MEETING VENUS
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Venusians: the Planet Venus in the 18th-Century Extraterrestrial Life Debate

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Abstract. In the seventeenth and eighteenth centuries it became possible to believe in the existence of life on other planets on scientific grounds. Once the Earth was no longer the center of the universe according to Copernicus, once Galileo had aimed his telescope at the Moon and found it a rough globe with mountains and seas, the assumption of life on other planets became much less far-fetched. In general there were no actual differences between Earth and Venus, since both planets orbited the Sun, were of similar size, and possessed mountains and an atmosphere. If there is life on Earth, one may ponder why it could not also exist on Venus. In the extraterrestrial life debate of the seventeenth and eighteenth centuries, the Moon, our closest celestial body, was the prime candidate for life on other worlds, although a number of scientists and scholars also speculated about life on Venus and on other planets, both within our solar system and beyond its frontiers.

This chapter discusses the arguments for life on Venus and those scientific findings that were used to support them, which were based in particular on assumptions and claims that both mountains and an atmosphere had been found on Venus. The transits of Venus in the 1760s became especially important for the notion that life could thrive on Venus. Here, I detect two significant cognitive processes that were at work in the search for life on Venus, i.e., analogical reasoning and epistemic perception, while analogies and interpretations of sensory impressions based on prior knowledge played an important role in astrobiological theories.

1. Introduction

The idea that life could exist on other celestial bodies has been discussed since antiquity. The debate that this idea engendered – the extraterrestrial life debate, or alternatively, the plurality of worlds debate – intensified in the seventeenth and eighteenth centuries,[1] happened for at least three reasons. Firstly, in the new heliocentric system Earth was a planet like the others and no longer the center of the universe. Secondly, the invention of the telescope revealed geographical features on the Moon, while the other celestial bodies no longer seemed to be smooth, even and perfectly spherical bodies. Thirdly, the discovery of new worlds overseas led to a heated debate on the unique status of the human being and of Christianity; cultural encounters, and the existence of life unrelated to our own culture.

Once the Earth was no longer considered the center of the universe, after the work of Nicolaus Copernicus and the publication of his *De revolutionibus orbium coelestium* in 1543, Galileo Galilei had aimed his telescope at the Moon in 1609 and found it a rough globe with mountains and seas, and physico-theologists were

[1] For the plurality of worlds debate see: Dick (1982, 1996); Guthke (1983); Crowe (1986, 2008) and Dunér (2012).

convinced that the all-powerful Creator must have filled the entire Universe with life, then the assumption of life on other planets became much less far-fetched.[2] In the extraterrestrial life debate of the seventeenth and eighteenth centuries our closest celestial body, the Moon, was the prime candidate for life on other worlds. However, a number of scientists and scholars also speculated about life on Venus and on other planets, both within our solar system and beyond its frontiers. In general there were no actual differences between Earth and Venus. They were both planets that orbited the Sun, were of similar size, and, as some astronomers claimed, Venus also possessed mountains and an atmosphere. If there is life on Earth, then one may ponder why it could not also exist on Venus. The following discusses the arguments for life on Venus and the scientific findings that were used to support them.

2. Cognitive processes in astrobiology

The arguments in favor of life on other planets, including Venus, are, I contend, characterized by two significant cognitive processes.[3] Firstly, *analogical reasoning*, i.e., the use of analogies from existing knowledge, and secondly, *epistemic perception*, the interpretation of what has been observed based on a preconceived understanding, concepts, and prior knowledge. These two cognitive processes are very prominent in the debate on the existence of mountains and an atmosphere on Venus.

An analogical argument could be explained as a search for similarities, i.e., a way of selecting features in the source domain that are to be mapped onto the target domain, and of transferring relevant properties from the source to the target. If x has the properties n_1, n_2, n_3, n_4, ..., and there is a y that has n_1, n_2, n_3, we can conclude that it also has n_4. If there is an x that has these qualities, then we conclude that all y that has some of these qualities also has the quality that we are seeking, $\exists x(P_1x \wedge P_2x \wedge P_3x \wedge P_4x \ldots \; P_nx) \wedge \; \exists y(P_1y \wedge P_2y \wedge P_3y) \Rightarrow \; \forall y(P_4y)$. This is, logically speaking, an invalid argument, but one that is widely used in science as a kind of heuristic method. The challenge is then to select the correct and relevant salient features from an infinite number of possible ones in the source domain, which features will then be transferred to and mapped onto the target domain. In the case of Venus, we know that Earth orbits the Sun, is solid, has a daily axial rotation, an atmosphere, mountains... and also life. Venus, too, orbits the Sun and is solid. If we can estimate the axial rotation and detect an atmosphere and mountains on that planet, it might also be true that it harbors life. These questions were in fact those that were investigated during the seventeenth and eighteenth centuries, and they included the length of its period of rotation and whether it had mountains, an atmosphere and life.

In the optical observations of Venus, especially during the transits of the 1760s, we also see how preconceived understanding shaped the interpretation of what the observers had seen. Through their senses, they received impressions from outer space, and they collected and collated information on distant worlds using their sight. What their senses conveyed had to be interpreted by means of specific cognitive processes before it became a reality. As observers, we do not just passively receive images from the world around us. Instead, the brain actively searches out patterns in what is conveyed to it through the senses, and interprets them through a process

[2] Copernicus (1543); Galilei (1610); Derham (1715).

[3] Concerning cognition and astrobiology, see: Dunér (2011a, b).

that is determined by both biological and cultural factors. Perception is not a neutral, objective, and realistic recording of reality. This conceptual or epistemic vision implies an identification of what is seen, and takes place by applying our concepts to visual perceptions, that is, concepts that affect what we see, and, should we lack any concept of a specific phenomenon, then it will be difficult to distinguish it among all our impressions. The world distorts our concepts, and the concepts distort our world. Striking examples of this epistemic perception are the maps of Venus that delineated the surface of the planet, where it was sometimes interpreted as possessing mountains and other geological features. Even a dim light, faint spots and lines, and a companion moon seemed to appear when Venus was viewed through a telescope. The astronomers interpreted their obscure observations in line with their prior knowledge and their ideas of the nature of the world, and they often found what they sought. If they believed in the existence of mountains and an atmosphere on Venus, then they duly found them.

3. Life on Venus

Before I return to the question of a Venusian atmosphere and mountains, I will outline the extraterrestrial life debate from the seventeenth to nineteenth century with respect to a habitable Venus. As has been mentioned, the Moon was the prime candidate for extraterrestrial life in the early modern period, and was later succeeded by Mars at the end of the nineteenth century. Meanwhile, however, the other planets, including Venus, were also discussed in terms of their habitability. These claims of a habitable Venus are found in the borderline between science and fiction; between empirical observations and the imaginings of the human mind. This is as much a cultural as a scientific debate. A curious mystery, which can be kept in mind, is why Venus, the closest planet to Earth in the solar system, never became as popular as the Moon and Mars as a candidate for a habitable world.

