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The IAU, from New Worlds to Exoworlds: recollections of a mandate

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Abstract. This paper presents my own recollections of the difficult relations that existed between the IAU and a fraction of the public, especially in the USA, following the IAU decision to reclassify Pluto as a dwarf planet at the 2006 General Assembly in Prague, and which ultimately led the IAU to organize the *NameExoWorlds* international contest to give public names to selected exoplanets and their host stars. In spite of the success of the International Year of Astronomy in 2009, the Pluto controversy continued, and its consequences climaxed during my term (2012-2015), as NASA's *New Horizons* probe approached Pluto for a flyby just before the 2015 General Assembly in Honolulu. It was during this period that the IAU launched the *NameExoWorlds* contest, which also came to a conclusion in Honolulu after over half a million votes were cast from all over the world. While the inside story of how the contest was organized has appeared elsewhere, here I focus on the historical and sociological context that made Pluto such a sensitive issue, especially in the USA, explaining why this contest generated another controversy between the IAU and the *New Horizons* team. However, after the world-wide success of *NameExoWorlds*, the IAU and the *New Horizons* team eventually reached an agreement on finalizing the characterization and names of a number of newly discovered Pluto and Charon surface features (an on-going process), while a new edition of *NameExoWorlds* is in preparation for the IAU centennial in 2019.

Keywords. Moon, Mars, Pluto, planet, dwarf planet, exoplanet, New Horizons, Uwingu, NameExoWorlds

1. The IAU under fire

The relations between the IAU and the public can be complex – and revealing of the perceptions of the Universe by some groups, which accuse the IAU of having a self-proclaimed monopoly on naming celestial objects. In their view, *naming* is equivalent to *owning*. Since the Universe belongs to everyone, they say, "democracy" should prevail over "elitism", and anyone should have the right to name celestial objects as he/she wishes. This non-scientific approach is not far from denying any authority of organizations like the IAU over the study of the sky. But of course science has nothing to do with democracy (but may contribute to it...).

The "Pluto Affair", born in the aftermath of the 2006 General Assembly (GA) in Prague, is a good illustration of this unprecedented situation – challenging the IAU in its mission to name celestial objects, or better said in this case, to classify objects, and all the IAU efforts towards the public during the International Year of Astronomy in 2009 did not change that. Worse, other controversies were open during the following decade about naming other popular objects, Mars craters and exoplanets. Outright hostility against the IAU was widespread among some groups, and active on social media – but sadly this hostility was in part fueled by lobbying groups close to professional astronomers.

In response to these attacks, the Executive Committee (EC), during my mandate, organized a contest named *NameExoWorlds*, soliciting the public world-wide to give names to selected exoplanetary systems and their host stars, following strict rules, largely inspired from those having existed more or less formally for almost a century about the public naming of asteroids and other minor bodies of the Solar System. The winners of this contest were announced at the 2015 GA in Honolulu, after nearly 600 000 votes were cast, from 182 countries or regions, and with a press coverage of over 800 articles world-wide. So the initiative was largely considered a success.

The technical details of the process have been described in detail elsewhere (Montmerle *et al.* 2016), but here I would like to put this initiative in a broader historical and sociological context, with some personal views about the relations between the IAU and the public during the last couple of decades, and taking the Moon and Pluto as starting points.

2. Charting the sky

Before the creation of the IAU in 1919, in the aftermath of the Versailles Treaty (see Blaauw 1994), catalogues and sky charts had been mentioning names of celestial objects for centuries: motionless stars (bright enough to be visible to the naked eye) and planets, the wanderers – seven of them until the mid-XIXth century. At the time, there were no established rules to name planets (and the brightest planetary satellites, following Galileo's first telescopic observations of Jupiter in 1610), although eventually all planetary names would come from the Roman and Greek mythologies. Stars, the most numerous objects in the sky, bore various names (mostly Arabic today for historical reasons), but a systematic designation system was invented as early as 1603 by Johann Bayer in the first celestial atlas ever, *Uranometria*. Star designations were made up of two components: a Greek letter, generally attributed in decreasing order of brightness, and the name of its parent constellation (in Latin genitive). This system, independently of historical names, is still familiar to us and to navigators, while restricted to naked-eye visible stars (for more details, see Ref. *IAU:NamingStars*†).

But as telescopes became more powerful, with steadily improving angular resolutions and magnitude thresholds, ever more numerous fainter stars were discovered, and more and more features could be observed on planets (sometimes yielding a confusing picture, see the example of Mars "canals" described by Schiaparelli, Lowell and Flammarion; more below). The worst case was that of the Moon's smaller craters, which eventually carried different names, depending on discoverers and observers. The situation in 1919 was such that, when the IAU created the Standing Committees (the ancestors of Commissions), one (No. 17) was specifically dedicated to Lunar Nomenclature (Blaauw 1994; Whitaker 2003).

At the same moment, a Standing Committee (No. 3) was founded on "Notations, Units, and the format of Publications" (Blaauw 1994), and later evolved into Commission 3 "Astronomical Notations", which defined the 88 modern constellations (Delporte 1930). Along with projects like the *Carte du Ciel* (1887-1970), which catalogued over 4 million stars brighter than 11.5 mag (Lamy 2006; Daston 2017), the IAU progressively became recognized as the international authority for designations and nomenclature. However, at the time of the 1932 GA in Cambridge (Mass., USA), attended by 249 delegates, there were just 23 member states, thus representing only a fraction of the world's astronomers and population, especially since major countries like Germany, Austria, and the Soviet Union were not members for political reasons —to be compared with today's 86 National Members (i.e., member states), and over 13,500 individual members coming from 21

† This is a reference to a web page: the URL and similar information are given at the end of the paper, after the "References" (bibliography) section

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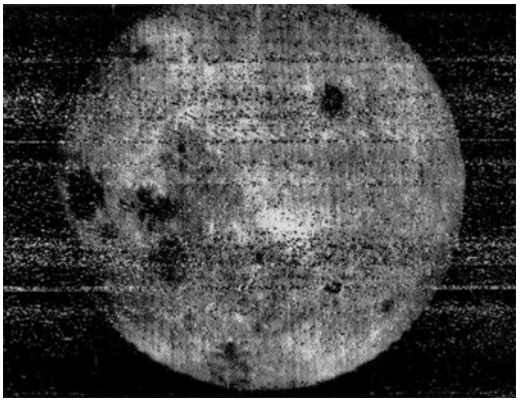

Figure 1. First ever picture showing the far side of the Moon (approximately 2/3 of the area to the right), sent by the *Luna-3* spacecraft during its flyby on Oct.7, 1959. The IAU played an important diplomatic role between the USA and the USSR in the approval process for naming the newly discovered lunar features, which climaxed in the '60s during the Soviet *Luna* programme and NASA surveys in preparation for the *Apollo* Moon landings, ten years later.

additional countries, in all a representation of 107 countries (for details, see T. Montmerle, this volume). At that time, there was no question of the public naming of planets or stars, with the notable exception of the name "Pluto" suggested by a little English girl for the planet discovered by Clyde Tombaugh two years earlier, which was quickly and informally adopted by the public and by the astronomical community (more below).

Much later, it is of interest to note that, as testified by documents in the IAU archives in Paris which I consulted, in the 'sixties the naming issue would become highly political: during the Moon race between the USSR and the USA, the IAU played in important role in negotiations about characterizing and naming the craters on the far side of the Moon. These were first discovered by the *Luna 3* Soviet spacecraft in 1959 (Fig. 1), then were surveyed in greater detail during the following decade by the USSR in the course of their *Luna* programme, and even more systematically by the USA during the preparations for the *Apollo* Moon landings in the 1969-1972 period (the *Ranger* and *Lunar Orbiter* orbiters, and the *Surveyor* landing spacecrafts).

Actually, the role of the IAU in designations (i.e., scientific names, as would appear for instance in a catalogue), or nomenclature (i.e., defining or adopting object categories, or names of various origins) was never made official by an international political organization (like the League of Nations or the United Nations). Its unique responsibility in designations is however explicitly mentioned in the IAU web pages (see *IAU:About*). At any rate, I personally believe that the role of the IAU in naming celestial objects, which is part of its missions (typically taken care of by its Working Groups, see, e.g., the Working Group for Planetary System Nomenclature, ref. *IAU:WGPlanetaryNames*), is *de facto* sanctioned every three years at the GA by the votes of its National Representatives. Given that, as mentioned above, 107 countries (out of 193 in the UN today —the difference being absent countries essentially in Africa and the Middle East, unfortunately, or very small countries) have astronomers who are IAU members, reaching over 13 500 worldwide to date, it can hardly be argued that the IAU is not the recognized authority to officially decide, or sanction, celestial names.

