Greek tradition. The 7 planets seemed to follow similar paths through a belt of constellations, patterns in the sky formed by the brighter of the fixed stars. Another attribute distinguished the planets from the stars: the latter seemed to be pin-pricks of lights, whereas the planets showed more structure. It was, perhaps, natural to speculate that the planets were objects that were closer to the Earth than the stars. In this geocentric model, the Earth was not thought of as a planet, but was the centre of the universe.

All this changed with the Copernican revolution, which put the Sun at the centre around which the planets orbited. The Earth was designated a planet, and the Moon its satellite. Instead of 7 planets, the new heliocentric model recognised 6 planets (Mercury, Venus, Earth, Mars, Jupiter, and Saturn), which orbited the Sun, following paths that were very nearly confined to a plane. In the new scheme, the Sun was not a planet, but some other kind of object, which shone with its own light, whereas the planets were visible because they reflected the light of the Sun: later, the Sun would come to be regarded as a fairly ordinary kind of star. Also, the Moon came to be considered a satellite of the Earth. The list of satellites soon expanded when Galileo trained a telescope on Jupiter and discovered four moons. The motions of the planets were studied in painstaking details: the naked-eye observations of Brahe provided the basis for Kepler's laws of planetary motion.[4] Meanwhile, there were developments on the terrestrial front, in trying to understand the motions of bodies (a stone thrown up, or a fired cannon ball). Galileo proposed a law of inertia -- that appeared counter to common experience -- and wrote eloquently about it. The great synthesis took place in the 17th century, when I. Newton formulated the laws of motion (of massive bodies) -- including Galileo's law of inertia – and the law of universal gravitational attraction between any two (or more) massive objects. A stone fell because the Earth exerted an attractive force on it, the Moon orbited the Earth for the same reason; conversely, the stone and the Moon exerted equal and

4 Kepler's laws are: (1) the orbit of a planet is an ellipse with the Sun located at one focus; (2) the line joining the Sun and a planet sweeps out equal areas in equal intervals of time; (3) the squares of the orbital periods are in direct proportion to the cubes of semi-major axes of the orbits. These laws are only approximately true, because the planets exert small (compared to the Sun) gravitational forces on each other.

opposite gravitational forces on the Earth. One mathematical theory could now explain such apparently diverse phenomena as the trajectory of a cannon ball, the heaving of ocean tides, the motion of the Moon around the Earth, Kepler's laws of planetary motion, and many others: modern science had arrived.

Over the course of the next two centuries, Newton's laws were applied to explain more complex behaviour, such as the strength of solids, and the flow of fluids. It is, perhaps, an exaggeration to state that no phenomenon was thought to be understood completely unless it could be explained in terms of a mathematical model that was based on Newton's laws. For instance, the behaviour of light, magnets, and electrical currents required the development of a theory of forces – J. C. Maxwell's Electromagnetism – other than gravitation. However, the ideal of the *scientific method* was Newton's mathematical model, subject to experimental verification. If experiments disagreed with any proposed model of a phenomenon, it was deemed necessary to modify the basic assumptions underlying the model, and apply accepted mathematical procedures to make new predictions; and so on. Science penetrated all engineering disciplines, and new mathematical fields were born. It is not the purpose of this essay to survey the progress of science in the 18th and 19th centuries. Our goal is more restricted, because we want to understand the definition of a planet; so we return to astronomy.

In 1801, G. Piazzi discovered a new object in the sky: named Ceres, it was initially thought to be a planet. Employing new mathematical methods, K. Gauss computed its orbit. Subsequent sightings of Ceres established that it was an object orbiting round the Sun, in the anomalously empty zone between Mars and Jupiter. Soon, other bodies (Pallas, Juno, and Vesta) were discovered to be in similar orbits. All these were collectively termed *asteroids* by Herschel, because – unlike planets -- they were so small that they showed up only as star-like points of light. On the other hand, Herschel's son John included these in his 1833 list of planets, so the planet count at this time was reckoned as 11. However, other bodies were discovered orbiting between Mars and Jupiter, and it soon became apparent that the asteroidal objects were too small to be included among the planets. Moreover, the giant planets, Uranus and Neptune, were discovered in 1781 and 1846, respectively. By 1853, the list of asteroids had grown to 23, and the planet count was 8, Uranus and Neptune included.