The first closer observations of extraterrestrial bodies were made by Galileo in the autumn of 1609. In the *Sidereus nuncius* from 1610, he shows, based on his telescopic observations and analogical reasoning, that the Moon has mountains and therefore has the same solid, opaque and rugged nature as the Earth. The irregular border between its dark and illuminated parts is incompatible with the idea that it is a perfect spherical solid. Galileo wrote:

> Anyone will then understand with the certainty of the senses that the Moon is by no means endowed with a smooth and polished surface, but is rough and uneven and, just as the face of the Earth itself, crowded everywhere with vast prominences, deep chasms and convolutions.[4]

The Moon had a smooth appearance, though, in its contour, which he explained was because it might have an atmosphere. Another important observation in this context is that he found that Venus has phases like the Moon. It seems, though, that Galileo never stretched his analogical reasoning as far as it would extend by expressly claiming the existence of life on other planets. However, he did not consider it impossible that there were inhabitants on these spheres, but he also said that we cannot take it for granted that life elsewhere in the universe must resemble our own. In 1612 Galileo wrote:

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[4] Galilei (1610); Spranzi (2004), p. 459.

> I agree with Apelles [the astronomer Christoph Scheiner] in regarding as false and damnable the view of those who put inhabitants on Jupiter, Venus, Saturn and the Moon, meaning by inhabitants, animals like ours, and men in particular.[5]

Later in the *Dialogo . . . sopra i due massimi sistemi del mondo* (1632), he stated that there is no water, no humidity, no seas on the Moon, and therefore no life.[6]

One of the most famous and popular accounts defending the existence of life outside Earth is Bernard Le Bovier de Fontenelle's book *Entretiens sur la pluralité des mondes* (1686), which consists of six evening discussions on the plurality of worlds between a philosopher and an aristocratic lady in the gardens of a country chateau.[7] Perhaps, says the philosopher, there are astronomers on Jupiter, and maybe we cause them to engage in scientific quarrels, and some philosophers have to defend themselves when they put forward the opinion that we exist. The marquise speculates in turn about the inhabitants of Venus, stating that they are perhaps, because they are closer to the Sun,

> little black people, scorch'd with the Sun, witty, full of Fire, very Amorous,. . . ever inventing Masques and tournaments in honor of their Mistresses.[8]

Even though these conversations are imaginary, they liberated the mind and made it possible to think about the existence of extraterrestrial life, while there did not seem to be any scientific reasons to disbelieve in the plurality of habitable worlds.

The Dutch scientist Christiaan Huygens expressed the view in his *Cosmotheoros* (1698) that there most likely was life out there.[9] He noted that liquid water is necessary for life, and he saw darker and lighter spots on the surfaces of Mars and Jupiter that he interpreted as water and ice. Beyond our solar system there are stars similar to our Sun, and he asked why these stars could not have their own planets with their own moons. As for Venus, he empirically stated that it is surrounded by a thick atmosphere. He could not clearly detect any patches on the surface that might be signs of seas and mountains. Perhaps, he said, there are no seas on Venus, or, as he believed more probable, the air and clouds around Venus reflect nearly all the light from the Sun.

Some philosophers and scientists even speculated about the inhabitants and the intelligence of these extraterrestrials. The philosopher Immanuel Kant wrote in *Allgemeine Naturgeschichte und Theorie des Himmels* (1755) that the intelligence of the extraterrestrials becomes

> more excellent and perfect in proportion to the distances of their habitats from the Sun.[10]

The Mercurians and Venusians are according to Kant less intelligent than Earthlings who are exactly in the middle. The Jovians and Saturnians are superior beings. Kant wrote:

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[5]Galilei (1612); Dick (1982), p. 86.

[6]Galilei (1632); Spranzi (2004), p. 468.

[7]Fontenelle (1686).

[8]Fontenelle (1686); Crowe (1986), p. 19.

[9]Huygens (1698).

[10]Kant (1755).

> From one side we saw thinking creatures among whom a man from Greenland or a Hottentot would be a Newton, and on the other side some others would admire him as [if he were] an ape.[11]

Interestingly, here Kant actually discusses how the body functions of humans are a result of their location in the solar system, and also how this location and their bodies affect their minds and their ability to think.

There was also a lively extraterrestrial life debate in Scandinavia. Two dissertations were defended in the 1740s in Uppsala with the professor of astronomy Anders Celsius chairing the proceedings, of which one refuted the idea of a habitable Moon, while the other defended the idea of the plurality of worlds.[12] The Norwegian historian Gerhard Schøning wrote about a fantastic voyage to Venus.[13] To my knowledge this is the first attempt at a Venusian odyssey in the history of science fiction. Venus, said Schøning, has mountains, valleys, plains, rivers, lakes, seas, forests, and a multitude of plants, stones, metals and soils. There are forests and meadows full of tame and wild creatures, the waters are full of fish, and the soil has many edible plants. There are also intelligent creatures, who, however, are in most respects very different from those on Earth. Schøning's story describes an Englishman who constructed a craft in which he took off from the highest mountain in Norway on the summer solstice of 1759. It was aimed at the Moon, but the space traveler fell asleep, veered off course and overshot the Moon. When he woke up, he was surrounded by mist and smoke through which he traveled as though beneath an ocean. He had entered the atmosphere of Venus, on whose surface he landed and he saw people passing by... and then, as the story reaches its most exciting point, the manuscript ends.

Probably one of the most original and curious contributions to this debate in the eighteenth century was a work that, without slightest irony, provided a sincere account of its author's encounters with extraterrestrials. In 1758, the Swedish spiritual visionary Emanuel Swedenborg published a book that described his encounters with extraterrestrial spirits, which he entitled *De telluribus in mundo nostro solari* (1758).[14] In it, he advanced theological arguments for the existence of extraterrestrials, i.e., that the planets and stars have a more important purpose than merely to rotate and to shine. The planets visible to our eyes, he says, can be plainly recognized as worlds, bodies made of earthly matter that reflect sunlight, mottled with dark patches like land masses on earth, revolving around the Sun, and rotating about their axes like our Earth:

> Can anyone knowing this and able to think rationally still claim that these are empty masses?[15]

In conversations with spirits, he discusses the argument that there is more than one world in the universe, based on the fact that the starry sky is so immense and contains countless stars, each one a Sun with its own planetary system.

Swedenborg not only assumes that there could be life on Venus; he even claims that he had met spirits from that planet and talked with them. He speaks of two

[11] Kant (1755), pp. 189 f.; Crowe (1986), pp. 52 f.

[12] Celsius (1740, 1743).

[13] Johansen (2012).

[14] Swedenborg (1758); Goerwitz (1985), pp. 417–446, 477–485; Bedford (2006); Dunér (2013).

[15] Swedenborg (1758), n. 3.

kinds of people on Venus, who are of opposite characters.[16] Some are gentle and humane; others are fierce and almost like wild animals. These latter inhabitants take great pleasure in stealing, and particularly in eating what they have stolen. They are for the most part giants, and people of our world only come up to their navel. Furthermore, they are stupid and do not ask what heaven is or enquire about everlasting life.

Swedenborg also calculated the total number of people or spirits. If there were a million worlds in the universe, and three hundred million human beings in each world, and two hundred generations in six thousand years, and each human being or spirit were given a space of three cubic meters, then when all this was added together, they would still not occupy a thousandth part of the volume of this world, but perhaps the volume of one of the satellites of Jupiter or Saturn.[17] Later in 1848, the Scottish church minister and science teacher Thomas Dick also tried to estimate the number of inhabitants on the planets of our solar system by comparing their magnitude with the population of our globe.[18] If the planets were populated as densely as in England, at a rate of 280 inhabitants to a square mile, we find that Venus would have 53.5 billion people, and Jupiter, the most populated planet, would have 6,967 billion; in total with all the planets, satellites, asteroids and the rings of Saturn, there would be 21,894 billion people in our solar system.