At the same time, there have already been initiatives outside the IAU to give public names to celestial objects or their features, but these had to meet the approval of the IAU. In fact, until the IAU GA in 2006, these initiatives all came from NASA, in the course of its planetary exploration programme, most notably with the *Magellan* and *Pioneer*

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Venus Orbiter space probes orbiting Venus. Owing to the close-up mapping first undertaken using the *Magellan* radar, Venus surface features much smaller than previously observable in radio waves from the Earth became visible for the first time (including some 900 craters). This led NASA to call for the public to give them names (implicitly by regular mail at that time) of famous women (Magellan 1991). In comparison, what happened after 2006 in the area of public naming of celestial objects or features was of course enormously amplified by the world-wide use of the Internet and social media.

3. From Mars to "Planet X"

The discovery of Neptune by Galle in 1846, following the calculations of Adams and Le Verrier attributing the observed deviations in the orbit of Uranus (itself discovered by W. Herschel in 1781) to the gravitational influence of an external, massive body, was a striking confirmation of Newtonian mechanics. This enhanced the Pantheon of known planets in the Solar System to eight members.

Then, could there be other worlds beyond Neptune?

The story leading to the discovery of Pluto in 1930 is too long and complex to be told here in full (see Hoyt 1980, in which I found most of the basic facts for this section). But it illustrates two different points of interest here: (i) the increasing role of the USA in astronomy at the turn of the XXth century, and (ii) the resulting widespread interest of the lay public, relayed by the press, for astronomical news (not fake !).†

Actually, the starting point of this story can be taken to be the discoveries about Mars in the late XIXth century, and their impact on the public – most notably the possible existence of Martians. In 1877, using the 49-cm Merz refractor of the Brera Observatory near Milan, Giovanni Schiaparelli discovered seemingly rectilinear features at the surface of Mars, which he studied and mapped for many years, following Mars' rotation and elongation. He called these features "canali", and gave them and other features various Latin names in the same spirit as features on the Moon ("Mares", "Montes", etc.). In Italian, "canale" means "channel" (natural), more than "canal" (artificial), and Schiaparelli did not himself imply that the features he saw were artificial, yet this name and his maps captured the imagination of the public. In 1898, Herbert George Wells published his famous science fiction book *The War of the Worlds*, in which England is invaded by hostile, technologically advanced Martians, eventually to be killed by terrestrial bacteria – a preview of biological warfare (if natural in this case).

During the same period, in the New World, the wealthy Bostonian Percival Lowell, businessman, mathematician and passionate amateur astronomer, decided to build an observatory near Flagstaff, Arizona, which was ready for observing in 1894. Lowell was well aware of Schiaparelli's work, and Mars was his prime interest in astronomy, so that the observatory location was dubbed "Mars Hill". Observation after observation, Lowell became convinced that true "canals" for irrigation has been constructed by an intelligent civilization to cope with the desertification of the planet. By 1905, he had recorded about 400 such "canals" (see Fig. 2). His work was strongly encouraged by the famous French astronomer and science writer Camille Flammarion, whom Lowell met in France, and who published in 1909 a revised edition of a book entitled *La planète Mars et ses conditions d'habitabilité* (first published in 1892, before Lowell's observations, and said to have triggered his decision to build the Flagstaff Observatory). This book presented a census of Mars maps and a text arguing in favour of the existence of a civilization advanced enough to have built a dense canal network across the whole planet (see also Moore 2016).

† For instance, after the confirmation of the General Theory of Relativity by Arthur Eddington's 1919 total eclipse observations, Albert Einstein was the star of a celebrity motorcade crossing New York City on Apr. 4, 1921 (see Isaacson 2007).

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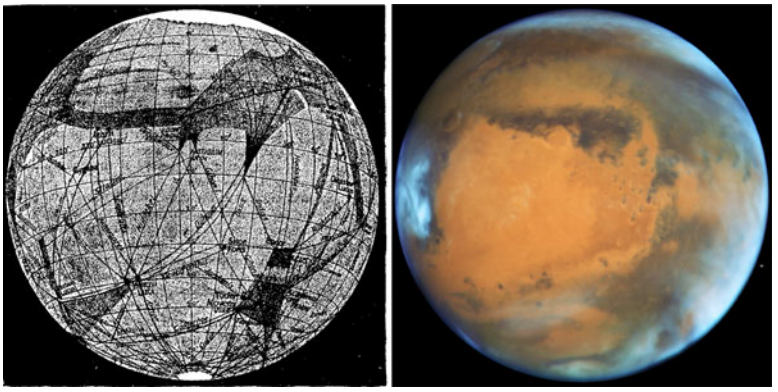

Figure 2. Mars map drawn by Lowell, 1905 (left); *HST*, Mars near opposition in 2016 (right). Note that the apparent "canals" are labeled with names. For comparison with Lowell's refractor observations, the *HST* picture is rotated upside down (South pole up). The upper dark elongated feature visible on Lowell's drawing may correspond, from left to right, to the aligned suite of features now named Sinus Sabaeus, Schiaparelli Crater, and Sinus Meridiani. Other extended features match reasonably well, showing the relatively high quality of Lowell's observations (albeit misinterpreted). (Bright features on this *HST* picture are clouds!)

Yet, as the quality (and size) of astronomical refractors and reflectors increased, the reality of "canals" – let alone their artificial origin – soon became increasingly challenged and attributed, at least for some of them, to optical artefacts. These disappointing news became known even to the general public. For instance, this was the correct explanation of Mars "canals" reported by T. Moreux, a French priest, disciple of Flammarion and famous science writer and teacher, in his 1924 popular book *La Vie sur Mars* (Moreux 1924). However, the possibility of "canals" built by an alien civilization on Mars remained highly popular in the USA, and a seemingly innocent CBS radio broadcast by Orson Welles, based on *The War of the Worlds*, triggered a form of panic throughout the country in 1938.†

Notwithstanding, Lowell pursued his Mars observations, but starting as early as 1905, he progressively turned to a new challenge: find a new planet in the Solar System, beyond the orbit of Neptune. Based on data available at the time, which seemed to show small deviations with respect to the computed orbits of Uranus and Neptune, Lowell, in the spirit of Adams and Le Verrier, and also following posterior suggestions, hypothesized that a more distant, trans-Neptunian planet caused these deviations, and used his mathematical skills to calculate the orbit and mass of this planet, which he dubbed "Planet X". Among other parameters, he calculated that its mass scale would be "in units of 1/50,000 of the Sun", more precisely between $1M_{\rm Earth}$ and $1M_{\rm Neptune} \simeq 17M_{\rm Earth}$ (we now know that Pluto's mass is much, much smaller: $2 \times 10^{-3} M_{\rm Earth}$; more below), a magnitude 11-13, and a disk larger than 1 arcsec in diameter. Unfortunately, two intensive observational campaigns did not produce results, and Lowell eventually passed away in 1916, without having succeeded in finding Planet X. However, he had left a substantial amount of money so that the search could be conducted by his successors.

Following Lowell's death, disputes over his heritage arose, and the search for Planet X was suspended at Flagstaff. Meanwhile, W.H. Pickering, a famous planet-hunter and competitor of Lowell in searching for a "Planet O" or a "Planet S", refined Lowell's predictions. In 1928, the planet mass was reduced to $0.5M_{\rm Earth}$, with an angular diameter

† Interestingly, canals were definitely ruled out for good only in the '60s by space missions: the *Mariner 4* Martian probe discovered the famous feature now associated with Valles Marineris, a canyon 3000 km long, up to 600 km wide, and up to 8 km deep, a very large "canal" indeed!