Presently there are about 10,000 numbered asteroids. The main asteroid belt lies between Mars and Jupiter. Due to Jupiter's gravitational perturbation, some asteroids are occasionally scattered out of this belt into orbits that bring them closer to the Earth. A few hundred of these near-Earth asteroids are now known, with the largest being about 38 km across. Over geological times, there have been many collisions with the Earth. Astronomers rarely miss an opportunity to warn the public about the threat to humanity's future that a collision with a 1000 feet pile of rock represents. “Aphophis: an Asteroid with Earth in its Crosshairs”, was a blurb on the cover of a popular science magazine that I came across. Recently, Discovery Channel ran a two-hour tribute to the human spirit titled, “Super Comet: After the Impact.” There are other groups of asteroids but, for our purposes, the most important asteroid-like bodies are those in the Kuiper Belt, far away beyond the orbit of Neptune. There are, perhaps, hundreds of thousands of objects, larger than a kilometer, populating this belt; it has been estimated that the total number of objects in the Kuiper Belt could exceed a billion. As with the near-Earth asteroids and Jupiter, Neptune's gravitational perturbation will occasionally send one of these hurtling toward the inner solar-system, manifesting itself as a short-period comet. We are getting a little ahead of our story, because speculation about the existence of such a trans-Neptunian belt dates back to the 1940s – and only in the 1990s did direct evidence begin to accumulate for the Kuiper Belt. When Pluto was discovered by C. Tombaugh in 1930, it was thought to be the 9^{th} planet, the last outpost of the solar system.

The ragged edges of the outer solar system

Pluto's mass was initially overestimated, which is perhaps why it was readily accepted as a planet. Gradually, solar system dynamicists marked it down as less than 1% of the Earth's mass. Orbiting beyond Neptune, Pluto is almost 40 times farther than from the Sun on average than the Earth, and takes 248 years to go once around the Sun. It was always somewhat of an oddity among planets, for the following reasons.

1. The orbits of the planets are approximate ellipses with the Sun at one focus. Dynamical evolution over billions of years has resulted in the orbits of the first 8 planets being well separated and nearly circular. However, Pluto's orbit is so eccentric that it crosses the orbit of its nearest neighbour Neptune.[5]

2. The planets are thought of have formed along with the Sun, about 4.5 billion years ago. As the protosolar nebula, consisting of a mix of gas and dust, collapsed under the force of its own gravity, a slight initial rotation caused the rotating nebula to spin ever more rapidly as it collapsed. The reason for this increase in rotation rate is the conservation of angular momentum, the same physical law that makes a rotating dancer whirl faster as he/she withdraws his/her extended leg/hands. To form the Sun, the collapsing cloud had to shed a disc of material that contained very little mass, but most of its angular momentum. The planets formed from this thin disc of material, so that the 8 planets and the numerous asteroids orbit the Sun very nearly in the same plane. Pluto, on the other hand, has an orbital plane which is inclined at an angle of about 16° with respect to this plane.

3. Before the discovery of Pluto, the 8 planets could be divided into two main

5 Although the orbits of Pluto and Neptune cross in space, they do not get any closer than about 14 times the Earth-Sun distance.

groups. The first group, the *Terrestrial* planets, consists of Mercury, Venus, Earth and Mars. They formed in the inner solar system, where it was too hot for water and other volatile gases to have condensed as ices. They are all small and rocky. The second group, called the *Jovian* planets, consists of Jupiter, Saturn, Uranus, and Neptune. Being farther away from the Sun, their cores probably grew from a mixture of rock and ices, which later captured significant amounts of surrounding nebular gas. These planets are the giants of the solar system, and do not have solid surfaces. Pluto, on the other hand, is farther out from the Sun than the Jovian planets. However, it is very small (radius a little more than 1000 km), and made up of rock and frozen ices.