The French popularizer of astronomy Camille Flammarion considered in *La pluralité des mondes habités* (1862) that it was absurd that the Sun was employed solely to illuminate and heat our small world. This absurdity became even more striking when Venus was found to be a planet of the same dimensions as the Earth, with mountains and plains, seasons and years, and days and nights analogous to our own. That analogy was expanded to the conclusion, that, since they are alike in their physical characteristics, they must be alike also in their role in the universe:

> if Venus were without population, then the Earth must be similarly lacking, and reciprocally, if the Earth were populated, Venus must be populated also.[19]

Flammarion demonstrates here a characteristic analogical thinking, typical of the astrobiological search for an Earth analogue. In a later work on popular astronomy he says of the inhabitants of Venus:

> this world differs little from ours in volume, in weight, in density, and in the duration of its days and nights. [...] It should, then, be inhabited by vegetable, human, and animal races but little different from those of our planet.[20]

4. Maps of Venus

It might be surprising that our closest neighbor, the solid planet Venus, was not discussed to a greater extent. My explanation for such neglect is that astronomy

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[16]Swedenborg (1758), n. 106.

[17]Swedenborg (1758), n. 126.

[18]Dick (1848), pp. 135 f.

[19]Flammarion (1862); Crowe (2008), pp. 417 f.

[20]Flammarion (1880); Sheehan & Westfall (2004), p. 214.

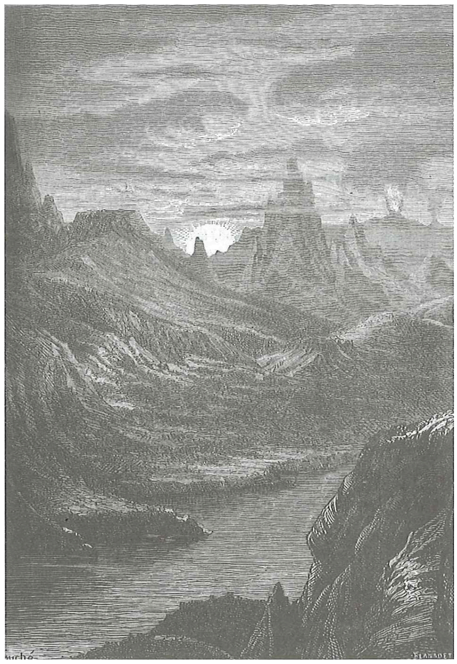

Figure 1. The mountains in the southern hemisphere of Venus, according to Camille Flammarion, *Les terres du ciel* (Paris, 1877).

of the period failed to clearly recognize geological features on its surface in the same way as those observed on the Moon and Mars. Whether these ideas about a habitable Venus were speculative or not, they were still all based to some extent on scientific observations and theories. Astronomical investigations of Venus during the seventeenth and eighteenth centuries involved its magnitude, revolution around the Sun, axial rotation, atmosphere, mountains, satellites, temperature, and chemistry.

In 1645 the Neapolitan astronomer Francesco Fontana recorded "a dark patch in the center of the disk" of Venus, which can be said to be the first attempt to note surface details there.[21] In 1667 Giovanni Domenico Cassini saw "various bright and dusky patches" from which he deduced the first estimated period of rotation of 23 hours and 21 minutes.[22] Francesco Bianchini drew the first "map" recording oceans and continents in 1726.[23] On mist-free days, at twilight, he saw rounded patches similar to lunar craters, and from their movements, he deduced that the period of rotation of Venus was 24 days and 8 hours.

There is no doubt that these records of the surface features of Venus were purely optical. Beside the fact that the optical quality of the telescopes not always was reliable, and that weather conditions could considerably influence the quality of the observations, there is obviously also an epistemic perception that changes the interpretations of the seen. The uncertain observations by Fontana, Cassini, Bianchini and others were interpreted in a particular way. If they believed in the existence of oceans and continents on Venus, they searched for them and found them, because

[21] Fontana (1646), p. 92; Cattermole & Moore (1997), p. 9; Moore (1956), p. 32.

[22] Cassini (1667), p. 122.

[23] Bianchini (1728); Sheehan & Westfall (2004), p. 139.

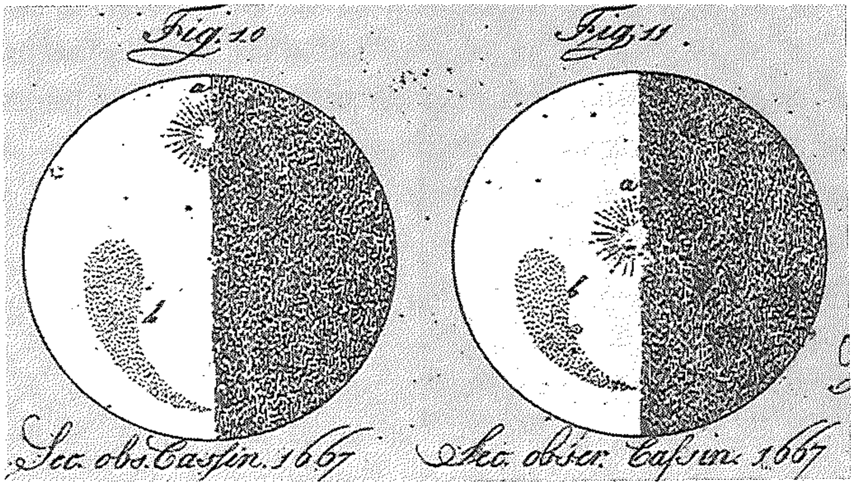

Figure 2. Drawings by Giovanni Cassini in 1667 of the surface of Venus, in Camille Flammarion, *Les terres du ciel* (1877).

