2

“I could see the dark part of Venus...”

The ‘canals’ of Mars are now viewed as an artifact of the era before the robotic exploration of the Solar System, all evidence for their reality, independent of the eyes and brains of the telescopic observers who recorded them, having vanished. And yet in at least some instances, there are hints that distinctly natural linear features on Mars inspired some of these observations. Other phantoms of the eyepiece, some of which we’ll explore later, have similarly come and gone throughout astronomical history, supported at times with evidence yet still subject to a little too much credulity. But one remains some four centuries after it was first described, stubbornly refusing to either submit fully to scientific explanation or go away altogether.

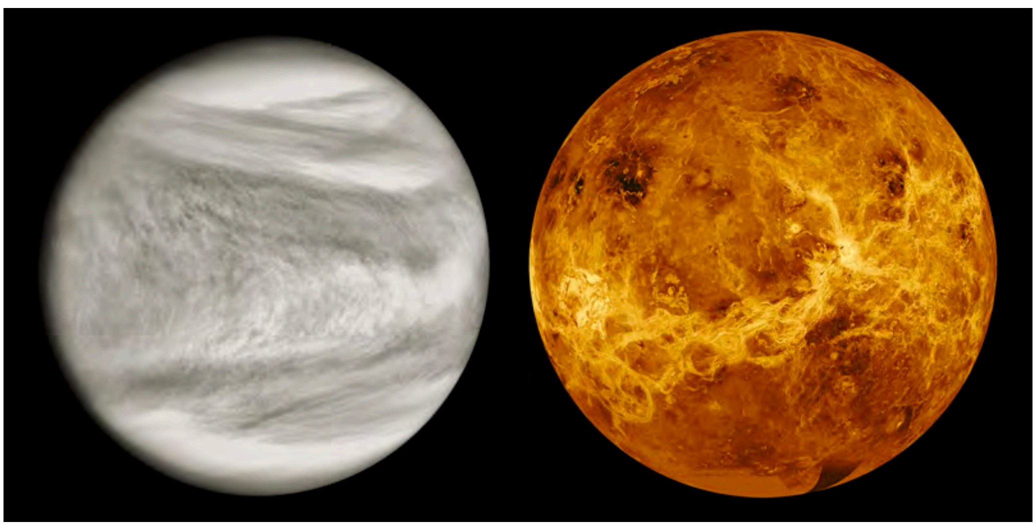

Figure 7: Two spacecraft views of Venus. Left: NASA image ARC-1981-A78-9167 made in ultraviolet light by the *Pioneer Venus Orbiter* on 29 September 1981. The image is rendered in a colormap approximating the true color appearance of the planet in visible light. Right: A global synthetic aperture radar view of Venus created from *Magellan* and *Pioneer Venus Orbiter* spacecraft data obtained in 1991, showing surface features otherwise obscured from view by its thick atmosphere. The false color suggests a visual impression of the surface illuminated by sunlight attenuated by its passage through the clouds. Both images courtesy of NASA/Jet Propulsion Laboratory.

After hundreds of years of scientific study, we confidently know a lot about the physical nature of Venus. Some five decades on since the first robot emissaries from Earth flew past it, we have characterized the planet in remarkable detail. Despite its nearly identical size, Venus bears almost no resemblance to our planet. Its dense atmosphere, composed almost entirely of carbon dioxide, traps heat from the Sun, raising the surface temperature above that of a household oven and a pressure equivalent to that found almost a thousand meters below the surface of Earth's oceans. In the middle layers of the atmosphere, winds reach speeds comparable to those of cruising commercial airliners on Earth. Opaque clouds of sulfuric acid droplets absorb and scatter essentially all optical light, rendering the surface of Venus permanently invisible from above (Figure 7, left). Its large iron core seems thermally inert, driving neither plate tectonics nor an appreciable magnetic field. The planet spins once on its axis every 243 days — the slowest rotation period of any major planet — in a direction opposite the sense of its orbit around the Sun. Radar measurements from orbit reveal a surface of many volcanoes and relatively few impact craters (Figure 7, right). Murky images of its surface taken by Soviet spacecraft that soft landed on Venus in the 1970s and 1980s show low outcrops of platy, igneous rocks amid grayish basaltic soils. Scenes are illuminated by a dull, reddish sky light of approximately the same brightness as an overcast day on Earth.

In short, the surface and lower atmosphere of Venus are a boiling, acidic hell, while its insides appear geologically dead. Whatever common properties our worlds shared early in their respective histories, science has shown that they long since parted company and evolved along highly divergent paths.

Yet Venus beckons to us in an odd and enduring way. Like Mars, it has a lengthy presence in human consciousness that reaches back far into prehistory, occupying a seat deep in the recesses of time. It is the planet that seems to appear earliest in our cultural history, with mentions in some of the world's oldest written folklore. In turn, our distant ancestors' attention may well have been drawn to Venus at the start of our recorded history as humans made the important transition from nomads to farmers and began an intellectual journey that may one day take us to the stars. Like the Earth's Moon, Venus was an early cultural milepost along that route.

Venus in myth and tradition

To the ancients in the West, Venus was a conspicuous 'wanderer' in the night sky, chief in brightness among starlike objects, always feminine in identity, defined by pairs of attributes reflecting various human motivations. The recognition of Venus as separate from both stars and the other planets was an important step in the expansion of human consciousness to recognize the existence of a space beyond our own Earth. Nearly six thousand years ago, during the millennium between the protohistoric Chalcolithic period and the Bronze Age, the earliest settled communities appeared in Mesopotamia. Atop a hill above what is now a dried-up, ancient channel of the Euphrates River in present-day southern Iraq, a city called Uruk emerged in phases beginning around 4000 BCE. From nearly its founding, Uruk was strongly associated with a goddess called Inanna, whose name derives from a Sumerian phrase meaning 'Lady Of Heaven.' To the Akkadians, Babylonians and Assyrians, she was Ishtar; to the Phoenicians, she was Astarte. As a deity, she had it all: in the mythology of Sumeria, she was the goddess of love and lust, beauty and fertility, knowledge and wisdom, and war and combat.