Hence, there were *dynamical* (1 and 2 above) and *structural* (3 above) grounds for believing that Pluto is different from the other 8 planets. Then, in 1978, it was discovered that Pluto had a companion: Pluto and Charon revolve around each other with a period of about 6 days. Satellites happen to be very much smaller than the planets about which they revolve, but Charon was only half as small as Pluto, so that the Pluto-Charon system could be considered a binary planet. For years this pair was considered an anomaly, until the discovery of the Kuiper Belt in 1992.

About 99.85% of the mass in the solar system is in the Sun, and most of the remaining mass is in the Jovian planets -- in contrast, the Sun has only about 0.5% of the angular momentum in the solar system. We can obtain some idea of the distribution of mass in the protoplanetary nebular disc, by imagining that the four Jovian planets were pulled apart, and the material spread smoothly in adjacent circular annuli. In the late 1940s and early 1950s, K. Edgeworth and G. Kuiper independently noted that the resulting disc would have a smooth distribution of mass, with the density decreasing smoothly with increasing distance from the Sun, until Neptune, where there seemed to be an apparent edge. The only known object beyond Neptune at that time was Pluto. But Pluto is so tiny that its mass would not make much contribution. They speculated that, if the edge was not real, there could be many as yet undetected objects. These could be icy planetesimals, small objects that had failed to aggregate and form planets because formation time scales would be very long in these rarefied outer regions. If so, the planetesimals should still be there, on nearly circular orbits, beyond Neptune. However, it was only in 1992 that the first Kuiper Belt object was sighted.[6] An entirely new region of the solar system was now open to study.

Astronomers have observed thousands of small icy bodies in the Kuiper Belt. Some of these were found to go around the Sun once every 248 years, the same as Pluto. Like Pluto, they are locked in a 3:2 gravitational resonance with Neptune (which goes around the Sun once every 165 years), and these small, icy bodies were referred to as “plutinos.” Subsequently, other objects comparable in size to Pluto

6 Edgeworth's work was overlooked until recently, and this trans-Neptunian disc of icy bodies has come to be called the Kuiper Belt.

have been found in the Kuiper Belt. The view that Pluto is just a very large member of the Kuiper Belt gained currency in the astronomical community. “Is Pluto a planet?” was a question that was raised frequently since the late 1990s. Those inclined to answer in the negative pointed out that if Pluto had been found today, it would not have been classified as a planet. Others argued that history should not be altered. When the object designated as 2003 UB313 was discovered in 2005, it became the most distant object ever seen in the solar system. Larger than Pluto, it takes 557 years to complete one trip around the Sun, on a highly eccentric and inclined orbit. We learn from Ref. 1 that 2003 UB313 “... brought about a bureaucratic crisis. If 2003 UB313 were deemed a planet, the responsibility for naming it would fall to the IAU's working group for planetary-system nomenclature, which has been particularly active in naming satellites. Otherwise, the object's discoverers would propose a name to the Minor Planet Center, which would then forward it for approval to a different IAU committee, the one for small-body nomenclature.” B. Marsden of the IAU's Minor Planet center has been quoted as saying, “I like to have 8 planets .... Life was so much simpler when there were only 8 planets. Let’s go back to that.” M. Brown, one of the co-discoverers of 2003 UB313, wrote, “everyone should ignore the distracting debates of the scientists.... Pluto is a planet because culture says it is.” Not unexpectedly, the IAU established a working group to come up with a classification scheme.

August 2005: the “raucous process” in Prague according to O. Gingerich

The Planet Definition Committee set up by the IAU consisted of 7 members, drawn from astronomers, science historians, and writers. The committee proposed that we recognise 12 planets in the solar system: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, the double planet Pluto-Charon, the asteroid Ceres, and the large Kuiper Belt object 2003 UB313. O. Gingerich chaired the committee, and his article in the *Sky & Telescope* (Ref. 1), “Losing it in Prague: the inside story of Pluto's demotion”, is an account of how the IAU eventually settled for 8 planets, demoting Ceres, Pluto and 2003 UB313 to “dwarf planets.” The article is largely an account of the duels fought between two groups of astronomers -- termed *structuralists* and *dynamicists* by Gingerich -- over 10 days, against the backdrop of the IAU's General Assembly in Prague. In this context, the structuralists are those who study the structures of planets; they are the extra-terrestrial equivalents of geologists. The dynamicists are those who study the orbital motions of the planets and the dynamical evolution of the solar system. The debates between these two groups was not new: Stern and Levison had suggested in 2000 that a planet could be defined as a body less massive than a star but large enough for its gravity to overcome the mechanical strength of its structure and pull itself into a round shape. This is hydrostatic equilibrium, and applies to most bodies with diameters larger than several hundred kilometers; smaller bodies have irregular shapes. The committee's proposal of 12 planets was based on hydrostatic equilibrium. From Ref. 1 we gather that the dynamicists regarded hydrostatic equilibrium, by itself, an insufficient criterion and forced the committee to come up with newer proposals. Sensing a juicy story, the news-media jumped in.