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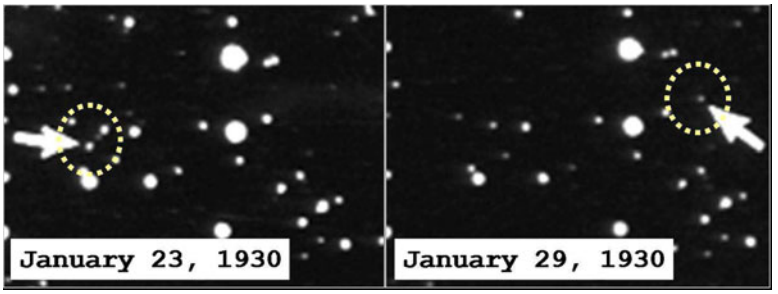

Figure 3. Close-up on the Pluto discovery plates, taken on Jan. 23 and 29, 1930 by Clyde Tombaugh, with the 13-inch refractor of the Flagstaff Lowell Observatory, equipped with a blink comparator. The arrows indicate the two successive locations of Pluto. This new technique would prove decisive for its discovery. (Lowell Observatory Archives)

of 0.5 arcsec. Apparently ignoring Pickering's work, the search for Planet X resumed at Flagstaff the same year, with the construction on Mars Hill of a new dome and telescope, a 13-inch photographic reflector equipped with a blink comparator, producing glass plates covering a $12° \times 14°$ sky area. A 22-yr old amateur astronomer from Kansas, Clyde Tombaugh, was in contact with the Observatory director, Vesto Slipher, for advice. Slipher found him so talented that he hired him to start the new search, based on a sky survey featuring repeated exposures of the same fields. Each plate recorded 50 000 to 500 000 stars (depending on the regions of the sky). The new equipment turned out to be decisive: two high-quality plates, taken on Jan. 23 and 29, 1930 in an area around δ Gem, showed a 15th magnitude object blinking at two different locations (3.5 mm apart on the plate), as can be seen on Fig. 3 (arrows).

Lowell's Planet X was found at last. The news spread out to other observatories, quickly confirming the discovery, and to the public, causing a sensation in the press and headlines of the *New York Times*. At least in America, the news was all the more welcome that it followed by three months only the "Black Friday" of Oct. 25, 1929, i.e., the start of the Great Depression. The name "Pluto" was adopted by the Lowell Observatory after many suggestions had circulated informally among the astronomical community and in the press. An added bonus was that the name Pluto started with the letters *P* and *L*, the initials of Percival Lowell... It had been proposed early on by a little girl, Miss Venetia Burney, aged 11, from Oxford, England, and cabled to Lowell Observatory by Oxford Professor and former Director of the University Observatory, H.H. Turner, who was also well-known for writing popularizing papers on astronomy for *The Times* in London (Turner 1930).

Remarkably, the IAU was not involved in this naming process. Yet H.H. Turner was very familiar with the IAU, having been President of two "Standing Committees" at the foundation of the IAU in 1919: No.17 (Lunar Nomenclature), and No.23 (*Carte du Ciel*) (see Blaauw 1994): there was apparently no official IAU process at the time for naming celestial objects (other than features on the Moon) in addition to scientific designations. In essence, it was implicitly admitted that it was the discoverer's privilege to name the new planet, all the more so since the Observatory was a private institution, which meant that the name had to be approved first by the Observatory trustees and by Percival Lowell's widow. Once decided, the name "Pluto" was simply communicated to the American Astronomical Society, and to the Royal Astronomical Society (of which H.H. Turner was a member), as it was spreading rapidly throughout the world.

All in all, this was probably the first modern example of an open (if improvised), *public* naming of celestial objects ! In spite of fact that the name finally adopted had not been

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proposed in America, the new planet *de facto* became an American planet, part of the national heritage — albeit tacitly — which was to become a source of problems and misunderstandings between the public (essentially in the USA) and the IAU, when it was reclassified as a dwarf planet in 2006.

4. Pluto: the IAU dragged into controversy

The status of Pluto as a planet like others in the Solar System had already been questioned for decades since its discovery. As time went by, better estimates of its size and mass became available. The discovery of its satellite Charon (Christy and Harrington 1978) allowed a true measurement of its mass ($0.002 M_{\rm Earth}$, or 1/6 the mass of the Moon), and *HST* images indicated a size smaller than the Moon, with some indications of surface features. But more importantly, the inclination (17° to the ecliptic) and size of its orbit (partly within Neptune's orbit when projected on the ecliptic, and with a high eccentricity $e = 0.25$), indicated major differences. Last but not least, other new worlds, minor Solar System bodies of size and mass comparable to Pluto or smaller, were discovered in the late '90s beyond Pluto's orbit, inside the so-called Kuiper belt, and classified as Trans-Neptunian Objects (TNOs), with an estimated population of 35 000 objects (Jewitt and Luu 1995). Among them, at least several hundred reside more or less in the same orbital plane as Pluto (also in a 3:2 resonance with Neptune). This multiplicity was strongly reminiscent of Ceres (discovered by Guiseppe Piazzi at Palermo Observatory on Jan. 1st, 1801), first thought to be the missing planet expected from Bode's law to lie between Mars and Jupiter, then soon appearing to be just the largest of a new class of objects, the "asteroids", forming a wide circular belt containing perhaps millions of objects of comparable size and (much) smaller.

So there were increasingly strong astronomical arguments in favour of creating a new class of Solar System objects sharing similar orbital properties, and of referring to Pluto as its most prominent member (a prototype of the class), with the perhaps unfortunate, but unavoidable, consequence of removing it from the list of historical planets, and thus pushing this list back to its 1846 eight-member census. This important dynamical argument, which was to be introduced in the discussion during the GA in Prague, is developed in detail by Soter (2006); for a more general discussion, see Basri and Brown (2006).

The discovery of the Trans-Neptunian objects, interestingly, came in much the same era as the discovery of the first exoplanets: first around a pulsar, strangely enough (Wolszczan and Frail 1992), then around a solar-type star (Mayor and Queloz 1995), quickly followed by many other discoveries (see, e.g., the `exoplanet.eu` web site). So all of a sudden our perception of planets and planetary systems was shattered, both within the Solar System, and outside it – around other stars. This radically new context spurred hot debates on "What is a planet?", both within the astronomical community, and within a large public, long before the IAU, after much hesitation, decided to revise the planetary status of Pluto (e.g., Tyson 2009; Weintraub 2007).

To possibly reconsider the scientific classification of planets, and thus of Pluto, the EC decided in 2004 to form a specific group (the "Planet Definition Committee", composed of seven members and chaired by Owen Gingerich) to work on this issue, with the idea to put forward appropriate Resolutions in time for a vote by the astronomers present at the 2006 GA in Prague. The work proved difficult, which was not too unexpected because Commission 53 of the IAU (Extrasolar Planets), involving the Solar System and exoplanet communities, and already in charge of this question at the request of the EC, had not been able to reach a consensus.

After much debate, even in the course of the GA (see Tyson 2009, for dissenting views; and also R. Ekers, this volume), which I didn't attend personally, two resolutions were put to the vote. The first resolution concerned the definition of a planet and of a dwarf

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RESOLUTION B5

Definition of a Planet in the Solar System

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, except satellites, in our Solar System be defined into three distinct categories in the following way:

(1) 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, and
(c) has cleared the neighbourhood around its orbit.

(2) A "dwarf 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[2],
(c) has not cleared the neighbourhood around its orbit, and
(d) is not a satellite.

(3) All other objects[3],except satellites, orbiting the Sun shall be referred to collectively as "Small Solar System Bodies".

[1] The eight planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.
[2] An IAU process will be established to assign borderline objects to the dwarf planet or to another category.
[3] These currently include most of the Solar System asteroids, most Trans-Neptunian Objects (TNOs),comets, and other small bodies.

Figure 4. Resolution B5 gives the IAU "Definition of a Planet in the Solar System", as voted during the 2006 General Assembly in Prague. The text was modified a number of times in the course of the meeting, but won a large majority of the votes by the astronomers present.

planet (Resolution B5, Fig. 4), and the second one (Resolution B6, Fig. 5) consisted of only one lapidary sentence: *Pluto is a dwarf planet by the above definition and is recognized as the prototype of a new category of Trans-Neptunian Objects.*

The results of the vote were significantly different for the two resolutions. According to several accounts (Weintraub 2007; Tyson 2009), 424 IAU members attended the 2nd Business Session of the GA (during which all the votes traditionally take place: administration and Resolutions). Since an estimated 2500 astronomers participated in the GA, and applying the usual statistics according to which $\sim 1/3$ of the participants stay for one of the two weeks, and $\sim 1/3$ stay for the whole GA, one can estimate that ~ 1700 members were present during the second week, so the participation was $\sim 25\%$. Resolution B5 was adopted by a large margin (over 90%), but the voters were more hesitant when it came to adopt Resolution B6, thereby removing Pluto from its full planet status: 237 votes in favour (56 %), 157 against, and 30 abstentions.