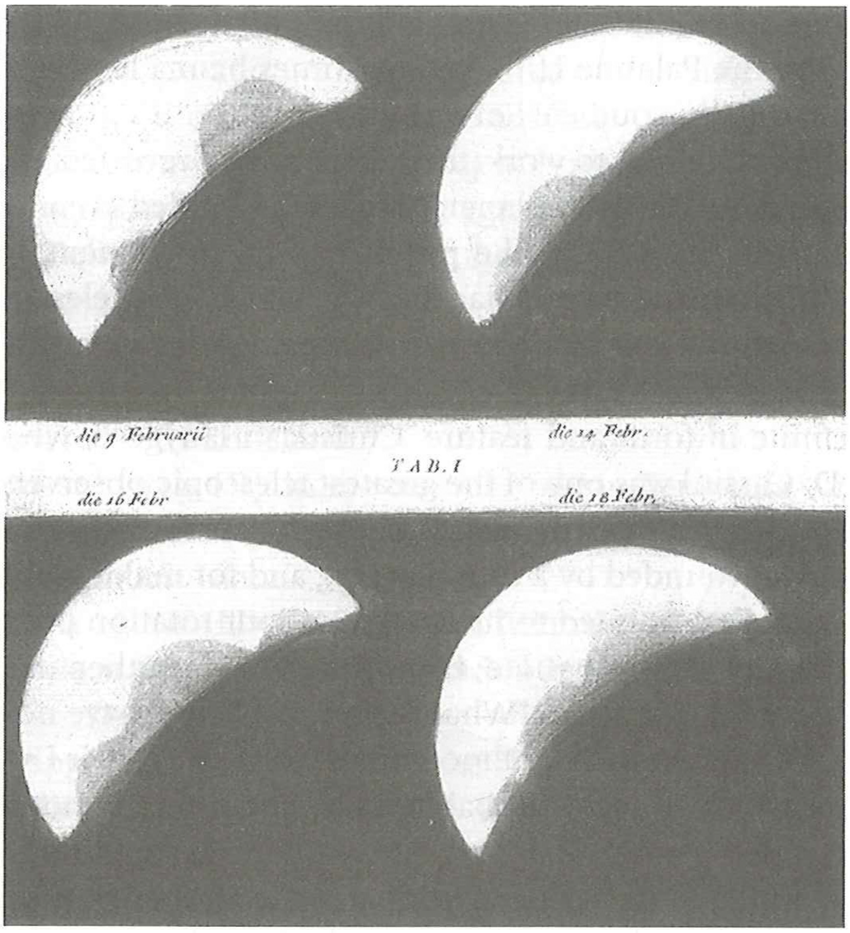

Figure 3. Francesco Bianchini's drawings of Venus in his work *Hesperi et phosphori nova phaenomena* (1728).

their prior knowledge and beliefs directed their attention towards certain interpretations. The "illusion" or "fault" in their perception did not lie primarily in the flaws in their optical equipment, but, as I maintain, in their imaginative minds, the cognitive apparatus that processed their sensory impressions.

5. The atmosphere of Venus

The first more certain telescopic observations of Venus, after Galileo's discovery of its phases, were made during the 1761 transit of Venus by, among others, Mikhail Lomonosov, who concluded that the planet is surrounded by a considerable atmosphere equal to, if not greater than, that which envelops our earthly sphere.[24] His observations were not unique. Many observers in Sweden and elsewhere reported certain phenomena during the transit that they believed to have been caused by an atmosphere surrounding Venus.[25]

Certain astrodynamic facts relating to Venus were well-known to the astronomical community, for example, its orbit around the Sun, magnitude, and phases, etc. The exact size of the solar system and the distances within it, though, were not known. The transits of Venus in the 1760s provided a unique opportunity to calculate the distance from Earth to Venus and to the Sun. Furthermore, the question of the atmosphere and topography of Venus was still unresolved, but observations of Venus against the solar disc changed that. Two dissertations on Venus were defended in Sweden during the eighteenth century, with the professor of astronomy Pehr Elvius chairing the proceedings. The student Birger Jonas Wassenius defended his thesis *De planeta Venere* in 1717, where he discussed the orbit of Venus, its distance from the Sun, diameter, motion, phases, etc., with references to Kepler, Riccioli, and Street.[26]

He followed the views of Kepler and Newton, and determined that the next transit of Venus would occur on May 26, 1761 (June 6, 1761 new style). First contact, according to Elvius and Wassenius, would occur at 08:16, which can be compared with Wargentin's observations on the actual day, 03:21.37. Last contact would occur at 15:02 according to Elvius and Wassenius (Wargentin's observation was 09:48.09). Wassenius later became known for his discovery of the prominences (protuberances) of the Sun during the eclipse of May 2/13, 1733 in Gothenburg.[27] The other dissertation, the mathematician Andreas Wijkström's *De venere in sole præsenti seculo videnda* from 1753 also included calculations in preparation for the transit of Venus.[28]

During the transit of Venus of 6 June 1761, two surprising phenomena were observed: a bright ring around Venus and the "black drop" during the contacts.[29] Almost all observers in Stockholm and Uppsala in Sweden, and Kajana in Finland saw the ring, and it was generally explained as being caused by an atmosphere on

[24] Cattermole & Moore (1997), p. 10; Marov (2005).

[25] Concerning the history of Venus transits, see: Proctor (1874); Woolf (1959); Maor (2000); Sellers (2001); Sheehan & Westfall (2004); Wulf (2012); Aspaas (2012); Pekonen (2012).

[26] Elvius (1717).

[27] Nordenmark (1959), p. 194.

[28] Wijkström (1753).

[29] Nordenmark (1939), p. 178.

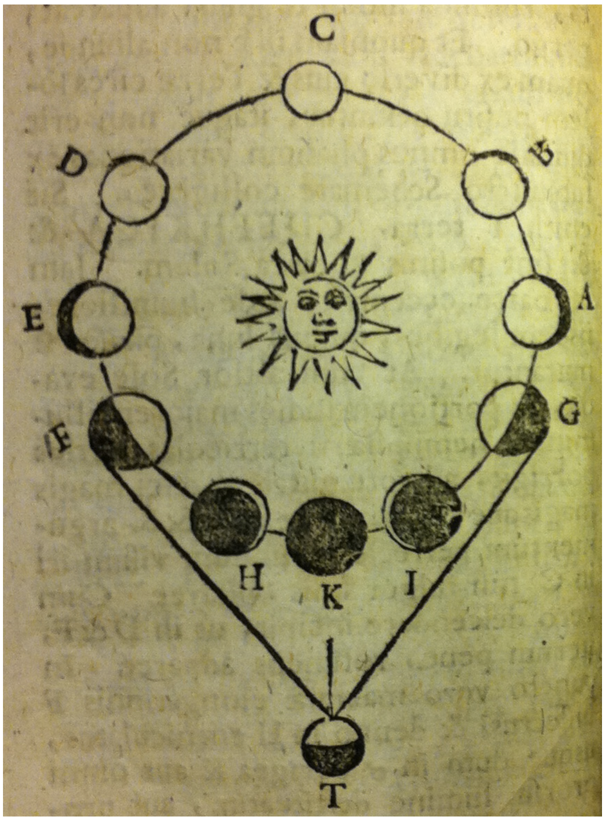

Figure 4. The phases of Venus, according to Birger Jonas Wassenius, *De planeta Venere* (1717).

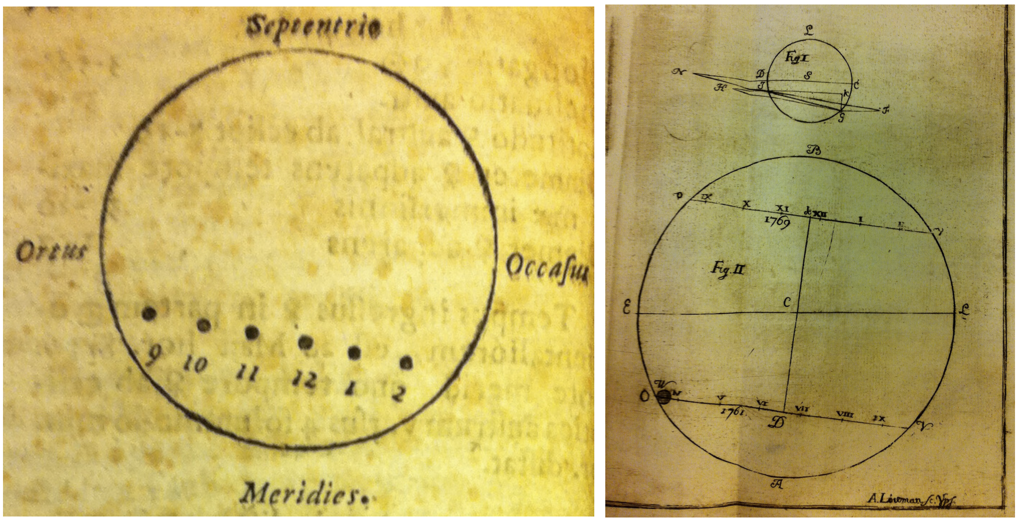

Figure 5. *Left*: The transit of Venus, according to Birger Jonas Wassenius, *De planeta Venere* (1717). *Right*: The future transits of Venus against the solar disc in 1761 and 1769, according to Andreas Wijkström, *De venere in sole præsenti seculo videnda* (1753).