In addition to being one of the most widely venerated figures in the Mesopotamian pantheon, Inanna was identified with the planet Venus. It comes as little surprise that Sumerians associated the planet with oscillations between pairs of attributes, given the careful observations of the sky, day and night, on which they relied to keep an accurate calendar for coordinating activities attendant to agriculture. Over many months, the planet moves away from the Sun in the sky, reaching a maximum separation before moving back toward the Sun and disappearing for several days before its apparent rebirth. Venus became a symbol of recurring patterns in nature, both human and divine.

From the regular apparition, and similar appearance, of both a 'morning star' and an 'evening star,' Sumerian astronomers concluded that the two were manifestations of the same thing. That duality may well have inspired a tendency to project onto Venus all manner of dichotomies, Inanna's vacillation between aspects reflecting some knowledge of a heavenly body that never strayed far from the Sun. As the next-brightest object in the sky after the Sun and Moon, the appearance of Venus in Mesopotamian iconography as an eight-pointed star (Figure 8) is a kind of visual shorthand still recognizable to us today.

As civilization arose elsewhere in the region, the cultural history of Venus as a heavenly body entered a long period of stasis. Ancient Near Eastern knowledge of the night sky was transmitted to the Greeks by way of Egypt, who found something like Venus in their native goddess Isis. Herself associated with a death-and-resurrection story, Isis was also connected to calendar-keeping in one mythological explanation for the annual rise and fall of the Nile River. But the Egyptians evidently did not make the connection between the morning and evening apparitions of Venus as manifestations of the same object, calling the morning star *Tioumoutiri* and the evening star *Ouaiti*.

The Greeks adopted this view and called Venus alternately *Phosphoros* ("Bringer of Light") or *Eosphoros* ("Bringer of Dawn"), and *Hesperos* ("star of the evening"), respectively. Much later when Saint Jerome translated the Bible into the Latin of his day, he rendered the Greek *heosphoros*

Figure 8: Detail of a stele commemorating the Babylonian King Melišhipak II (r. 1186–1172 BCE, center) presenting his daughter to the seated goddess Nanaya, who represented certain aspects of Inanna-Venus. The king holds his hand before his mouth in a respectful gesture to the goddess. Symbols evoking the gods Sin (crescent moon, top-center), Shamash (the Sun disc, upper right), and Ishtar (eight-pointed star, upper left) were included with the scene as apotropaic devices to protect the stele from desecration. Department of Oriental Antiquities, Musée du Louvre, Paris. (Photo courtesy of Marie-Lan Nguyen.)

of the Septuagint and the Hebrew Helel as *lucifer* ("Light Bearer"), giving us a name for the Devil that persists to our own time.[1] Venus is the only planet specifically mentioned in the sacred writings of the early Greeks, and it appears in the works of great poets like Hesiod and Homer. During his extensive travels in Egypt, the fifth-century BCE Greek historian Herodotus identified Isis with Demeter, the Greek goddess thought responsible for the cyclical fecundity of the Earth throughout the year, indicating the continuity of the Sumerian Inanna story from the Bronze Age to classical antiquity. By the Hellenistic period (fourth to first centuries BCE) the Greeks merged the morning-star/evening-star aspects of the planet in the form of the existing goddess Aphrodite Ourania, although it's not clear whether that merger

[1] See, e.g., Isaiah 14:12, "Quomodo cecidisti de cælo, Lucifer, qui mane oriebaris!" (King James Version: "How art thou fallen from heaven, O Lucifer, son of the morning!")

reflected some specific intuition about the singular nature of the two "stars."[2]

In his vast treatise on the natural world, *Naturalis Historia*, the first-century CE Roman author Pliny the Elder summarized the knowledge received from the ancient world that came before him. "Below the Sun," he wrote,

> revolves the great star called Venus, wandering with an alternate motion, and, even in its surnames, rivaling the Sun and the Moon. For when it precedes the day and rises in the morning, it receives the name of Lucifer, as if it were another Sun, hastening on the day. On the contrary, when it shines in the west, it is named Vesper, as prolonging the light, and performing the office of the moon. … It excels all the other stars in size, and its brilliancy is so considerable, that it is the only star which produces a shadow by its rays. There has, consequently, been great interest made for its name; some have called it the star of Juno, others of Isis, and others of the Mother of the Gods. By its influence everything in the earth is generated. For, as it rises in either direction, it sprinkles everything with its genial dew, and not only matures the productions of the earth, but stimulates all living things.[3]

When the Romans adopted the Greek hero Aeneas as the founder of their civilization, they incorporated a mythological origin story connecting their race to Venus: Aeneas was the son of the prince Anchises and Aphrodite. The Romans adopted the latter as *Venus*, whose name derives from a Proto-Indo-European root word meaning "to strive for, wish for, desire, love."[4]

I wanted some insight to better understand why this planet in particular was so alluring to humans who lived in times separated from our own by thousands of years, and one person immediately came to mind. Mary Stewart Adams is an expert in the folklore of the night sky who combines her extensive knowledge of ancient mythologies with the research and ideas of contemporary astronomy to critically examine the nature of the relationship between humans and the cosmos. Mary is also a passionate defender of the night from the ravages of light pollution, which separates us from witnessing firsthand the starry heavens that inspired our distant ancestors to create such beautiful stories. What, I asked her about the mythological Venus, stands out most distinctly?

"What most delights me is the consistency of attribute," Mary wrote me

[2]By the "Golden Age" of Athens (fifth century BCE), the Greeks began to demarcate two distinct aspects of Aphrodite: the celestial (*Ourania*) and the terrestrial (*Pandemos*). The former was associated with the figure later Latinized as *Urania*, the Muse of Astronomy and a daughter of Zeus by Mnemosyne.

[3]*Naturalis Historia*, 2.6. Translated by John Bostock and appearing in his edition of *Natural History* published at London in 1855.

[4]c.f. the English word "venerate", from the Latin *venerātus*, perfect passive participle of *veneror* ("worship, reverence").

from her home in Michigan. “Venus seems always to be connected with love and beauty, with the ferocity of protecting what is loved, and with the feminine divine.” But then she immediately turned over the cultural picture of Venus I had in mind to show the imperfections of the mythological figure represented by the planet. “It is curious to me that, although Venus was associated with devotion and reverence, her depiction in Greek and Roman mythology should include infidelity.” Venus used her power to make the gods love those whom they would otherwise not. Yet by causing Venus to fall in love with Anchises, Jupiter teaches her an important lesson: she is no stronger than the other gods. Here the façade begins to crack, revealing in the divine a very human inclination toward hubris.