In addition, built in Resolution B6 was a sentence making reference to a new category of Trans-Neptunian Objects, with a footnote "An IAU process will be established to select

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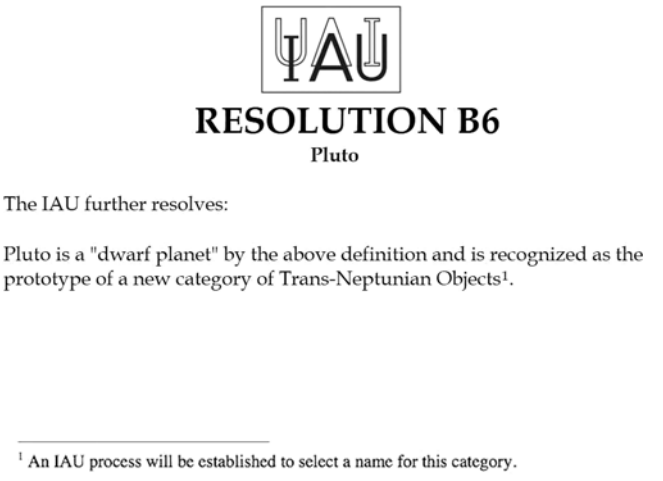

RESOLUTION B6

Pluto

The IAU further resolves:

Pluto is a "dwarf planet" by the above definition and is recognized as the prototype of a new category of Trans-Neptunian Objects[1].

[1] An IAU process will be established to select a name for this category.

Figure 5. Resolution B6, introducing the term "dwarf planet" and sealing the fate of Pluto. This joint resolution won less support, with only 56% of the votes in favour of it. Publicly, the text was widely referred to as the IAU "demoting" Pluto, in spite of the positive sentence "is recognized as the prototype of a new category..."

a name for this category" (Fig. 5): a third Resolution, proposing the name "Plutonian Object" for this category, was rejected, albeit marginally (183 in favour, 186 against). In addition, a fourth Resolution, on the "Definition of a Classical Planet", competing with Resolution B5, was rejected with only 91 votes in favour.

On Aug. 24, 2006, i.e., one day before the end of the General Assembly, the IAU announced a Press Conference by way of a Press Release, summarizing the motivations and the results of the votes for six adopted Resolutions, including the two about Pluto, and for the two others which did not pass (IAU_2006_03).

Obvioulsy, even among GA participants there was no unanimity about Pluto, and the adopted Resolutions were immediately criticized by the American media (e.g., Britt 2006, Overdye 2006; more examples in Tyson 2009), arguing in particular that the few hundred colleagues having voted in favour of both Resolutions represented only a small fraction of the IAU members —reaching almost 10 000 at that time. (The small participation of 25% quoted above may look surprisingly small, but it is not unusual for votes at GAs, although maybe most participants did not realize the importance of this vote, or perhaps felt incompetent to make a decision.)

Even though Resolution B5, and its corollary Resolution B6 on Pluto were scientific ones, the IAU also faced severe criticism from the US astronomical community, noting however that, for various reasons, only about half of the US astronomers are IAU members (totalling over 3000), and thus the remaining ones would not have been involved in the decision anyway. The reaction to the vote came in the form of a petition, launched shortly after the end of the GA, on Aug. 31, by Mark Sykes, director of the Planetary Science Institute in Tucson, and Alan Stern, Executive Director of the Space Science and Engineering Division of the Southwest Research Institute (now in Boulder, Co.) (see the "Postscripts" in Weintraub 2007, for details and comments). Entitled *Protest the IAU Planet Definition*, it drew in a few days over 350 signatures, but that was it. No justification is posted any more on its original web site, which in fact is still open (https://www.ipetitions.com/petition/planetprotest/), but it originally read: "*We, as planetary scientists, and astronomers, do not agree with the IAU's definition of a planet, nor will we use it. A better definition is needed*" (Weintraub 2007, one of the signatories). The signatories total 405 to this day, as presented on

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the web site, but the full list is hard to recover (there are only names with countries, some obviously only nicknames, like "Viva La Pluto"; and they are available only by groups of twenty). However, the original list of 2006 has been reconstructed recently (Laurele 2017). The vast majority were indeed active planetary astronomers, but actually only about fifteen were working outside the US, reinforcing the impression that the controversy over the new status of Pluto was primarily a US problem, not an international one.

Actually, this petition did not appear to have made much impact in the press and the media. The IAU attracted all the light – and all the flak. Even though the IAU never mentioned the expression, the widespread way to describe the IAU Resolution in the press was that Pluto had been "demoted", or "downgraded", from its status – very negative statements indeed, whereas Resolution B5 was on the contrary meant to be very positive: "Pluto is recognized as the *prototype* [my emphasis] of a new category [of Trans-Neptunian Objects]". A detailed explanatory theme on Pluto was soon posted on the IAU web site (Ref.: *IAU:Pluto2006*).

Coincidentally (or perhaps not?), 2006 was also the year of the launch (on Jan. 19, just six months before the Prague GA), of NASA's *New Horizons* mission to Pluto, led by Alan Stern, one of the "protest" petition organizers. Instead of the expected appeasement as years went by, the fight for "Pluto is a planet" continued in America. This fight became more and more focused against the IAU as *New Horizons* approached its target, a flyby due to take place just a month before the 2015 GA in Honolulu – more than nine years after its launch, and also, as it turned out, synchronized with a GA!

When I took over as General Secretary at the 2012 GA in Beijing, a full six years after Resolution B6 had passed, this climate of controversy had not subsided. Angry letters from the public (again almost exclusively from the USA) reached the IAU Secretariat on a fairly regular basis (fortunately not too frequently, typically a few per month), requesting Pluto to be reinstated in its pre-2006 status, many of them sent by schoolchildren, obviously under the influence of their teachers or parents (e.g., like the one shown in Fig. 6, received in 2014). Emails were also sent directly to me as GS, sometimes insulting or extremely violent (I remember for instance: "IAU astronomers should be put to the wall and shot"!!). Press campaigns continued (e.g., ET 2014, Fig. 7).

While these were after all sometimes unpleasant but private initiatives, the situation started to deteriorate again with the opening of a new front, not about the IAU planet definition, but against what was described as an IAU unacceptable, "elitist" monopoly: the prerogative of giving official designations to celestial objects and their features. The flak again came from the *New Horizons* PI, Alan Stern. By creating the *Uwingu* web site, A. Stern (albeit not explicitly) attacked the IAU on two fronts: in 2013, *Uwingu* invited the public to give names (with very few restrictions) to exoplanets (without prior selection) for a research crowd-funding fee (Uwingu 2013, Fig. 8; see, e.g., comments by Francis 2013, Gannon 2013); and in 2014, similarly to give names to Mars craters (also almost without restrictions – people could name their favourite crater after their pet animal! (Uwingu 2014, Fig. 10)). Although these names were clearly said in the *Uwingu* web site to be unofficial, the IAU, with the efficient help of its Press Office and under the guidance of its Head, Lars Lindberg Christensen, prepared several press releases drawing attention of the public to the possible confusion such names, though unofficial, would create among amateurs and professional alike, and to the fact that having to pay a fee, even if it were for a good cause, was against the IAU policy to consider the universe as free for humanity (Refs. IAU_2013_01: Fig. 9; IAU_2014_02). These press releases in turn drew angry responses from *Uwingu* (e.g., Kramer 2014, Fig. 11), but the IAU had made its point and more balanced discussions ensued in the press about the appropriate way to name celestial objects.