Here is how the tussle between the two groups seems to have played out, according to Gingerich. "8 classical planets (Mercury to Neptune), Ceres, and a growing number of plutons" is offered, but the dynamicists turn it down and put in a resolution of their own, requiring that a planet be not only round, but also "the dominant object in its local population zone" (again, this criterion goes back to Stern and Levison: some bodies in the solar system are massive enough to have swept up or gravitationally scattered away most of their near neighbours. Less massive bodies are not able to do this, so they exist in swarms). Realising that their opponents could not be deflected from their stand, the committee agrees to include this criterion, and suggests that planets be classified into two groups, "classical planets" and "dwarf planets." But the dynamicists would have none of this, and insist on the primacy of definition to the role of orbits and the dynamical evolution of the solar system. They reject "plutonians", and simply want the categories, "planets" and "dwarf planets." Structuralists argue that, dropping the word "classical" gives one a sense that "dwarf planets" are somehow not planets. Gingerich has to leave, but manages to send an email requesting that the word "classical" be added before planets. On August 24th, at the closing session of IAU's General Assembly, members are given a chance to add the word "classical" to the definition of a planet. But to Gingerich's horror, dynamicists had managed to replace "the dominant object in its local population zone" by "cleared the neighbourhood around its orbit." The members receive yellow cards, and hold the cards up to cast their vote for or against a resolution: inclusion of the word "classical" is defeated by a substantial majority. So, according to the IAU, there are "planets" and then there are "dwarf planets" in our solar system.

The struggle had been fierce, and the dynamicists had won. A New York Times editorial rejoiced that Pluto's dethronement was a good idea because otherwise schoolchildren would soon have a list of planets too long to memorise.[7] Plutophiles organised protest rallies. The widow of the discoverer of Pluto was quoted as saying that her husband would not have wanted this, but that he would have understood. In a display of cosmic detachment, a noted Indian astrologer observed that Pluto's demotion would not affect his predictions, because Pluto was never included in his calculations anyway.

The aftermath

To clear the air, dynamicists had to respond in some manner, and this has happened with S. Soter writing in the *Scientific American* (Ref. 2). Titled "What is a planet?", Soter's article is a clear and accessible account of the scientific basis

7 A good counter to this is the following remark, recalled by Gingerich, made by a member of the planet-definition committee: "What's wrong with kids learning the names of 50 planets? After all, they can learn (the names of) 50 states and 50 state capitals."

underlying IAU's definition and Pluto's demotion. Unlike Gingerich's article, little or no attention is paid to the sociology of science. Drawing upon many examples, Soter seems to make a compelling case for the dynamicists' point of view, that a planet ought to dominate its orbital zone. He points out that there is a clear division between planets and lesser bodies, by estimating the “mass ratio”, a quantity defined as the mass of a body divided by the total mass of all other bodies that share its orbital zone. All eight planets (Mercury to Neptune) have a mass ratio exceeding 5000, with Earth's mass ratio being the largest at 1.7 million: Pluto, on the other hand, is estimated to have a mass ratio less than 1. He suggests that a mass ratio of about 100 would serve as a convenient dividing line between planets and non planets in our solar system. Planets have also been discovered around some stars other than the Sun. There are about 20 of these exoplanetary systems, and Soter argues that orbital dominance by one or a few bodies seems to be the rule. The IAU's definition required a planet to be a body that has cleared the neighborhood around its orbit. Soter remarks that the “...IAU definition has the right idea, but its unqualified use of the word “cleared” has inadvertently caused some confusion.” For instance, Jupiter, the largest planet of the solar system, controls the orbits of the Trojan asteroids, but the Trojans are clearly in Jupiter's neighbourhood. Pluto itself is very much in Neptune neighbourhood, but its orbital motion is in synchrony with Neptune’s orbital motion.