So what was it about the planet Venus that earlier humans found most alluring as they saw it in the night sky? Mary recalled the belief that Plato expressed in *Timaeus*, a dialog composed in the fourth century BCE in which it is suggested that each human soul literally arrived to Earth from a particular star. Because of human origins among the stars, Mary said, the ancients believed that humans had a more ‘inner’ relationship to the planets than what we experience when we gaze upon them as though from ‘without.’ “This is really a gift given to the human being by Venus.”

To understand why, she said, we have to look back to a time in human history during which there was no separation in the consciousness between the celestial and terrestrial worlds as we experience them now. The cosmos was widely believed to influence the destinies of individual humans, and in this astrological context the position of the planet Venus at the moment of one’s birth would have been regarded as a sort of celestial statement about the capacity of that individual to rise up to the function or gift bestowed by Venus. It was a personal relationship. “Venus was considered the realm where, as the soul was incarnating, the ‘decision’ was made with regard to nationality and family and the type of relationship one would have in these communities, whether it be loving or estranged.”

I wondered: did that relationship persist through a person’s life? Mary believed so. “I imagine that Venus stirred a sense of gratitude for any type of grace that was experienced in life,” she wrote, “and that its beauty and brilliance confirmed this sense that here was the spiritual divinity that could guide the human being along a path of goodness, truth and beauty.”

There is something distinctly familiar in that sentiment. Perhaps, I suggested, that is why even after the scientific study of the planet Venus began in earnest, telescopic observers reported seeing things there we don’t see now, such as oceans and mountains. It was almost as if they wanted to believe that Venus as a place was much like our very familiar Earth. Was that plausible? “I think it is simply that we inherently long for affirmation that there is a mystery in our being, that not all things can be described or understood through the intellect or by logic, but that dream and imagination are sometimes better ways to address longing. In this regard it's not so much how well the idea reasons, but how the idea *feels*, and as Goethe said, 'Beauty is everywhere a welcome guest.'" To the end of antiquity, the planet Venus was seen not as a place but as the realization of an ideal, a cosmic embodiment of beauty. It took the upending of the classical world to shake that view, to be replaced by one in which Venus was an object with real, physical characteristics.

The traditional story of history books is that, after the fall of the Western Roman Empire and the decline of its influence in western Europe, the lamp of learning was effectively extinguished as the Medieval period began and not lit again until the blooming of the Renaissance. But the light of the intellectual world didn't flicker out; rather, it simply migrated east, largely bypassing the Byzantines and establishing itself in great cities of the Islamic world like Baghdad and Cairo. In the last great era of Western astronomy before the introduction of the telescope, Islamic astronomers made remarkable observations that pushed the limits of human visual acuity. There are indications that some Islamic skywatchers with especially keen eyesight detected the crescent shape of Venus when it appeared near the Sun in the sky, giving them the hint that something was different about this wanderer that set it apart from the other planets.[5] That observation was not fully confirmed for almost five hundred years, awaiting the magnifying power of the telescope.

As the Medieval period ended in Europe, the emergence of modern Western civilization unfolded mostly like we learn about in school. The still-monolithic Christian Church under the authority of the Roman Pontiff began a long, gradual decline in both its temporal and spiritual power in Europe. Europeans 'rediscovered' great written works of science and literature from the ancient world, in many cases due specifically to the assiduous work of Islamic scholars who translated and transmitted them back to Europe. At the same time, explorers were setting sail on voyages of discovery that proved the world was considerably bigger than previously imagined. And with a renewed interest in learning and exploration came technological innovations that would literally transform our view of the cosmos.

Although humans discovered the basic principles of optics and were making simple lenses out of polished crystal as early as the first millennium BCE, there were few practical applications of this technology until the late

[5] There is some debate over whether people with unusually good visual acuity may have been able to resolve the crescent shape of Venus during certain of its phases. q.v. Henry MacEwen, 1895, The Visibility of the Crescent of Venus, *Journal of the British Astronomical Association*, 6, 34–35; and W.W. Campbell, 1916, Is The Crescent Form of Venus Visible to the Naked Eye?, *Publications of the Astronomical Society of the Pacific*, 28(2), 85.

Middle Ages. In the eleventh century the Islamic scientist Ibn al-Haytham, known in the West as "Alhazen," published *Kitāb al Manāẓir* ("Book of Optics"). This seven-volume treatise summarized essentially everything that Alhazen could find about knowledge of optics in the ancient world, relying particularly on *Optics*, a work by the second-century CE Greco-Egyptian astronomer Claudius Ptolemy, and an account of the anatomy of the human eye by Ptolemy's contemporary, the Roman physician Galen. Alhazen's *Book of Optics* was rendered into Latin as *De Aspectibus* ("On the Aspects") by an unknown translator toward the start of the thirteenth century, and it quickly became influential in Europe.

European opticians, influenced by Alhazen, were experimenting with grinding and polishing glass lenses by 1250, adapting them to applications like vision-correcting spectacles soon after. The magnifying capabilities of lenses were exploited to produce the first monoculars, or spyglasses, roughly three hundred years later. And while we don't know who invented what we now call the telescope, history records that the first patent application for one was submitted by Hans Lippershey (1570–1619), a spectacle maker from Middelburg, the capital of the Dutch province of Zeeland. In October 1608, Lippershey applied for a patent on an instrument whose purpose was "for seeing things far away as if they were nearby." It's unclear exactly what inspired him, but one account has it that Lippershey stumbled upon the idea for a spyglass after watching children in his shop holding up pairs of lenses that magnified the image of a weather vane atop a distant roof.

The entrepreneur in Lippershey smelled a government contracting opportunity: with this device, for example, one could gather important intelligence about invading navies while they were still far out at sea. While Lippershey's patent application was ultimately unsuccessful, the idea of the spyglass caught fire and rapidly spread across Europe. It was only a matter of time before someone turned a telescope skyward.