Venus.[30] The Uppsala report to the proceedings of the Royal Swedish Academy of Sciences stated that Venus probably had an atmosphere, which caused refraction of the sunbeams. Just three days after the transit, on June 9, 1761, the astronomer Fredric Mallet reported to the secretary of the Royal Swedish Academy of Sciences, the astronomer Pehr Wilhelm Wargentin, that all the observers in Uppsala concluded that Venus had an atmosphere because of the light seen around it before it entered the solar disc.[31] Wargentin himself also observed the luminous ring and believed that

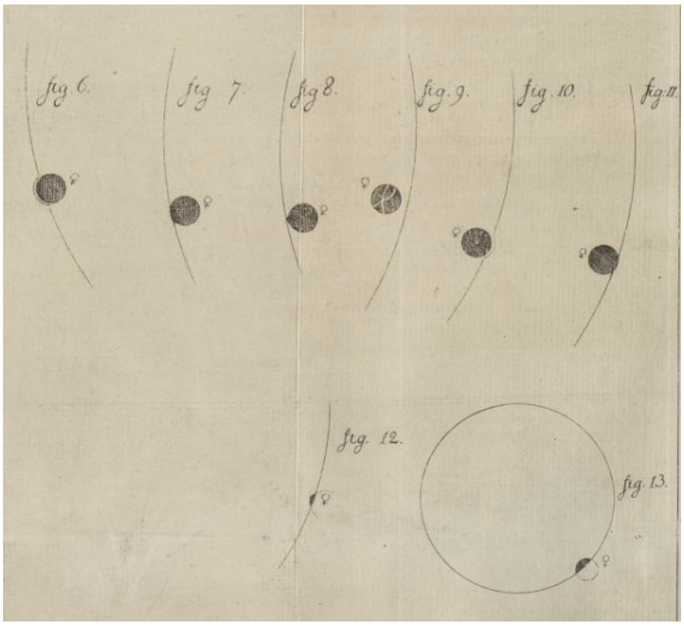

Figure 6. The luminous ring and the black drop. From the proceedings of Royal Swedish Academy of Sciences 1761. *Kungl. Vetenskapsakademiens handlingar* 1761, tab. III.

it indicated an atmosphere. In another letter by Mallet to the Finnish astronomer Anders Planman from July 9 of the same year, he wrote that an atmosphere was visible during first contact, as he saw a light around Venus before it entered the solar disc.[32] Another Swedish astronomer, Bengt Ferner, reported from Paris:

> During the whole time of my observing with the telescope, and the blue and green glasses, I perceived a light round about Venus, which followed her like a luminous atmosphere, more or less lively, according as the air was more or less clear.[33]

The scientist and chemist Torbern Bergman published the results of his observations in Uppsala in the *Philosophical Transactions* of 1762, and in the same article he

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[30] "Observationer på planeten Veneris gång genom solens discus, d. 6 junii 1761", in *Kungl. Vetenskapsakademiens handlingar* 1761.

[31] Letter from Mallet to Wargentin, June 9, 1761, Royal Swedish Academy of Sciences, Stockholm. Nordenmark (1939), p. 180; Lindroth (1967).

[32] Letter from Mallet to Planman, 9 July 1761, Helsinki University Library. Nordenmark (1939), p. 179.

[33] Ferner (1762), p. 223.

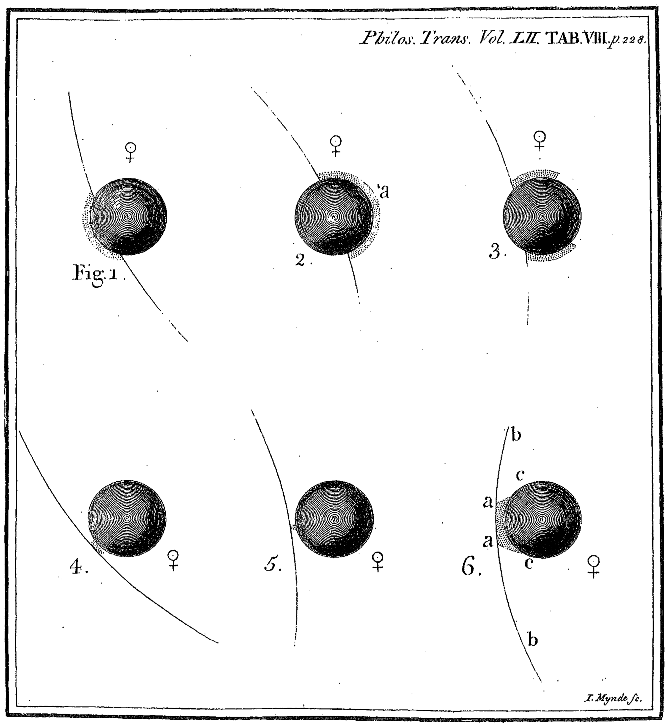

Figure 7. The luminous ring and the black drop of Venus. Thorbern Bergman, "An Account of the Observations made on the same Transit at Upsal in Sweden: In a Letter to Mr. Benjamin Wilson, F. R. S. from Mr. Thorbern Bergman, of Upsal", *Philosophical Transactions* 52 (1762).

discussed the existence of an atmosphere around Venus as an explanation for the refraction phenomenon.[34] The ring was re-observed on June 3, 1769, and its causes were still being debated even then, but this phenomenon was unanimously taken as proof of the existence of an atmosphere on Venus.[35] The professor of astronomy at Uppsala, Daniel Melanderhjelm, also tried to explain the black drop as being due to refraction in the atmosphere of Venus.[36] In 1798 he published an article discussing the atmospheres of the planets of the solar system.[37] Even though he referred to Schröter's investigations of the atmosphere of Venus, the article primarily addressed the Earth's atmosphere, and here he stated that all atmospheres of the planets in the solar system are of the same nature, of the same sort of particles.[38]

Most Swedish observers of the 1761 and 1769 transits believed that the black drop was not an effect caused by an atmosphere on Venus. Wargentin opposed Melanderhjelm's explanation of the black drop as caused by an atmosphere and

[34] Bergman (1762), p. 228; Olsson (1956).

[35] Wargentin (1769), pp. 146–158, see also pp. 158–175; *Philosophical Transactions* 59 (1769), pp. 170–194.