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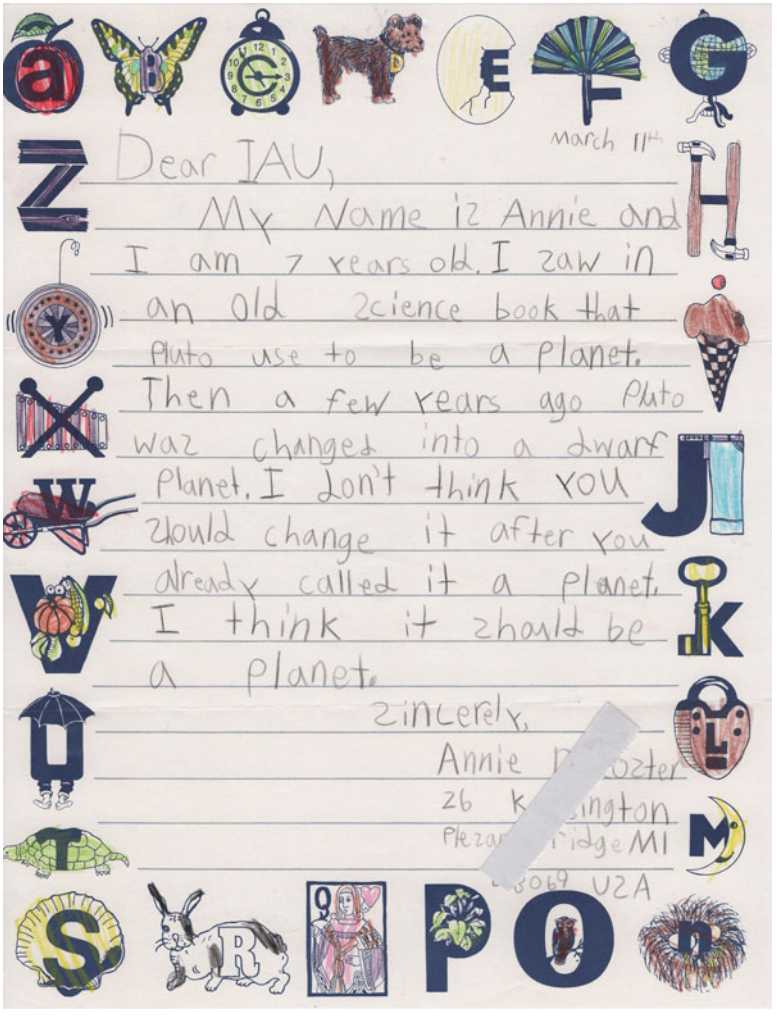

Figure 6. Letter sent to the IAU on March 11, 2014 (the year appears on the envelope) by Annie [name withheld], a seven-yr old American girl, quite typical (but much more decorative!) of letters sent by children to the General Secretary over the years. Note that Annie wasn't even born when the IAU re-classified Pluto, so she refers here only to an old science book – likely belonging to her parents – rather than to an up-to-date one.

5. The IAU strikes back

Still, those examples showed that the IAU seemed always on the defensive when attacked, and not necessarily convincing the lay public and the media. In 2009, the UNESCO-endorsed International Year of Astronomy was organized by the IAU, and proved to be a tremendous success (just to give two numbers: an estimated 850 million people participated in astronomical events in 125 countries!). It could have been legitimately thought that the IAU would then emerge more popular and "forgiven", so to speak, for whatever Pluto sin it would have committed, but as mentioned above, the launch of *New Horizons*, notwithstanding, restarted the campaign against the IAU.

There were many discussions at the time between the Executive Committee and Division Presidents, and with other experts involved in Solar System and planetary research, the two fields directly concerned by the *Uwingu* campaigns, on how to react.

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Figure 7. Example of a press article pushing for restoring the status of Pluto, here just a few months before the 2015 Honolulu General Assembly (Ref. ET 2014). Note the caption to the figure in the article: "The celestial body... is the planet that was so rudely downgraded to 'dwarf planet' eight years ago."

Figure 8. Screenshot of the *Uwingu* web site inviting the public to name exoplanets. The fees for proposing a name ($9.99), and for voting on names already in the database ($0.99), are given. These fees are described as crowd-sourcing fees for funding space exploration and other activities.

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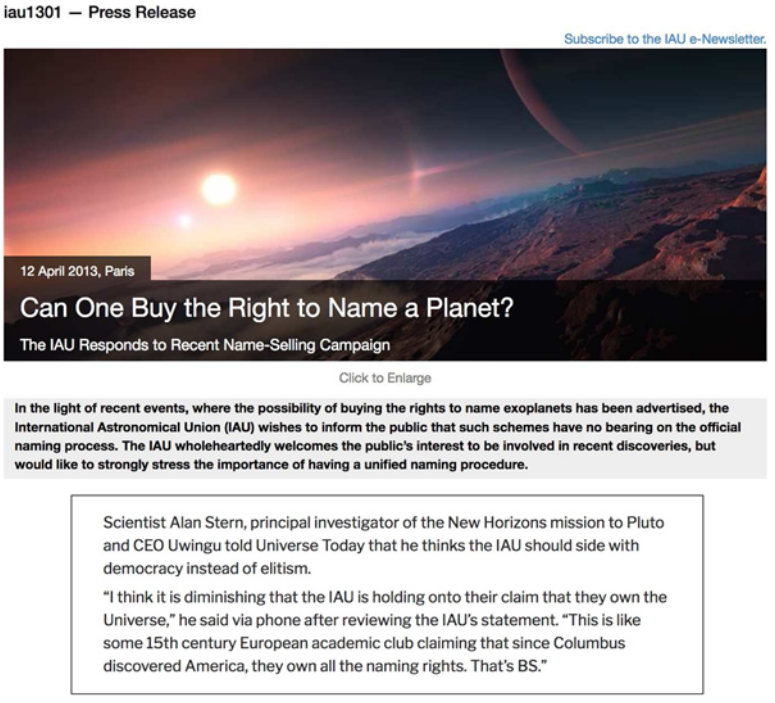

Figure 9. IAU Press Release in reaction to the *Uwingu* exoplanet naming campaign (2013, Fig. 8), and (under it) the text of one of the many interviews in the same vein by the *New Horizons* PI in counter-reaction (Atkinson 2013, *Universe Today* web site)

Figure 10. *Uwingu* certificate of Mars crater naming (2014). The proposed names were added to the NASA maps of Mars, and displayed on their web site.

These experts were from the WG on Planetary System Nomenclature (WGPSN), the WG on Small Bodies Nomenclature (WGSBN), and the IAU Minor Planet Center, as well as experts in communicating with the public (the IAU Press Office in Munich and the newly created IAU Office for Astronomy Outreach in Tokyo). Since about 1000 scientifically interesting Mars craters already had IAU-sanctioned names, it was thought that an IAU campaign aimed at restoring the status of unofficial craters, or launching its own call for the public naming of new craters, would only create more confusion.

The situation for exoplanets was different. By 2013, about 1000 exoplanets were known, but only had professional, "licence-plate" designations, e.g., "HATS-71A b". The obvious

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Figure 11. Example of a comment about the IAU Press Release criticizing the *Uwingu* initiative for the public naming of Mars craters (Ref. IAU_2014_02). Note that the IAU is surprisingly referred to as "Astronomy Group".

connection with the possibility of life elsewhere in the universe and/or the eventuality of discovering a twin Earth (sometimes dubbed "Earth 2.0"), enflamed the imagination of the public, this time truly world-wide. An example that really sent waves into the IAU (and its General Secretary) was a petition addressed to the IAU, entitled *To rename the newly discovered planet "HD 106906 b" to Gallifrey! In honour of Doctor Who and its 50 years!*, and launched that year by a young Australian fan, who referred to the famous BBC science-fiction series – Gallifrey being the home planet of its namesake (Mennenhet 2013). Within a few weeks only, the petition had reached over 100 000 signatures, and was closed at 139 274 while still going strong, when I sent a reply mentioning that the IAU was in the process of elaborating its own process to invite the public to name exoplanets, and that the name "Gallifrey" could perhaps be re-proposed, but this time according to the rules (it wasn't).

Indeed, unlike *Uwingu*, the IAU, in particular with its Commission 53 on Extrasolar Planets, had an unchallenged expertise to select, on a scientific basis, confirmed exoplanets or exoplanetary systems (i.e., having mass estimates, orbital characteristics, etc.), so that the sample would be as diverse as possible, and with no risk of exoplanets being removed later from catalogues in case of a dubious detection. Therefore, offering the public world-wide a process to give carefully selected exoplanets an official name, provided the IAU with a highly visible initiative, at the same time as restoring the value of science. To this end, the EC created an "EC Working Group on Public Naming of Planets and Planetary Satellites" (see Montmerle *et al.* 2016, for details), which set up a contest called *NameExoWorlds*, launched in 2014 (Ref. IAU_2014_04). The goal was to announce the results at the following GA (Honolulu, 2015), so time was short.