Galileo discovers the phases of Venus

In early 1609 the Florentine scientist Gailieo Galilei (1564–1642) was traveling in Venice when he first heard of something then called the "Dutch perspective glass." Despite having never examined one in person, immediately upon his return home to Padua he set about fashioning his own example. He toyed with the design, fitting different lenses into a leaden tube until he achieved an acceptable result. Sensing some potentially sensational attention for the benefit of his academic career, Galileo hurried back to Venice, telescope in tow, and presented the device to the Venetian Senate in the presence of Doge Leonardo Donato. On 21 August, from an elevated viewing area in the bell tower of St. Mark’s cathedral, Galileo publicly demonstrated the telescope before the Doge and members of the Senate (Figure 9), who in turn gave him a permanent position at the University of Padua and doubled his salary.

Figure 9: *Galileo presents the telescope to the Senate of Venice* (*c*. 1840) by Luigi Sabatelli (1772–1850), housed at the Tribune of Galileo in Florence, Italy. Photo by Wikimedia Commons user Sailko, licensed under CC BY-SA 3.0.

Galileo continued to refine the design of his telescope, improving its performance through the autumn of 1609. In the waning weeks of that year into the first frosty nights of 1610, he pointed it toward the Moon and Jupiter. The latter was readily observable, high in the evening sky in the constellation Taurus throughout the winter of 1609–1610, and he quickly found (and was the first to describe) its set of four large moons. They appeared to Galileo as featureless points of light slowly wandering back and forth along an imaginary line passing through the planet itself. Since the objects were bound to follow Jupiter wherever it wandered across the sky, Galileo quickly concluded that they must be in orbit about the planet, and that our point of view was more or less in the same plane as their orbits.

The existence of the ‘Galilean Moons’ was an unexpected repudiation of the cosmology of Aristotle (384–322 BCE), who held that the Earth was the fixed center of the universe. What was Jupiter doing with what appeared to be its own miniature planetary system? The delicate dance of the little spots about Jupiter from night to night was strongly reminiscent of the Sun-centered model of Nicolaus Copernicus (1473–1543) if one simply exchanged Jupiter for the Sun, upending the view in Galileo's time that Jupiter was fully subordinate to the Sun in the hierarchy of the Solar System.

Galileo, very aware of the source of his livelihood, immediately named the curious objects after his patron, Cosimo II de Medici (1590–1621), Grand Duke of Tuscany. In the dedication of his groundbreaking treatise *Sidereus Nuncius*, published a month later, Galileo entreated the Grand Duke to "behold, therefore, four stars reserved for your illustrious name ... that make their journeys and orbits with a marvelous speed around the star of Jupiter ... like children of the same family." The implied comparison of himself to the king of the Roman gods probably flattered the Grand Duke.

Jupiter was the only bright planet observable in the evening during the first half of 1610; Mercury and Venus were gradually lost in the glare of morning twilight around the time Galileo was making his Jupiter discoveries. But Venus reappeared in the early evening during late summer, and near the beginning of October Galileo found it with his telescope. He saw no indication of moons orbiting Venus as they did Jupiter. The planet appeared unremarkable to him, a dazzling, featureless circle that might as well have been a perfect mirror. Yet his intuition led him to keep watching.

As the weeks passed he saw the shape of Venus gradually begin to enlarge, distort and elongate as the planet approached Earth in its orbit (Figure 10). By December, the conclusion was inescapable: even at the poor resolution of Galileo's simple telescope, Venus could no longer be fairly described as a circular disc. Just as in the case of the little solar system he found centered on Jupiter, the dominant cosmology of his time made no accommodation for observed fact that Venus exhibited phases like those of Earth's Moon.

Given how quickly others in Europe were fashioning telescopes for astronomical use, Galileo well knew that his monumental discovery about Venus could easily be scooped. While he realized that he wouldn't have the luxury of observing a full cycle of the phases before publishing the details, he wanted to make a select few astronomers aware of what he had seen. To buy some time, Galileo followed a common practice of the era: he encrypted his result into a Latin anagram. On 11 December, he wrote to the German astronomer Johannes Kepler (1571–1630) "Haec immatura a me jam frustra leguntur o y", which translates roughly as "This was already tried by me in vain too early." However, the extra "o" and "y" at the end of the statement were a clue to Kepler that Galileo was transmitting a secret message to him. It turned out that Galileo wasn't all that good at constructing anagrams, and couldn't find a place to insert the extra letters for his real message to the recipient. Kepler took the hint and unscrambled the letters to form a new sentence: "Cynthiae figurae aemulatur mater amorum" ("The mother of

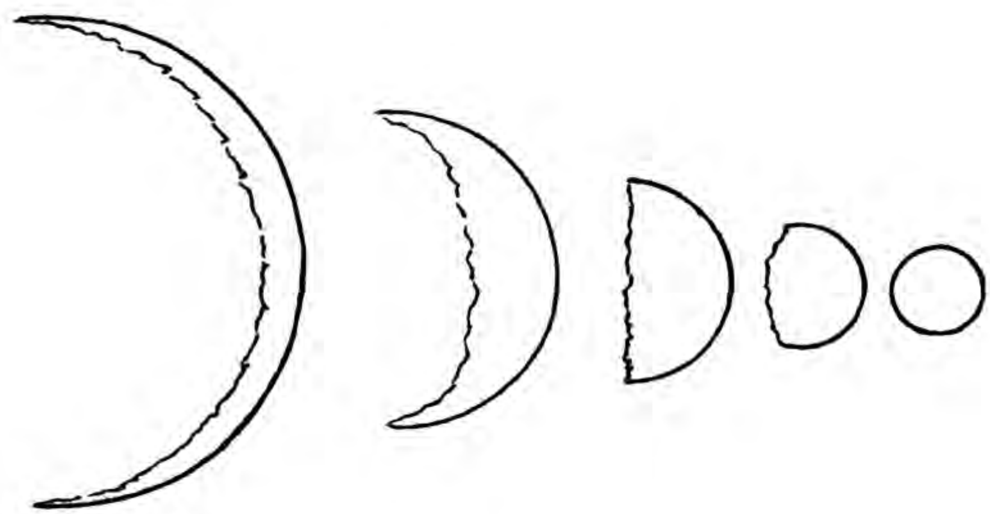

Figure 10: Galileo's drawings of his observations of the phases of Venus, published in *Il Saggiatore* (The Assayer), 1623.

lovers imitates the shapes of Cynthia"). Knowing that the "mother of lovers" was Venus, Kepler quickly understood: Venus undergoes a regular cycle of phases like the Moon. It was big news indeed.