[36] Melanderhjelm (1769), pp. 161–173; Nordenmark (1939), p. 181, 189.

[37] Melanderhjelm (1798); see also German edition (1800), pp. 96–112.

[38] Melanderhjelm (1798), p. 37.

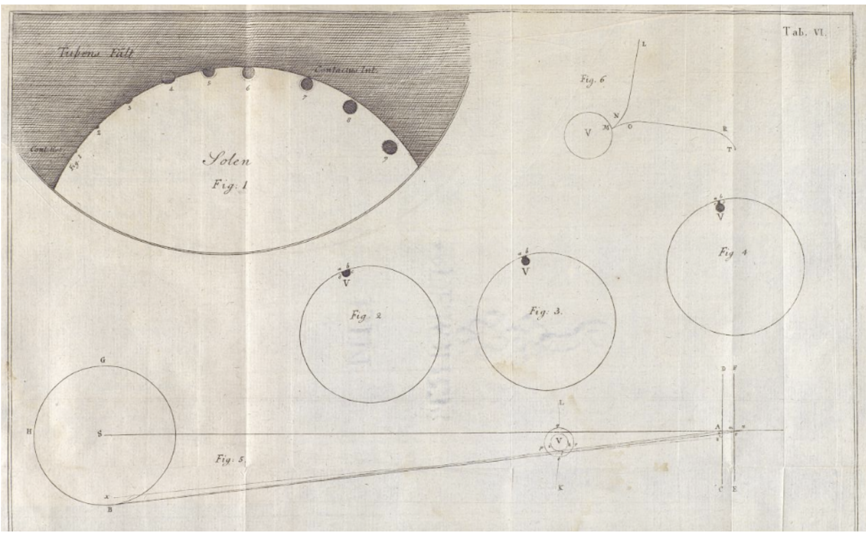

Figure 8. Daniel Melanderhjelm tried to explain the black drop as being caused by refraction in the atmosphere of Venus, in "Uttydning på de Phænomener, hvilka åtfölja Planeten Veneris Passage genom Solen", *Kungl. Vetenskapsakademiens handlingar* 1769.

explained it instead as a diffraction phenomenon.[39] Melanderhjelm's observations were, as he said, just "fallaciæ visus", optical phenomena.[40] The physician Johan Carl Wilcke performed a number of experiments during the summer of 1769 showing that the same phenomenon arises with a black body seen against a luminous body without any need to assume an atmosphere.[41] Wargentin and Wilcke did not disbelieve in the existence of an atmosphere, but the black drop could not provide proof of this. In 1770–1771 Andreas Planman published two dissertations defending the theory that the phenomena observed during the transits were caused by a Venusian atmosphere.[42] He presented a number of observations of the transit of 1761 that supported the theory of an atmosphere around Venus, among others, the luminous ring and the black drop.[43] He also made analogical comparison with the atmosphere of the Earth. Wargentin thanked Planman for the copies of the dissertations that he had sent, but he admitted that he remained unconvinced that the atmosphere of Venus was the cause of all the phenomena seen during the transit.[44]

The atmosphere of Venus was also observed in Saint Petersburg. The Russian polymath Mikhail Lomonosov argued that the observations of the transit of Venus

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[39] Nordenmark (1939), pp. 189 f.

[40] Letter from Wargentin to Planman, June 12, 1770, Helsinki University Library. Nordenmark (1939), p. 190.

[41] Letter from Wargentin to Planman, October 26, 1770, Helsinki University Library. Nordenmark (1939), p. 190.

[42] Planman (1770, 1771).

[43] Planman (1770), pp. 3 f.

[44] Letter from Wargentin to Planman, January 4, 1771, Helsinki University Library. Nordenmark (1939), p. 192.

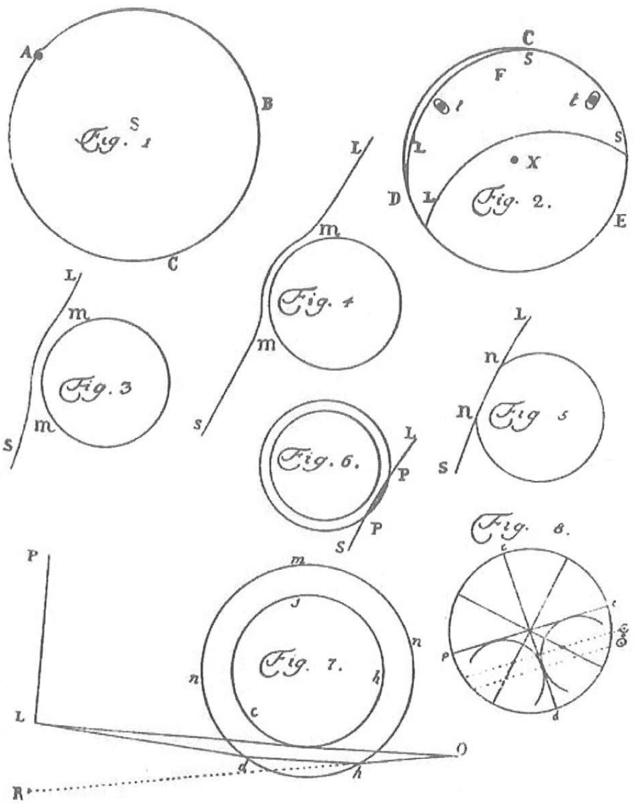

Figure 9. Mikhail Lomonosov's study of the transit of Venus in 1761. From Marov (2005), p. 215.

in 1761 supported the idea of a Venusian atmosphere.[45] Because an existing atmosphere had been proved, it could be concluded that Venus is also inhabited. Lomonosov wrote:

> Based on these observations I conclude that the planet Venus is surrounded by a distinguished air atmosphere similar (or even possibly larger) than that is poured over our Earth.[46]

Lomonosov, contrary to what has been argued,[47] was neither the first, nor the only one, to conclude that the phenomena were caused by a Venusian atmosphere. Bergman and others published their results first, even though Lomonosov showed some detailed supporting arguments for the explanation of this phenomenon, and thus the transits proved the existence of an atmosphere on Venus.

6. The mountains of Venus

Whether Venus has mountains and a surface similar to the Earth with valleys and seas, had been debated ever since the first Venus maps appeared in the seventeenth

[45] Crowe (1986), p. 160.

[46] Marov 2005, pp. 214 f.; Lomonosov (1955a, 1955b, 1961).