In brief, the process called for three steps implying mass voting via the Internet:
– registration not by individuals, but by groups or associations ("clubs") with an interest in astronomy;
– vote by these clubs to choose the exoplanetary systems to be named among a list provided by the IAU (the list comprised 260 systems of one to five exoplanets, totalling 305 candidates);

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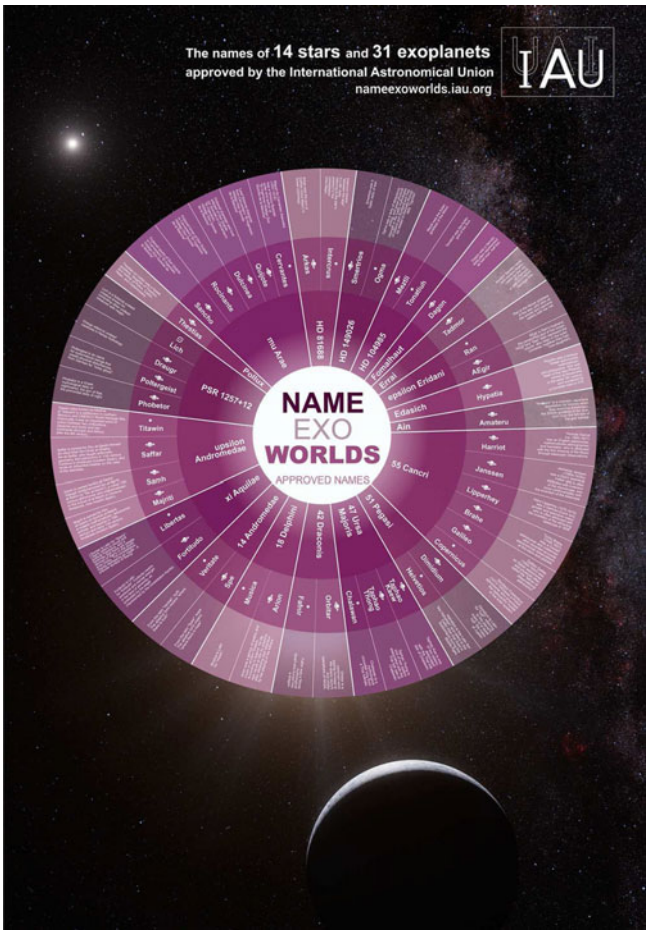

Figure 12. "Wheel of Fortune" created by the IAU Press Office to illustrate the results of the *NameExoWorlds* contest (Ref. IAU_2015_14). The details are explicited in the Appendix.

– selection of the top 20 voted systems;
– clubs proposing names for only one of these systems: one name for each planet in case of a multiple system, and a name for the host star (if not already known; see below), the existence of some generic link between all the names within the chosen system being encouraged;
– public vote world-wide in favour of the names proposed by clubs.

The winners were the clubs having proposed names obtaining the largest number of public votes for each system.

All in all, the process went rather smoothly, but two hurdles had to be circumvented: one was the Zooniverse organization, in charge of setting up the public vote, pulling out abruptly just a few weeks before the Honolulu GA; the other was the late discovery that one of the names proposed turned out to be that of a person having been involved in politics early in his life, which was forbidden by the rules, resulting in the cancellation of the corresponding votes. In spite of these last-minute hurdles, and thanks to the efficient action of Sze-leung Cheung, International Outreach Coordinator of the OAO in Tokyo, the contest results could be announced as planned at a special session during the Honolulu GA, after having received over half a million votes, from 182 countries and territories (Ref. IAU_2015_14; [Fig. 12]). The winners turned out to be evenly spread

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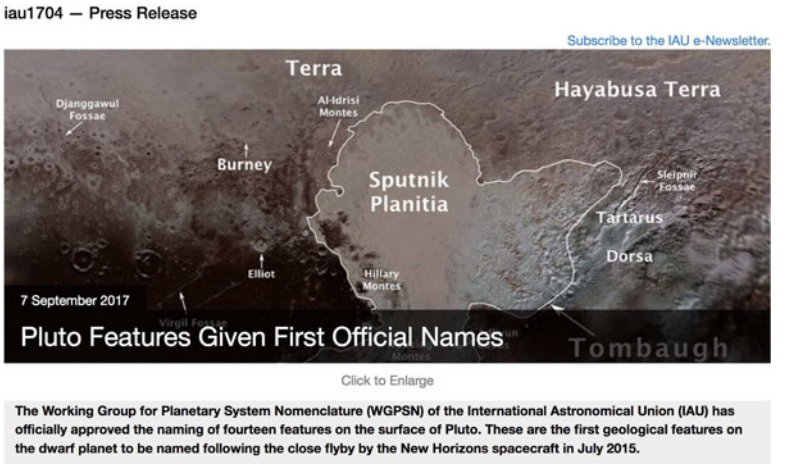

Figure 13. IAU Press Release (Ref. IAU_2017_04) announcing the approval by the Working Group for Planetary System Nomenclature of a first set of 14 surface features of Pluto, discovered by *New Horizons* and initially proposed by the team.

across the continents (see Appendix, from Montmerle *et al.* 2016), and won the right to give names to Minor Planets of their choice (Ref. IAU_2017_04). Over 800 press articles were published world-wide in the course of the contest.

6. Peace at last?

The first images of the *New Horizons* flyby, in July 2015, immediately showed that the mission was a spectacular success, recognized both scientifically and in the general public world-wide. In a way, if Pluto, because of the IAU Resolution adopted nine years earlier, had seemingly lost its American planet status, the flyby images certainly gave it a universal status this time – dwarf planet or not. The irony of it is that, after having visited Pluto, the *New Horizons* spacecraft is now directed towards more distant official dwarf planets: it reached (4086958) $2014MU_{69}$ in a fly-by on Jan. 1, 2019, and this small body (the farthest solar-system object ever photographed by a space probe) was provisionally nicknamed *Ultima Thule* (Ref. IAU_2019_01).

Still, there were some remaining frictions with the IAU, about the characterization and naming of Pluto surface features. Following NASA rules, these have to be formally approved by the IAU, on behalf of its Division F Working Group on Planetary System Nomenclature. The issue is not so much about the names themselves, but about the exact definition and borders of the features, following the same rules as established for other Solar System objects (see the example of Venus above) and drawn, as for the Moon, from geological terminology (in Latin). Eventually, an agreement was found between the IAU and the *New Horizons* team, even inviting public participation to name the two latest HST-discovered Pluto satellites (Kerberos and Styx) in the meantime (Ref. IAU_2013_03), bringing the "Pluto War" to an end (Refs. IAU_2015_02, IAU_2017_04 [Fig. 13], and IAU_2018_03). The *Uwingu* web site itself closed in 2017, thus ending also the "Mars and Exoplanets (naming) War".

Then – what about the status of Pluto and of the IAU planet definition now?

As far as one can tell, the dwarf planet status of Pluto now seems to be widely accepted, by the public (see Wikipedia for example), and within the international community (NASA has enforced the application of the IAU 2006 Resolutions), especially as more and more dwarf planet candidates are now known: currently, three of them have been confirmed by the IAU in the outer Solar Sytem in addition to Pluto (Eris, Haumea

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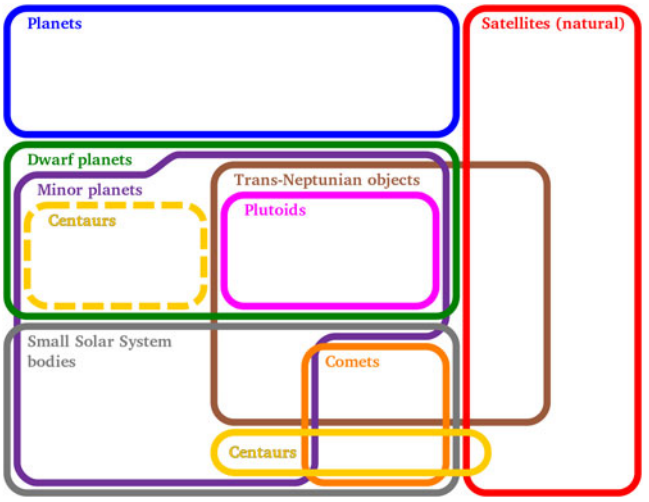

Figure 14. An Euler diagram (i.e., overlapping categories) of Solar System objects, illustrating the complexity of the problem of their scientific classification, and in particular that of the dwarf planets (Source: Wikipedia).

and Makemake). The largest asteroid, Ceres, once considered the missing planet after its discovery as already mentioned, then later the prototype of asteroids, is now also classified as a dwarf planet by the IAU. The status of comparable minor bodies of the Solar System is pending, and it is not excluded that other planetary categories will need to be created. But one should admit that the classification of Solar System bodies is a complex issue, often involving, like Ceres, more than one class for the same object (see Fig. 14 showing an Eulerian diagram for Solar System bodies).