On 30 December, Galileo wrote to the German Jesuit astronomer Christopher Clavius (1538–1612). Feeling increasingly confident that the apparent phases of Venus were in fact real, he described his observations in plain language for the first time. "When Venus began to be visible in the evening sky," Galileo recounted,

> I started observing it and saw that its figure was circular, though extremely small. Afterwards, I saw [Venus] growing in magnitude significantly, though always maintaining its circular shape. Approaching maximum elongation, Venus began to lose its circular shape on the other side from the Sun and within a few days had acquired a semicircular shape. This shape it maintained for a number of days. More precisely, it maintained [this shape] until it began to move toward the Sun, slowly abandoning the tangent. It now begins to assume a notable corniculate shape. Thus, it will continue to decrease during the period in which it remains visible in the evening sky.[6]

Galileo remained puzzled by this behavior. A crescent shape was in no way reconcilable with the reigning view of Ptolemy, whose cosmology aligned clearly with Aristotelian principles. In the Ptolemaic system of

[6]From *Le opere di Galileo Galilei* in 20 volumes, Edizione Nazionale, ed. Antonio Favaro, Florence, 1890–1909. It is quoted in translation by Palmieri (2001).

Galileo's time, Venus was assumed to be "above" the Sun in a hierarchy of objects whose perfectly circular orbits centered on the Earth. But the observed motions of the planets didn't comport with the geocentric ideal, so Ptolemy bent the model until it fit the data. He resorted to a series of 'epicycles,' small, circular orbits-within-orbits executed about the line of the larger Earth-centered orbit. None of this had any basis in the fledgling notion of physics as it existed in antiquity, and a thousand years would pass before keen observers noticed that the simplest explanations for natural phenomena tend to be the right ones. Starting with a conclusion, Ptolemy added more and more moving parts until it all seemed to work well enough.

Galileo knew that a full or gibbous Venus was consistent with an orbit "above" the Sun in the Ptolemaic hierarchy, while a crescent Venus was only compatible with an orbit in which the planet was forever "below" the Sun. The trouble, of course, was that Venus exhibited *both* crescent and gibbous phases, which could not be reproduced within the framework of a geocentric Solar System. Ten more years of thought would pass before Galileo finally convinced himself that Venus orbited not the Earth but rather the Sun itself, and therefore the Ptolemaic model was fundamentally wrong. He presented the conclusion in *Il Saggiatore* ("The Assayer"), published at Rome in October 1623, one of the first written works on what we would now call the scientific method.

Telescopic observers of Venus in the early seventeenth century were tremendously limited by the various imperfections of early instruments, including the low angular resolution of their small objective lenses and the poor quality of the glass used to make them. These telescopes suffered from chromatic aberration, an optical effect resulting from the tendency of glass to bend the paths of light rays through different angles according to their colors. This meant that the red light rays came to one particular focus behind a lens while the blue rays came to a different focus, leading to brilliantly colored haloes around astronomical objects. The effect was exaggerated for bright objects like the planets, making it difficult to distinguish subtle differences in color and intensity. In many respects, the resulting images weren't just aesthetically unpleasant: they could actually induce the observation of apparent phenomena that didn't really exist.

The early adopters of 'Galilean' refracting telescopes understood that the colors were ephemeral and produced in the optics themselves while they struggled to find innovative ways to correct for the effect. Around 1730, an English lawyer and amateur inventor named Chester Moore Hall tinkered with lenses, finding that a combination of dissimilar lens materials and optical surfaces of different kinds of curves could overcome chromatic aberration. But even after improved lens designs began to yield planetary images with better fidelity, the shimmering disc of Venus gave up no new secrets. No matter how impressive the image, the planet remained utterly featureless. Was it a perfect sphere, devoid of topography? Was it covered in water? Was its apparent surface actually a uniform layer of clouds? Neither bigger telescopes nor higher magnification yielded any additional detail that might help answer any of these questions. For decades, Venus gave up no more of her secrets.

And what of the Earth's Moon, in comparison to Venus? Unaided human eyes turned to our Moon see a lot, given that the angular diameter of the full Moon is some thirty times that of Venus when it approaches Earth most closely. At its widest, the human eye pupil opens to a diameter of about eight millimeters when fully sensitized to very dim light. A lower limit to the eye's power to resolve objects of small angular size is set by the so-called diffraction limit, a property imposed by the wave nature of light. A keen observer under ideal conditions, working at the diffraction limit of the human eye, might resolve features with angular diameters as small as 15 to 20 seconds of arc, each second being one part in 3,600 of one angular degree. At the minimum possible distance from the Earth to the Moon, roughly 363,000 kilometers, an ideal human observer might be able to discern features corresponding to linear sizes as small as 30 kilometers.

But the situation in practice is complicated by glare and contrast effects, which tend to degrade visibility and therefore render small objects more difficult to see, as well as the optical distortion caused by Earth's often turbulent atmosphere. It's also the case that the Moon is sufficiently bright, even against a dark background sky, that the pupil of the eye constricts in trying to handle the large dynamic range of the illuminated surfaces in view, so the angular resolving power set by diffraction is decreased. However, some lunar features such as its dark lava plains, or "maria," are easily visible by virtue of their contrast against lighter-colored surroundings. These tend to be hundreds to thousands of kilometers across.