[47] Marov (2005).

century. Here, again, the conclusions were often a result of analogical reasoning and epistemic perception. In 1700, Philippe de la Hire reported mountains on Venus.[48] This was later cited by Jean le Rond d'Alembert in the *Encyclopédie* as indicating that the other planets also had mountains. The changes observed on the surface of Venus, Mars, and Jupiter, indicated, furthermore, that they have an atmosphere and that other planets do too. Since planets are opaque bodies, receiving their light from the Sun, and have mountains and changing atmospheres, d'Alembert concluded that it must follow that they also have lakes and seas, in other words, they are bodies just like our Earth. Nothing, he says, can then prevent us from believing that the planets are inhabited.[49]

The great observational astronomers William Herschel and Johann Hieronymus Schröter engaged in a heated argument as to the presence or absence of mountains on Venus.[50] However, they both agreed that Venus has an atmosphere. Among arguments for the presence of an atmosphere was the fact that the horns of the crescent Venus were often seen to extend beyond the semicircle, and sometimes even stretched around the dark hemisphere forming a luminous ring.[51] It was well known in the era of Schröter and Herschel that Venus and the Earth, with regard to their size and mass, were almost perfect twins. It then became also reasonable to assume that their atmospheres were similar too, with regard to their extent and composition. Herschel, who believed in the existence of intelligent creatures on Venus, stressed the advantages of such a cloud shield.[52]

In February 1788 Schröter perceived the ordinarily uniform brightness of the disk as being marbled by a filmy streak, and he concluded that what he was seeing was the outmost part of a dense, cloudy atmosphere.[53] Moreover, the horns of the crescent were seen to extend beyond the semi-circle, which could not be the case in the absence of an atmospheric mantle. By studying spots on the shifting surface he estimated the period of rotation of Venus at 23 hours, 21 minutes and 7 seconds, and thus very close to that of the Earth. Interestingly, up to 1962, estimates of the period of rotation of Venus ranged from between less than 24 hours to up to 225 days, although no one ever expected the period to be longer than the Venusian year.[54]

Even Herschel had seen in 1780 on Venus "a bluish, darkish spot, and another, which is rather bright", and he stated: "that Venus has a motion on its axis cannot be doubted, from these observations; and that she has an atmosphere is evident, from the changes I took notice of, which surely cannot be on the solid body of the planet."[55] With regard to both Mercury and Venus, Herschel also said that

> we do not see, as in the case of the Moon, the real surfaces of these planets, but only their atmospheres, which are loaded with clouds, and

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[48] de la Hire (1700), p. 296.

[49] d'Alembert (1765), vol. XII, p. 705; Crowe (1986), p. 126.

[50] Baum (1973).

[51] Moore (1956), pp. 73 f.; Schröter (1796), p. 85; Herschel (1912), vol. I, p. 449.

[52] Moore (1956), p. 74.

[53] Cattermole & Moore (1997), p. 11.

[54] Cattermole & Moore (1997), p. 14.

[55] Herschel, 19 June 1780; Cattermole & Moore (1997), p. 11.

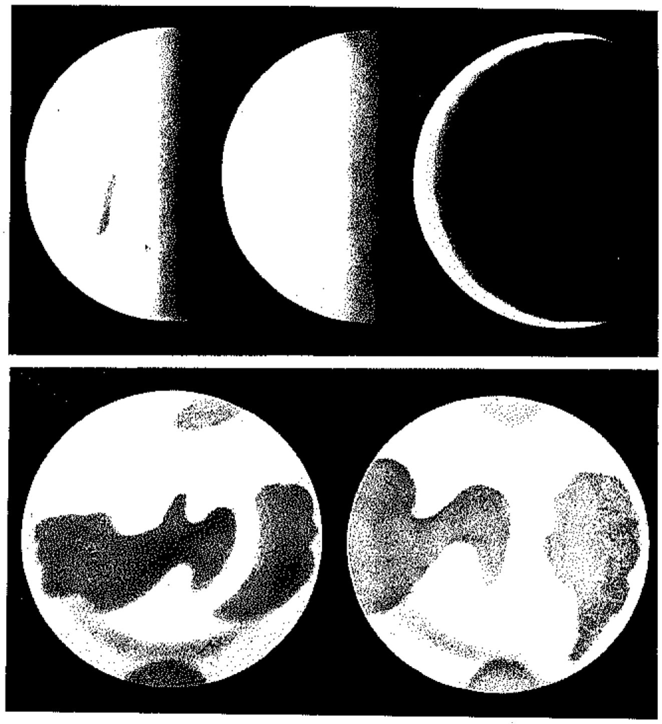

Figure 10. Johann Hieronymus Schröter's drawings of the terminator and the atmosphere of Venus. From Cattermole & Moore (1997), p. 10.

which may serve to mitigate the otherwise intense glare of their sunshine.[56]

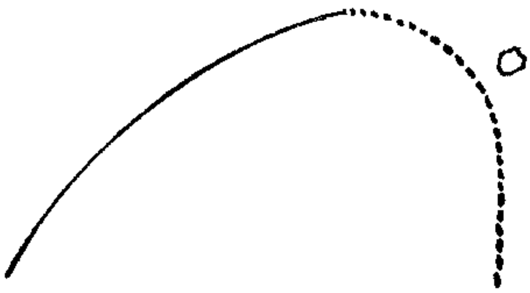

Figure 11. On December 28, 1789, Schröter saw off the southern cusp of Venus a detached point of light, an enlightened mountain. From Baum (1973), p. 52.

On December 28, 1789 Schröter saw that the southern cusp of Venus was blunted, and that there was a small luminous speck beyond it.[57] He saw the same thing again in 1790 and 1791 and concluded from these observations that it must be a very lofty

[56]Moore (1956), p. 36.

[57]Baum (1973), p. 52.

"enlightened mountain" that was catching rays of the Sun.[58] Similar phenomena are often observed on the Moon when peaks close to sunrise or sunset are viewed clear of the terminator. Furthermore, Schröter claimed in 1792 that he had observed mountains on Venus six times higher than the highest one on Earth, that is, equal to a height of 23 miles (37 kilometers)! Schröter wrote:

> though we cannot suppose a smaller, but rather a greater force of gravity on the surface of Venus than our own globe, nature seems, however, to have raised on the former such great inequalities, and mountains of such enormous height, as to exceed 4, 5, and even 6 times the perpendicular elevations of Cimboraco, the highest of our mountains.[59]

The French astronomer Charles Marie de la Condamine had during an expedition to Peru in 1735 measured the height of Cimboraco (now Chimborazo in Ecuador) at 3,200 French toises (6,237 meters).

Herschel re-observed Venus in 1793, and he questioned Schröter's findings. He agreed that Venus has an atmosphere, but he never found those high mountains that Schröter mentioned.[60] His daily records read again and again: "No mountains visible".[61] In the *Philosophical Transactions* he states:

> As to the mountains in Venus, I may venture to say that no eye, which is not considerably better than mine, or assisted by much better instruments, will ever get a sight of them.[62]

Herschel's conclusion was that Venus in fact has an opaque atmosphere, which makes all the features of its surface invisible. Schröter responded in 1795 by stating instead that Venus generally has a clear and transparent atmosphere. Venus must have it, he says,

> I cannot think [...] that Providence would bless the inhabitants of Venus, incomparably less than with the happiness of seeing the works of almighty power, and of discovering, like a Herschel, still more and more distant regions of the universe. We must [...] adhere to this analogy, till indisputable experiments convince us of the contrary.[63]

Schröter then compiled all his findings relating to Venus in a book, *Aphroditographische Fragmente*, published in 1796, where his pluralist conviction reappears. According to Michael Crowe this was the first book ever about the planet Venus, but, as we have seen, a fifty-eight-page dissertation on it had already been published in 1717 in Uppsala, i.e., Elvius' and Wassenius' *De planeta Venere*.[64]

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[58] Schröter (1796), pp. 29–32.

[59] Schröter (1792), pp. 336 f.; Baum (1973), p. 57; Crowe (1986), pp. 71 f.

