Jürgen Blunck

Solar System Moons

Discovery and Mythology

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Foreword

Springer is proud to be publishing Dr. Jürgen Blunck's last book, *Solar System Moons*, in the International Year of Astronomy 2009. Sadly, Dr. Blunck passed away during the copy-editing phase in summer 2008, leaving some technical questions on the manuscript unanswered. We have sought to complete the book as carefully as possible and would like to gratefully acknowledge the kind support of the author's wife, Mrs. Zofia Blunck.

Jürgen Blunck received his PhD in history at the University of Kiel in 1961. His last employment before he retired in 2000 was as librarian senior councilor at the Berlin State Library. In September 2002 he was nominated as a consulting member of the IAU Working Group on Planetary System Nomenclature (WGPSN). In his journal articles and book publications he focused on the history of planet cartography. He was the author of several books in English and German, namely "Mars and Its Satellites", "Götter in Planeten und Monden", "Der rote Planet im Kartenbild", "Wilhelm Beer – Genius der Astronomie und Ökonomie", and "Wie die Teufel den Mond schwärzten".

Dr. Blunck's last book, *Solar System Moons – Discovery and Mythology*, is an entertaining and educating work collecting in a concise format (he used to refer to it as a "manual") the astronomical facts on the discovery of the satellites and rings of the solar system planets and the mythological backgrounds of their names.

Tamara Biese and Ramon Khanna
Springer-Verlag, Heidelberg

Preface

In the history of modern astronomical research, the discoveries of the planetary satellites have, numerically speaking, represented (apart from the inflationary increase in known minor planets) its greatest success. This is due to the space probes that have been sent into the outer solar system in recent decades, as well as (and particularly) advances in CCD technology, which have made it possible to detect satellites that are as small as a kilometer in size. Fifty years ago, in order of the sequence of planetary orbits beyond the Earth's orbit, two satellites of Mars, eleven satellites of Jupiter, eight satellites of Saturn, five satellites of Uranus and two satellites of Neptune were known. By the year 2007, this number of known satellites had grown dramatically: besides the two Martian satellites, 63 satellites of Jupiter, 62 satellites of Saturn, 14 satellites of Uranus, 13 satellites of Neptune, and four satellites of the former planet Pluto—which was downgraded to a "dwarf planet" by the General Assembly of the International Astronomical Union in Prague in 2006—had been discovered. This "downgrading" also happened to the newly discovered Pluto-like object named Eris, a dwarf planet with one known satellite.

Now that satellites only a kilometer across have been found, it is natural to consider the definition of a satellite. The term "satellite" was first used by Johannes Kepler in his pamphlet *Narratio de Iovis Satellitibus*, Frankfurt 1611. Officially, a satellite is a solid object in orbit around a planet, dwarf planet, minor planet or trans-Neptunian object. A natural satellite is sometimes referred to as a "moon" in popular usage. However, Earth's own satellite is called "the Moon" in both scientific and popular speech. All satellites are designated with Roman numerals and a name. Of course, this does not resolve the question of how big a body must be to be classified as a "satellite." A satellite smaller than one kilometer across has not yet been discovered, and it is not clear whether such small satellites would be given proper names.

The naming of a satellite occurs in parallel with its discovery, although it can sometimes be a lengthy procedure. Satellite baptism was and still is the indisputable right of the discoverer, who voluntarily only proposes names that are in line with the names of previously discovered satellites of the (dwarf) planet around which the newly discovered satellite orbits.

Two exceptions have been made during the history of satellite designation. First, the initial seven satellites of Saturn were named by William Herschel's son John, after the initial use of numbers alone to denote them caused confusion. It was also John Herschel who in 1851 named four hitherto unnamed satellites of Uranus. Second, all of the satellites of Jupiter discovered between 1892 and 1974, which had remained unnamed according to the explicit wishes of the discoverers, were nevertheless assigned names by the International Astronomical Union in 1975; these names were figures from the court of Jupiter/Zeus in Greco-Roman mythology.

From 1919 onwards, the responsibility for deciding upon satellite names rested upon the shoulders of the International Astronomical Union, before this responsi-

bility was shifted in 1973 to a special Working Group for Planetary System Nomenclature (WGPSN).