In any case, it's fair to say that a visual observer with typical eyesight might be able to make out something on the Moon with a linear size of about 300 kilometers, and one with especially keen eyesight might be able to do 100 kilometers better than that. I've tried it myself many times; for example, I can readily make out the roundish Mare Humorum (diameter 390 kilometers) and Mare Nectaris (340 kilometers) as clearly separate from their surroundings, whereas I have never confidently detected the crater Grimaldi (175 kilometers) despite its dark, lava-flooded floor and the bright, adjacent highlands. These features are indicated with labels on an image of the full Moon in Figure 11. The much higher angular resolution of telescopes, rather than their light-gathering capacity, is what lends so much more detail

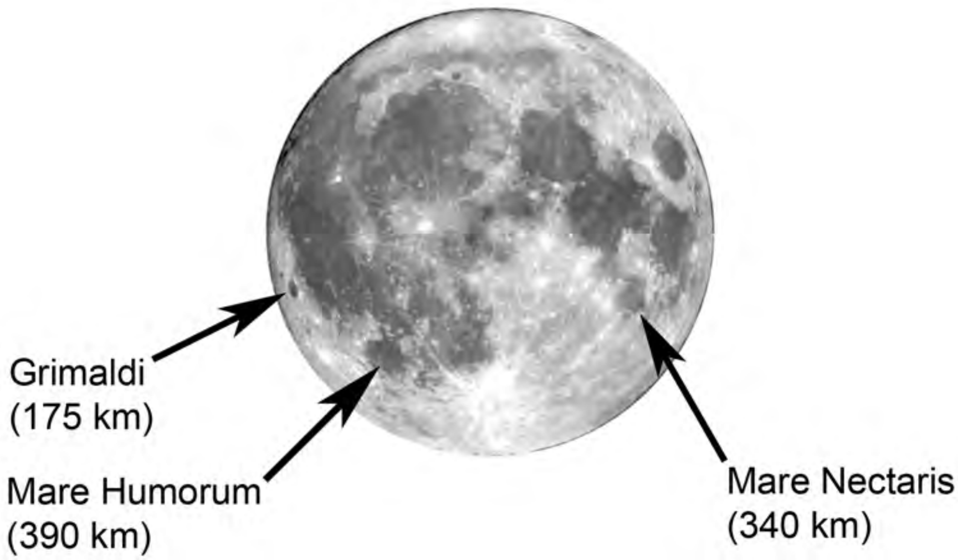

Figure 11: Lunar features near the spatial resolution threshold of the unaided human eye at the distance of the Moon referred to in the main text. Photo by the author.

to views of the Moon than our eyes could ever reveal.[7]

Applying the same logic to Venus, given its apparent angular size and minimum distance (about 38 million kilometers), a modest telescope of a few tens of centimeters' aperture could reveal features on Venus as small as about 100 kilometers across. Since that figure is comparable to the size scales of various terrestrial landforms, and if Venus were a world not unlike Earth, we would naively expect to see through our telescopes a mottled surface with distinct continents, seas, mountain ranges, and even polar ice caps. Yet the telescope revealed none of these things to Galileo and his contemporaries, even though later as telescope quality improved observers began to report shadowy markings most consistent with cloud patterns. That is, until around the middle of the seventeenth century.

In 1651 another Italian, Giovanni Battista Riccioli (1598–1671), wrote about telescopic observations of Venus he made several years earlier: "As chance would have it, … a partial circle of light could be seen enclosing the otherwise dark side of the disc, brightening it particularly toward the eastern limb." It seems at first glance like a straightforward and otherwise

[7] A good overview of the resolving power of the unaided eye as applied to lunar features can be found in Joseph Ashbrook's article "Lunar Studies Before the Invention of the Telescope," originally published in *Sky and Telescope*, June 1962, p. 322. It was republished in the compilation *The Astronomical Scrapbook: Skywatchers, Pioneers and Seekers in Astronomy* (Cambridge, Mass.: Sky Publishing, 1984, p. 233).

uninteresting account of what Riccioli saw on the night of 9 January 1643 through a simple refracting telescope that his friend, the lawyer Francesco Fontana (1580–*c.*1656), loaned him. In fact, Riccioli saw something entirely without precedent in the history of astronomy up to that point in time.

It was only a generation after the invention of the telescope for astronomical purposes, prior to which nothing was known about the planets other than they constantly changed their apparent positions on the night sky unlike the seemingly fixed stars beyond. Until Galileo turned his simple spyglass on the night sky for the first time, no one had any good idea what the planets were like, much less that they were worlds unto themselves. The moons of Jupiter and the phases of Venus and Mercury confounded European observers in their attempts to understand the observations in light of the dominant cosmology of the era. But, just as in Giovanni Schiaparelli's time, telescopes showed what they did, and they left certain impressions on the people who viewed the planets through them.

The optical shortcomings of Fontana's simple refracting telescope were clear to Riccioli on the night he first saw the disc of Venus in its entirety; the planet "was, compared to the Sun, red to yellowish, and, on the side facing the direction of the Sun, a blue-green: but those colors were most likely caused by the particular variety of glass used in the telescope optics." And yet there was the otherwise un-illuminated 'night' side of Venus, glowing unmistakably against the darker night sky surrounding it.

The same sensation was neatly summarized by the German astronomer Christfried Kirch (1694–1740) as he peered through the eyepiece of his 26-foot telescope at the Berlin Observatory on the evening of Friday, 8 March 1726: *Ich konnte das tunkle Theil Veneris erkennen* ("I could see the dark part of Venus").[8]

Riccioli was the first to describe what later became known as the Ashen Light (Figure 12), a ghostly emanation from the nighttime hemisphere of Venus, a complete explanation for which has eluded science for almost 400 years.[9] Writing toward the end of the nineteenth century, the Irish linguist and journalist Ellen Mary Clerke (1840–1906) gave perhaps the most poetic description of the Ashen Light to date. It is the circumstance, Clerke wrote,

> when the shadowy form of the full orb is seen to shine dimly within her crescent. . . . More wonderful still, this "glimmering sphere" is then crowned, as with a silver halo, by a thin luminous arch, forming a secondary sickle

[8]Quoted by Eduard Schönfeld in *Astronomische Nachrichten*, Vol. 67, No. 1586, p. 27, 1866.

[9]The same phenomenon is sometimes referred to as the "secondary light" of Venus, especially in scientific journals of the nineteenth century, to distinguish it from the "primary light" reflected directly from the Sun.

Figure 12: An artistic rendering of the telescopic appearance of the Ashen Light of Venus during the planet's crescent phase based on various eyewitness reports.