[60] Herschel (1793); Herschel (1912)), vol. I, p. 442.

[61] Baum (1973), p. 58.

[62] Herschel (1793), p. 216; Moore (1956), p. 107; Baum (1973), p. 59.

[63] Schröter (1795), p. 169.

[64] Schröter (1796), pp. 193 f.; Crowe (1986), p. 72; Elvius & Wassenius (1717).

Another pluralist, Johann Elert Bode at the Berlin observatory, accepted Schröter's claims about the existence of mountains and valleys on Venus.[65] Bode applied an apparently analogical reasoning. He concluded that if Venus had land and sea, mountains and valleys, clearings and condensations occurred in its atmosphere, and it had a companion moon, then it was entirely similar to our Earth and consequently also habitable. As late as the end of the nineteenth century there were those who supported Schröter's mountain theory. Among others, the French artist and astronomer Étienne Léopold Trouvelot recorded, as Schröter had done, luminous spots beyond the terminator, and he also observed the polar hoods of the planet.[66]

7. The illusions of Venus

The observers of Venus saw things that needed explanations and interpretations. They seemed to detect vague spots, streaks, lines, drops, a dim light, and a vague companion. Such optical misinterpretations, or rather what could be explained as an epistemic perception, were involved in the claims of observations of companion moons of Venus, which had been debated since the seventeenth century.[67] In 1686, Cassini thought he saw a luminous shape in the same phase as Venus. In 1780, Wargentin published a paper in the proceedings of the Royal Society of Sciences in Uppsala, where he discussed the hypothetical moon around Venus, and declared that all those astronomers who had seen it had been exposed to an optical phenomenon.[68]

The ashen light, the dim visibility of the non-sunlit side of Venus, when it is in the crescent stage, was first reported in 1643 by Giovanni Riccioli. This phenomenon was also the object of an epistemic perception that needed interpretations of the seen. Franz von Paula Gruithuisen in Munich declared that the light had been seen in 1759 and again in 1806, an interval of seventy-six Venusian years, and he wrote: "The observed appearance is evidently the result of general festival illumination in honor of the ascension of a new emperor to the throne of the planet."[69] However, Gruithuisen later modified his explanation and instead of a Venusian coronation, he suggested that the light might be caused by the burning of large areas of jungle to create new farmland. Other explanations were also put forward. Herschel proposed that it was caused by phosphorescent oceans, while P. de Heen proposed in 1872 that it was a kind of Venusian equivalent to the terrestrial aurorae.

In 1877 Giovanni Schiaparelli at Brera observatory in Milan recorded in detail the Martian network of canals for the first time, and was followed by the American astronomer Percival Lowell, who detected hundreds of Martian canals that he interpreted as an artificial irrigation system. Similar observations of Venusian canals were claimed at the end of the nineteenth century. Henri Joseph Anastase Perrotin in Nice recorded vague streaks on Venus. Lowell himself published a chart of the planet in 1897, and he wrote:

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[65] Crowe (1986), p. 74 f.; Bode (1801); trans. (1804), p. 34; new ed. (Stockholm, 1813); Bode (1792); Bischof (1796); Bode referred to Bianchini (1728); Schröter (1793), p. 136; Schröter (1796); and Herschel's papers in the *Philosophical Transactions*.

[66] Cattermole & Moore (1997), p. 12.

[67] Kragh (2008).

[68] Wargentin (1780), vol. III; Nordenmark 1959, p. 227.

[69] Cattermole & Moore (1997), p. 17.

> The markings themselves are long and narrow but, unlike the finer markings of Mars, they have the appearance of being natural, not artificial. [...] The markings, which are of a straw-colored grey, bear the look of being ground or rock, and it is presumable from this that we see simply barren rock or sand weathered by aeons of exposure to the Sun."[70]

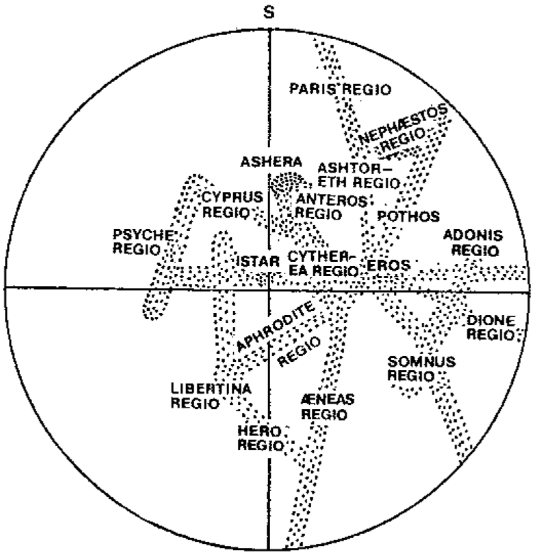

Figure 12. Percival Lowell's map of Venus. From Cattermole & Moore (1997), p. 15.

There were hopes that the invention of spectroscopic analysis in the nineteenth century would show obvious lines for oxygen and water vapor in the atmosphere of Venus, and some preliminary results seemed to support that. The idea of life on Venus was alive far into the twentieth century. In 1915, the Swedish physicist Svante Arrhenius believed Venus to be a living world, moist and steamy with luxuriant vegetation and primitive life.[71] The present climatic conditions on Venus resembled those on Earth about 250 million years earlier, when the Carboniferous coal deposits were formed. It was only in 1966 and 1967 that the Russian space probes Venera 3 and Venera 4 dived into the cloud shield, and a very hostile environment was discovered.

8. Conclusion

The history of the search for life on Venus bears witness to the inventions and imaginings of the human mind, and about attempts by the active human mind to grasp reality. Cognitive processes such as analogies and epistemic perception played an important role in the conceptualization of the universe, and in the interpretation of sensory impressions. Venus was compared to Earth, in order to find similarities and dissimilarities, and in making analogies between the two. The observations

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[70] Cattermole & Moore (1997), p. 15.

[71] Arrhenius (1915); Moore (1956), p. 108.

through telescopes of the distant planet had to be evaluated and interpreted, as the blurred surface did not immediately reveal its true nature.

Such analogical reasoning could be summarized as a search for similarities in an inductive manner, in order to pinpoint as many as possible, especially those of a significant nature, i.e., those critical features that indicate a habitable environment. It was known that both Earth and Venus were planets of a similar size, both orbited the Sun, and were exposed to its light and heat, and that both globes were opaque and had a solid ground. These similarities could be extended, as some astronomers maintained, to both of them having nearly exactly the same period of axial rotation, as well as a companion moon, an atmosphere, mountains and seas. If Earth and Venus seemed to be perfect twins, then there must be life on Venus too.

The blurred images seen in the telescope were faint sensory impressions that needed interpretations by applying prior knowledge and conceptions to what the eyes perceived. The active mind searched for regularities, order, and comprehensibility in the observations. Our impressions of the external world change our conceptions, while our conceptions in the same time change how we view the world. We can be sure that nobody had ever seen the surface of the planet, yet they imagined it, and thought they saw it, interpreting their sensory impressions in the light of their knowledge and expectations. The epistemic perception led them to conclusions about what they had seen. Unlike the shameless goddess after whom she is named, Venus the planet hides beneath an impenetrable veil of clouds.

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