The planet definition adopted in 2006, on the other hand, is still not considered fully satisfactory by many astronomers, and campaigns to restore the original status of Pluto are not over (see, e.g., Laurele 2018). But the fact is that, twelve years after it has been adopted, and in spite of criticisms, no-one has officially proposed a better definition in the form of a new IAU Resolution replacing Resolution B5. Perhaps one will emerge in professional papers, albeit too complex or short-lived to be the object of a future Resolution. After all, there is no IAU Resolution defining a "star" or a "galaxy" – let alone a "brown dwarf", or even... a "giant planet"! Simply take your favourite dictionary, and, for the time being, it will probably give you the answer at the level you need.

Or perhaps there is simply no answer (or only multiple answers) to the question: "What is a planet?", no more that there is one to an equally fundamental question: "What is life?".

7. The future: other public names for celestial objects?

The *NameExoWorlds* contest had a specific feature that went rather unnoticed, but which is consubstantial to planet formation: naming not only the planets making up a multiple system, but also naming their host star, since they were basically formed together. The organizers of the contest came to realize that there was no official, IAU-sanctioned catalogue of star names! Yet we all know that many stars have had some form of public names since the dawn of civilization, coming from cultures all around the world.

So a small group of astronomers and historians, led by Erik Mamajek (JPL), decided to form a Working Group on Star Names, endorsed by IAU Division C, first to formally adopt the public star names from the *NameExoWorlds* contest, and then to compile, as much as possible, the literature and various historical sources, and, after a critical

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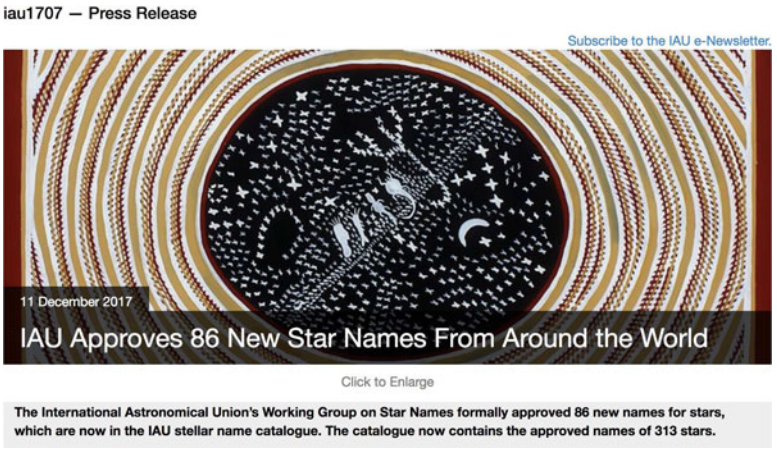

Figure 15. IAU Press Release (Ref. IAU_2017_17) announcing the formal approval of 86 star names from all over the world by the Working Group on Star Names, bringing the current census to 313. (The illustration is courtesy of Australian Aboriginal Wardaman artist Bill Yidumduma Harney.)

examination, decide to attribute a unique, historical or cultural name to the relevant, visible stars. Among other criteria, a unique name can be one selected among many spellings for the same star (arising for instance from the many different transliterations of Arabic names over the centuries), or names from other, non-Western cultures (like Australian Aboriginal or Polynesian star names). The work is now in progress, and has currently yielded a catalogue of 313 star names from over a dozen cultures (see Fig. 15, Ref. *IAU:WGStarNames*).

As concerns the near future, a second edition of the *NameExoWorlds* contest will be set up in the framework of the centennial anniversary of the IAU in 2019 (Ref. IAU100_2018). As discussed in this paper, the first edition had been organized in a very particular context in the aftermath of the discovery of the new planetary systems (outer Solar System on the one hand, exoplanets on the other); the second edition will be organized in a different context, so as to involve all countries from the start. Still, requests by the public to give names to other celestial objects like stars or even nebulae (which often already have popular names, or nicknames, sometimes introduced by astronomers themselves) keep being sent to the General Secretary or other IAU officials, so perhaps in a more distant future the public will be again called in by the IAU for another exciting naming campaign.

8. Discussion

Beckman: I am fully in agreement with the IAU's policy of giving formal names to astronomical objects, including the *"Name Exoworlds"* action. However with Pluto the problem is that the IAU does not have a mandate to DEFINE astronomical objects. If this is correct, the IAU exceeded its mandate in that case.

Montmerle: I wasn't in Prague, and I didn't participate in the planet definition process. I agree with you in principle (there is no definition by the IAU of a "star"). But at that time, I believe there was a strong pressure on the IAU (i.e., its leadership) to give a "planet definition". After all, the IAU does have the mandate to represent all astronomers worldwide, and since the process eventually included a vote by the astronomers (according to the rules existing at the time), I would say that the "mandate" you mention was *de facto* given to the IAU by its members, as indicated by the vote. One may dispute it, but the process strictly followed the IAU rules of the time.

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Now electronic voting has been added to these rules, which will indeed when used engage the community on a broader scale than only the GA participants. The example of the *"Hubble–Lemaître Law"* is a first illustration of this new process.

As an aside, concerning the "Planet Definition", no one has proposed a new (better?) definition. I am sure the IAU would be ready to submit a new definition to a vote, should there be one in the future.

Acknowledgements

It is a pleasure to thank Ginette Rude, IAU Archivist in Paris until her retirement in 2017, who did a great service to the IAU by providing us with many historical records. I would like to mention in particular the composition of past IAU committees (now available on the IAU web site), and here, copying for me a thick folder of correspondence exchanged in the late '60s between the IAU Secretariat, NASA officials, and the Soviet Academy of Sciences during the Moon race, which may be the subject of a future publication. It is also a pleasure to thank Lars Lindberg Christensen, Head of the IAU Press Office in Garching, who provided me with valuable comments on the manuscript.

References

Basri, G., Brown, M. E. 2006, *Ann.Rev.Earth Plan.Sci.*, 34, 193

Blaauw, A. 1994, *History of the IAU: The Birth and Half-Century of the International Astronomical Union* (Dordrecht: Kluwer), 296 pp.

Christy, J. W., Harrington R. S. 1978, *AJ*, 83, 1005

Daston, L. 2017, in *Science in the Archives* (L. Daston, Ed., U. Chicago Press), p.159

Delporte, E. 1930, *Délimitation scientifique des constellations (tables et cartes): Report of IAU Commission 3* (Cambridge: The University Press); reprinted as *Atlas Céleste*, 2013

Hoyt, W. G. 1980, *Planets X and Pluto* (Tucson: University of Arizona Press), 302 pp.

Isaacson, W. 2007, *Einstein, His Life and Universe* (New York: Simon & Schuster), 680 pp.

Jewitt, D., Luu, J. 1995, *AJ*, 109, 1867

Lamy, J. 2006, *La Carte du Ciel* (EDP Sciences, Les Ulis, France), 250 pp.

Mayor, M., Queloz, D. 1995, *Nature*, 378, 355

Montmerle, T., Benvenuti, P., Cheung, S.-L., Christensen, L. L., Lecavelier Des Etangs, A., Liu, Xiao Wei, Lubowich, D., Mamajek, E., Schulz, R., Valsecchi, G., Williams, G., Williams, R. (Executive Committee Working Group: Public Naming of Planets and Planetary Satellites) 2016, *Transactions of the International Astronomical Union* (Cambridge University Press), Series A, 29, 539–548, arXiv:1607.00304

Moreux, T. (Abbé) 1924, *La Vie sur Mars* (G. Douin, Paris), 92 pp.