> facing the one nearest the sun, and doubtless due to the refraction of his rays round the globe of the planet, through the upper regions of her twilit atmosphere.[10]

We don't know for sure what it is, or even *if* it is. The Ashen Light has become a sort of 'Loch Ness monster' of planetary astronomy reported only by eyewitnesses. It has firmly (and, perhaps, conveniently) refused to submit to convincing photography or digital imaging in the time since those processes were invented. And its visibility seems in no way predictable, working strongly against efforts to independently establish its very existence. "There is one characteristic of the phenomenon abundantly verified by the numerous observers who have recorded it," the editors of the scientific journal *Nature* noted in their 'Astronomical Column' of June 1876, "which cannot be overlooked in our endeavours to arrive at its true cause, viz., its inter-

[10] 1893, *The Planet Venus*, London: Whiterby and Company, 15–19.

mittent or only occasional visibility." The Ashen Light is at the same time seductive and frustrating, defying all attempts at definitive elucidation while simultaneously resisting assignment to the scrap heap of astronomical myth. It seems to forever exist in the shadowy twilight between truth and fiction.

Yet there have been periods of time in astronomical history in which "the Ashen Light has been glimpsed by almost every serious observer of Venus," wrote the great English amateur astronomer, Sir Patrick Moore (1923–2012), in 1982. Moore himself was a prolific observer of the Ashen Light, recording the phenomenon on dozens of occasions from the 1950's nearly until his death. Convinced of its reality by sensing the Light repeatedly with his own eyes, Moore argued that the phenomenon positively cried out for investigation: "Genuine or not, the Ashen Light has been seen so frequently, and by so many experienced observers, that it has to be explained in some fashion. . . . [T]he observations of the Light are too numerous, and too concordant, to be dismissed."

The Revered Thomas William Webb, whose *Celestial Objects for Common Telescopes* (1859) remained essential reading for the British amateur astronomer for over a century after its publication, described the Ashen Light as a "truly unaccountable appearance" of Venus that was, nevertheless, "remarkably well attested."[11] Even Percival Lowell, who as far as we know did not witness the Ashen Light himself — or, at least, didn't record it in his voluminous observing notebooks — commented in 1909 on both its persistence in observational history and the failure of all attempts to find a sufficiently scientific cause: "The phenomenon has seemed the weirder for the difficulty of explaining it." *Sky and Telescope* magazine's Thomas Dobbins wrote in 2012 of the Ashen Light's outright rejection by many modern astronomers. "Many authorities dismiss the Ashen Light as an optical illusion," Dobbins noted. "Skeptics find it hard to believe that the phenomenon has not been recorded in images or spectrograms obtained with large Earth-based telescopes, let alone by the various spacecraft that have orbited Venus."

How, then, would one go about finding a solution to such an ephemeral problem? One place to start is the historical record and the words of Ashen Light eyewitnesses who committed their recollections to paper. Certain patterns emerge by surveying accounts of their observations. For instance, reported sightings are not evenly distributed through time. Figure 13 shows the frequency of nearly five hundred reports by decade between the early eighteenth and the early twenty-first centuries, presented in such a way that the number in each bin is a percentage of the total number of reports. One quarter of all recorded sightings happened in the 1950s, which may bear significantly on physical interpretations of the phenomenon. But it may simply

[11] 1873, 3rd ed., London: Longmans, Green & Co., 55.

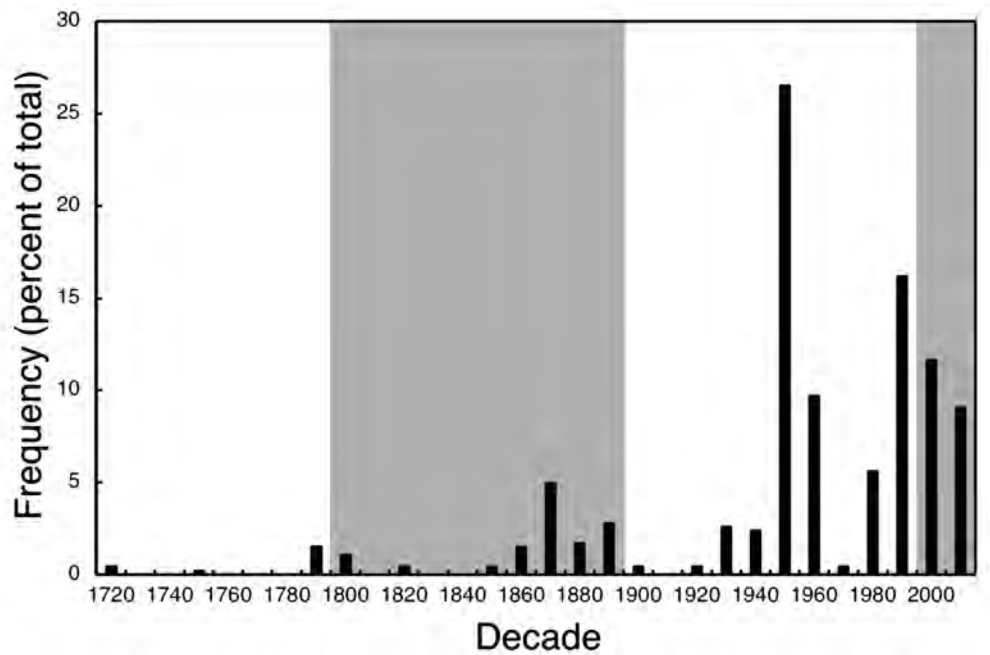

Figure 13: A histogram showing the frequency of 465 Ashen Light observations between 1721 and 2017. The columns are organized by decade, and labeled according to the first year of each. The number of observations in each decade is divided by the total, and the result converted into a percentage. The gray shaded regions set the nineteenth and twenty-first centuries apart from the eighteenth and twentieth centuries for clarity.

be that more observers were looking at Venus during that particular decade than others, and that the spike in the distribution hints at observer bias. This, too, could explain the number of reports from the second half of the nineteenth century, as planetary astronomy was rather in vogue during the late Victorian era. And relatively few telescopes existed in the world in the period of time represented by the graph's earliest decades, during which very few people anywhere were looking carefully at Venus.