The steps involved in naming a newly discovered object accompanying a planet are fixed according to international guidelines. The object is reported by the discoverer to the Central Bureau for Astronomical Telegrams (CBAT) in Cambridge, MA, USA, and it then receives a temporary designation, such as S/2007 S1 for a satellite of Saturn or R/2004 S1 for a ring of Saturn. Having been designated in this way, the object is announced in the IAU Circulars, a series of postcard-sized announcements.

Names for newly discovered satellites are developed jointly by the WGPSN and the IAU Commission 20 (Positions and Motions of Minor Planets, Comets and Satellites). Names are not assigned to satellites until their orbital elements are reasonably well known. As soon as the new satellite is confirmed (e.g., by rediscovery), the discoverer suggests a name that is then discussed by the WGPSN; in this case initially by its Outer Solar System Task Group and then by its other members. This panel reports directly to the IAU's Executive Committee, after which its recommendations are approved by the General Assembly, which meets every three years.

Greco-Roman names dominate satellite nomenclature, and the Roman version prevails among Greco-Roman names.

The rules for naming the satellites of Saturn changed somewhat in 2000. The many irregular satellites discovered in that year were grouped after their semi-major axes, their inclinations and their eccentricities, and they received names from other languages, mainly the names of giants. An Inuit group, a Gallic group and a Norse group were suggested by the discoverers and adopted by the International Astronomical Union. The myths of the relevant peoples and even characters from children books were used to name these satellites.

This manual contains chronological overviews of the discoveries of satellites and rings, background information on how they were named, and also selections from the sources from which the names of the satellites originated. Finally, plates containing data on the orbital elements and discoveries of the satellites are provided.

Further information on the planetary satellites, especially the names of their many topographic surface features, is available on the Internet (see the *Gazetteer of Planetary Nomenclature*).

The satellites of minor planets are not taken into account in this manual.

Berlin, January 2008 Jürgen Blunck

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The Satellites of the Dwarf Planets

The Satellites
and
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Photograph on opposite page: Mars and the tiny Phobos and Deimos, photographed by James McGaha on August 29, 2003, using a ToUcam on a 36-inch reflector atop Kitt Peak

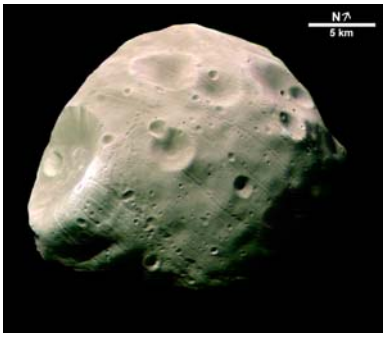
The Satellites of Mars

The Satellites of Mars

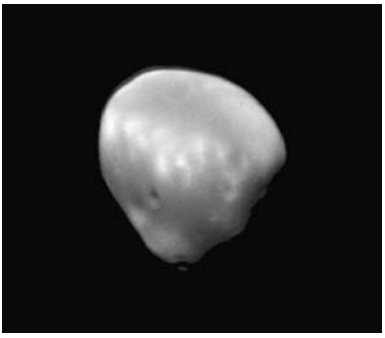
Discovering and Naming the Satellites

It was Johannes Kepler (1571–1630) who first predicted the existence of two satellites of Mars. In 1611 he misinterpreted an anagram by Galilei concerning Saturn as the announcement of Martian satellites: "Be greeted, double knob, children of Mars." Based on numerological arguments, he also noted that it seemed to him quite probable that Mars had two companions, since Mars orbits between Earth—a planet with one moon—and Jupiter, a planet with (at that time) four known moons.

In 1726, Jonathan Swift (1667–1745), master of English satire, published the novel *Gulliver's Travels.* In book 3, chapter 3 he described two satellites of Mars, giving relatively accurate values for their orbital parameters: he stated that Phobos is 13,600 (actually 6000) km from the surface of Mars and that this moon orbits Mars in 10 (actually 7.7) hours, while he said that Deimos is 27,200 (actually 20,100) km from Mars and that it has an orbital period of 21.5 (actually 30.3) hours. Swift was obviously familiar with Kepler's three laws of planetary motion. Swift's description of the Martian satellites influenced, among others, François Marie Arouet Voltaire (1694–1778), who describes two small satellites of Mars in his philosophical work of fiction *Micromégas* (1752), also as astronomical research. The systematic search for Martian satellites performed by Johann Heinrich Mädler in Berlin in 1830 and by Heinrich Louis d'Arrest in Copenhagen in 1864 using telescopes was hopeless. It was necessary to wait for Mars to reach opposition at perihelion in 1877.