There are some curious consistencies that merit comparison between Gingerich's and Soter's articles. The large Kuiper Belt object, which is referred to as 2003 UB313 by Gingerich, is referred to as Eris by Soter. Why do these two astronomers insist on using two different names? This is what I learned from the Wikipedia. When the object was discovered in 2005 (from images taken in 2003), it was known by the provisional designation 2003 UB313, which was granted automatically by the IAU under their naming protocols for minor planets. The delay in assigning a name was due to uncertainty over whether the object would be classified as a planet or a minor planet; different nomenclature procedures apply to these different classes of object. The decision on a name had to wait until after the August 24th 2006 IAU ruling defining the object as a dwarf planet. Accompanying Gingerich's article is an image of the 12 planets that the planet-definition committee originally proposed. Accompanying Soter's article is a photograph of 9 children masquerading as the planets; 8 of them take the stage, while the ninth is relegated to a wing and bears a sign with the name, “Pluto”. We may suspect that a battle has taken a particularly vicious turn when children are brought in.

Is the planetary science community really divided into structuralists and dynamicists? Expensive space missions cannot be launched without close cooperation between many specialists, including engineers. The history of the solar system cannot be fully narrated without explaining the structural and dynamical origins of some of the most primitive meteorites. However, cooperation in a long-term endeavour is not incompatible with a desire to dominate. What can one expect of a group of people who, in their professional organisation, may resemble entrepreneurs or special interest groups? Some of the more innocent consequences of IAU's definition may be readily imagined. An astronomer may consider it a put down if he/she were introduced in a social setting as someone who works on dwarf planets, not planets. On the other hand, if planets had been classified as “classical planets” and “dwarf planets”, the hypothetical researcher of “dwarf planets” may be introduced simply as someone who works on planets. More serious consequences could be those connected to research funding: someone who works on dwarf planets may legitimately fear that his/her research funds may, in the future, be reduced to dwarf levels, compared to someone else who works on planets. The issue could be deadly serious, and hard to accept for some, especially when IAU's definition was arrived at by the process of voting by just a few hundred of its nearly ten thousand members. The public may be forgetful of the foibles of scientists, but the same may not be expected of philosophers of science. Can scientific questions be settled by voting? Shouldn't debate and dialogue lead to a nearly unique opinion on any scientific question (even if the answer is, “not yet settled”)? There is, perhaps, no homogeneous class of scientists, but a majority of them are likely to endorse the view of a famous physicist, that the philosophy of science is about as useful to scientists as ornithology is to birds.

Certain quarters warn us that the issue may be far from being considered settled. Fuming against the entire process, the editor-in-chief of *Sky* & Telescope, R. Fienberg writes (Ref. 3), “By IAU's wording, a dwarf planet is not a planet, even though a dwarf galaxy is still a galaxy, and a dwarf star is still a star. Absurd!” Fienberg considers Gingerich a dear friend and mentor. As editor-in-chief of *Sky & Telescope*, he is in a position to decide on matters concerning publication in this popular astronomical magazine. Thumbing his nose at the IAU, he states defiantly, that the “...*Sky & Telescope* won't use it (i.e. the term dwarf planet) without qualifiers. For example, we'll refer to Pluto as a “dwarf planet” (with quotation marks) or as a so-called dwarf planet, but never simply as a dwarf planet...” He is optimistic that the new definition cannot last long, and that the IAU is bound to change it during its next General Assembly in Rio de Janeiro in August 2009.

References

1. *Losing it in Prague: The inside story of Pluto's demotion*, O. Gingerich, Sky & Telescope, November 2006, page 34.

2. *What is a planet?*, S. Soter, Scientific American, January 2007, page 34.

3. *Pluto doesn't care*, R. Fienberg, Sky & Telescope, November 2006, page 8.

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