Soter, S. 2006, *AJ*, 132, 2513

Turner, H. H. 1930 (Obituary), *J.Roy.Astr.Soc.Canada*, 24, 402

Tyson, N. DeGrasse 2009, *The Pluto Files: The Rise and Fall of America's Favorite Planet* (W. W. Norton & Co., New York, London), 194 pp.

Weintraub, D. 2007, *Is Pluto A Planet? A Historical Journey through the Solar System* (Princeton University Press), 262 pp.

Whitaker, E. A. 2003, *Mapping and Naming the Moon* (Cambridge University Press), 242 pp.

Wolszczan, A., Frail, D. A. 1992, *Nature*, 355, 145

Web sites cited

1. IAU web pages

IAU:About
www.iau.org/administration/about

IAU:Naming
www.iau.org/public/themes/naming

IAU:NamingStars
www.iau.org/public/themes/naming_stars

IAU:Pluto2006
www.iau.org/public/themes/pluto
IAU:WGPlanetaryNames
www.iau.org/science/scientific_bodies/working_groups/98
IAU:WGStarNames
www.iau.org/science/scientific_bodies/working_groups/280

2. IAU Press Releases

IAU_2006_03
IAU 2006 General Assembly: Result of the IAU Resolution votes
www.iau.org/news/pressreleases/detail/iau0603
IAU_2013_01
Can One Buy the Right to Name a Planet ?
www.iau.org/news/pressreleases/detail/iau1301
IAU_2013_03
Names for New Pluto Moons Accepted by the IAU After Public Vote
www.iau.org/news/pressreleases/detail/iau1303
IAU_2014_02
Concerns and Considerations with the Naming of Mars Craters
www.iau.org/news/pressreleases/detail/iau1402
IAU_2014_04
NameExoWorlds: An IAU World-wide Contest to Name Exoplanets ...
www.iau.org/news/pressreleases/detail/iau1404
IAU_2015_02
Campaign for Public Participation in Naming Features on Pluto
www.iau.org/news/pressreleases/detail/iau1502
IAU_2015_14
Final Results of NameExoWorlds Public Vote Released
www.iau.org/news/pressreleases/detail/iau1514
IAU_2017_01
17 Minor Planets Named by NameExoWorlds Contest Winners
www.iau.org/news/pressreleases/detail/iau1701
IAU_2017_04
Pluto Features Given First Official Names
www.iau.org/news/pressreleases/detail/iau1704
IAU_2018_03
Pluto's Largest Moon, Charon, Gets its First Official Feature Names
www.iau.org/news/pressreleases/detail/iau1803
IAU100_2018
100 years: Under One Sky
www.iau.org/public/iau100
IAU_2019_01
Naming of (486958) 2014 MU69, Nicknamed Ultima Thule
www.iau.org/news/announcements/detail/ann19001

3. External web sites cited (in chronological order)

Magellan 1991
Public Invited to Name Features on Venus (NASA/JPL)
www2.jpl.nasa.gov/magellan/pr1353.html
Britt, R. R. 2006
Pluto Demoted: No Longer a Planet in Highly Controversial Definition
www.space.com/2791-pluto-demoted-longer-planet-highly-controversial-definition.html
Overbye, D. 2006
Pluto Is Demoted to 'Dwarf Planet'
www.nytimes.com/2006/08/24/science/space/25pluto.html

https://doi.org/10.1017/S1743921319000176 Published online by Cambridge University Press

Menhennet, S. 2013
(Gallifrey petition)
www.change.org/p/international-astronomical-union-to-rename-the-newly-discovered-planet-hd-106906-b-to-gallifrey-in-honour-of-doctor-who-and-its-50-years-even-if-it-s-just-a-second-name-or-officially-recognised-as-also-known-as-gallifrey-gallifreyfound
[139274 signatures]
Uwingu 2013
About Exoplanet Naming and Voting
www.uwingu.com/nominate-planet-names/about-planet-naming-and-voting
Francis, M. 2013
How to Name a Planet
www.newyorker.com/tech/annals-of-technology/how-to-name-a-planet
Gannon, M. 2013
Can You Buy Exoplanet Naming Rights ? –No Astronomy Group Says
www.nbcnews.com/id/51527444/ns/technology_and_science-space/t/can-you-buy-exoplanet-naming-rights-no-astronomy-group-says/#.W7OD81KYTUI
Uwingu 2014
The People's Map of Mars
www.uwingu.com/mars
Kramer M. 2014
You Can Name a Mars Crater, but Astronomy Group Spoils the Fun
www.space.com/25028-mars-crater-names-uwingu-iau.html
ET 2014
After being demoted to a dwarf planet in 2006, Pluto might get its status back
economictimes.indiatimes.com/magazines/panache/after-being-demoted-to-a-dwarf-planet-in-2006-pluto-might-get-its-status-back/articleshow/44734176.cms
Laurele 2017
87 Years of Pluto: Complete List of Signatories Who Signed 2006 Petition Rejecting IAU Definition
laurele.livejournal.com/84027.html
Original 2006 petition www.ipetitions.com/petition/planetprotest
[405 signatures]
Laurele 2018
Pluto: The IAU Position is Opinion, not Fact
laurele.livejournal.com/93342.html

Appendix: Stellar and planetary names officially adopted in 2015 as a result of the *NameExoWorlds* contest (Montmerle *et al.* 2016).†

Star/Planet	*Designation*	*Adopted name*	*Country*	*Club/Association*
Star	14 And	Veritate	Canada	Astronomy Club
Planet	14 And b	Spe		
Star	18 Del	Musica	Japan	High School
Planet	18 Del b	Arion		
Star	42 Dra	Fafnir	USA	Astronomy Club
Planet	42 Dra b	Orbitar		
Star	47 UMa	Chalawan	Thailand	Astronomy Club
Planet	47 UMa b	Taphao Thong		
Planet	47 UMa c	Taphao Kaew		
Star	51 Peg	Helvetios	Switzerland	Astronomy Club
Planet	51 Peg b	Dimidium		

† (Citations and club names can be found at nameexoworlds.iau.org/names).

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Star/Planet	*Designation*	*Adopted name*	*Country*	*Club/Association*
Star	55 Cnc	Copernicus	Netherlands	Astronomy Club
Planet	55 Cnc b	Galileo		
Planet	55 Cnc c	Brahe		
Planet	55 Cnc d	Lipperhey		
Planet	55 Cnc e	Janssen		
Planet	55 Cnc f	Harriot		
Planet	Ain b (ϵ Tau b)	Amateru	Japan	Astronomy Club
Planet	Edasich b (ι Dra b)	Hypatia	Spain	Student Association
Star	ϵ Eri	Ran	USA	Middle School
Planet	ϵ Eri b	AEgir		
Planet	Errai b (γ Cep b)	Tadmor	Syria	Astronomy Club
Planet	Fomalhaut b (α PsA b)	Dagon	USA	Astronomy Club
Star	HD 104985	Tonatiuh	Mexico	Astronomy Club
Planet	HD 104985 b	Meztli		
Star	HD 149026	Ogma	France	Astronomy Club
Planet	HD 149026 b	Smertrios		
Star	HD 81688	Intercrus	Japan	Astronomy Club
Planet	HD 81688 b	Arkas		
Star	μ Ara	Cervantes	Spain	Astronomy Club
Planet	μ Ara b	Quijote		
Planet	μ Ara c	Dulcinea		
Planet	μ Ara d	Rocinante		
Planet	μ Ara e	Sancho		
Planet	Pollux b (β Gem b)	Thestias	Australia	Astronomy Club
Star	PSR 1257+12	Lich	Italy	Astronomy Club
Planet	PSR 1257+12 b	Draugr		
Planet	PSR 1257+12 c	Poltergeist		
Planet	PSR 1257+12 d	Phobetor		
Star	υ And	Titawin	Morocco	Astronomy Club
Planet	υ And b	Saffar		
Planet	υ And c	Samh		
Planet	υ And d	Majriti		
Star	ξ Aql	Libertas	Japan	Student Association
Planet	ξ Aql b	Fortitudo		

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