Phobos; image taken on 22 August 2004 by the HRSC (High-Resolution Stereo Camera) on Mars Express at a distance of less than 200 km. Copyright ESA/DLR/FU Berlin, G. Neukum



Deimos image taken on 10 July 2006 with the Mars Orbiter Camera (narrow angle) on Mars Global Surveyor at a distance of 22,985 km. Copyright ESA/DLR/FU Berlin, G. Neukum

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On August 11, 1877, after many nights of searching in vain for satellites fueled by the encouragement of his wife Angeline, Asaph Hall finally succeeded in finding a faint object on the following (eastern) side and a little north of the planet using the 26-inch Clark refractor at the US Observatory in Washington DC. The "faint object" was the outer satellite. Hall discovered the inner moon on August 17. Measurements were made of these objects on August 18, which were then recorded as the "Mars satellites" (1878, *Monthly Notices*, 38, 205).

The two natural satellites were named by Asaph Hall after the two comrades of Mars, Deimos (Fear) and Phobos (Flight). In his *Observations and Orbits of the Satellites of Mars* (1878, US Govt., Washington), Hall writes:

> Of the various names that have been proposed for these satellites, I have chosen those suggested by Mr. Madan of Eton, England [Henry Madan (1838–1901), Science Master of Eton College], viz: Deimos for the outer satellite; Phobos for the inner satellite. These are generally the names of the horses that drew the chariot of Mars; but in the lines referred to they are personified by Homer, and mean the attendants, or sons of Mars. These lines occur in the Fifteenth Book of the *Iliad* (line 119), where Ares is preparing to descend to the earth to avenge the death of his son. Bryant's translation is as follows: "He spoke, and summoned Fear and Flight to yoke His steeds, and put his glorious armor on."

The two fearful figures attending the warriors were not just servants of Ares; they were his sons (*Iliad* 13,299; Hesiod, *Theogony* 933), and consequently independent deities (and unambiguously described thus by Plutarchus). They were only represented as steeds by Antimachus (frg. 35), who misinterpreted the quotation from Homer mentioned above. The names were originally used by Hall in a latinized version, i.e., Deimus, Phobus (1878, *Astronomische Nachrichten*, 92, 2187).

Latin versions of Greek names are common among the nomenclature of the Solar System; however, there are no consistent Latin translations of Deimos and Phobos. The Romans called Deimos Pallor (Livy), Terror (Ovid), or Formido (Claudianus), while Phobos was mostly known as Pavor.

Sources of Satellite Names

Mars I PHOBOS (Φοβος; "Panic", "Rout")
Mars II DEIMOS (Δειμος; "Fear")

Hesiodus: Theogony 933 (932–937):
Also Cythera [Aphrodite] bare to Ares the shield-piercer Phobos [Panic] and Deimos [Fear], terrible gods who drive in disorder the close ranks of men in numbing war, with the help of Ares, sacker of towns; and Harmonia whom high-spirited Cadmus made his wife.

Homerus: Iliad 13,299 (298–300):
And even as Ares, the bane of mortals, goes forth to war, and with him follows Phobos [Panic], his son, valiant alike and fearless, that turns to flight a warrior …

Homerus: Iliad 15,119 (113–120):
(The Olympic gods are talking about the course of the Trojan War:)

but Ares smote his sturdy thighs with the flat of his hands, and with wailing spake, and said: "Count it not blame for me now, O ye that have dwellings on Olympus, if I go to the ships of the Achaeans and avenge the slaying of my son [Askalaphos of Orchomenos], even though it may be my fate to be smitten with the bolt of Zeus, and to lie low in blood and dust amid the dead."

So spake he and bade Deimos [Terror] and Phobos [Rout] yoke his horses, and himself did on his gleaming armour.


Phobos

Plutarchus: Theseus 27,2:
For a long time there was hesitate and along on both sides in making the attack, Theseus, after sacrificing To Phobos [Fear], in obedience to an oracle, joined battle with the women [Amazons].

Plutarchus: Alexander 31,5:
Alexander, while his Macedonians slept, himself passed the night in front of his tent with his seer Aristander, celebrating certain mysterious rites and sacrificing to the god Phobos [Fear].

Photograph on opposite page: Jupiter and its satellites (*from above*: Io, Europa, Ganymede, Callisto). Copyright NASA

The Satellites of Jupiter