One might ask, for example, whether there is any connection with the magnetic activity cycle of the Sun. If the Ashen Light is caused by anything like the Earth's aurorae, then its appearances might correlate with periods of time in which the Sun is more alive with flares and mass ejections that spew charged particles outward into the space surrounding the planets. If a correlation between the intensity of solar activity and the likelihood of Ashen Light observations were found, it would strengthen a Sun-Venus explanation.

To help search for any such connection, Figure 14 adds average sunspot counts by decade to the distribution of Ashen Light sightings from Figure 13. The data are inconclusive on this point; still, there are hints in this figure that something is indeed up. The apparent spike in the number of Ashen Light sightings in the 1950s correlates with one of the strongest solar maxima of the past 250 years. Given that this peak also coincides in time with the International Geophysical Year of 1957–1958 (Chapter 6), it may be indeed that more people than usual were observing the planets during those years and therefore more likely to note anything unusual about the telescopic appearance of Venus. Note further that the declining trend of sightings since the 1990s mirrors the overall decline in sunspot counts during the past three decades. Any simple connection between solar activity and the likelihood of the Ashen Light being seen is therefore neither ruled in nor out by the data.

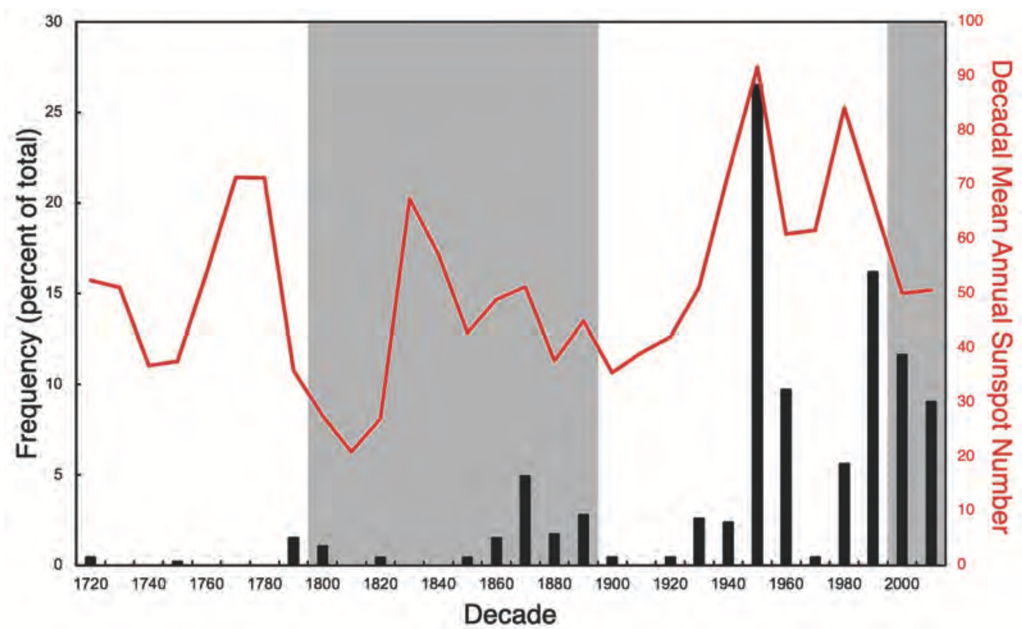

Figure 14: A recasting of the frequency of Ashen Light sightings by decade, as in Figure 13, but with the addition of the average annual number of sunspots by decade shown in red on the secondary vertical axis. For visual convenience, gray-shaded regions again separate the centuries.

Attempts to connect appearances of the Ashen Light with various influences are frustrated by its fundamental unpredictability. “Outbreaks,” during which many observers widely scattered in geography report seeing the Ashen Light night after night for weeks on end, punctuate periods in which one finds no reports in the literature for as long as a decade. Richard McKim, director of the British Astronomical Society sections on Venus, Mercury and Mars, noted that “sometimes the Ashen Light is visible for many days in succession, as in 1940, 1953, 1956 and 1957. At other times, despite excellent observing conditions, it remains elusive.” The existence of outbreaks just raises more questions: was it the case that whatever causes the Ashen Light wasn’t active during that time? Or could it just be that no one was looking?

It also doesn’t seem to be a simple trick of the telescope, which for any particular instrument and observer would manifest itself every time Venus were observed. It would then be possible to stage conditions under which Ashen Light is reported by any user of a given telescope.[12] That no one has fully reproduced the effect, much less captured a photograph of it, lends credence to the notion that the Ashen Light is at least not a purely instrumental artifact.

That it might have something to do with the atmosphere of Venus is supported by observations of a so-called 'limb brightening' effect in which the intensity of the Ashen Light seems to tick upward somewhat just before the reaching the edge of the planet's disc, resulting in the appearance of the 'silver crown' described by Ellen Mary Clerke. Imagine a spherical planet whose solid surface is covered by a luminous atmosphere of uniform thickness, making the atmosphere a kind of concentric "shell" around it. If the atmosphere emits light evenly throughout its bulk, then its brightness in any given direction depends on how much of the atmosphere one looks through. If the observer is hovering over the planet and looking directly down toward its center, the light-emitting part is "one atmosphere" in thickness, and yields a certain brightness. But as the observer's gaze moves from the center of the planet's disc to the edge, the effective path length through the atmosphere increases; at the planet's limb, one sees through many "atmospheres" of thickness, which appears consequently brighter. Since the path length is longer at the limb than toward disc center, a greater amount of atmosphere contributes light in the direction of the observer, who sees the apparent brightness of the planet increase from center to limb.

The German astronomer Hermann Joseph Klein (1844–1914) described this effect in the context of Ashen Light observations:

> If a planet enveloped by an atmosphere is illuminated from the outside, [and] if the envelope of the vapor does not absorb the light like a dense layer of fog, the edge of the planetary disc must appear a little brighter than the center. This is indeed the case with the secondary light of Venus, when the observers of the phenomenon saw the edge of the planetary disc stand out sharply from the heavens.[13]

The English surgeon, antiquarian and amateur astronomer Charles Leeson Prince (1821–1899) wrote of seeing a "phosphorescent flitting of light

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[12] See the experiments exactly to this point reported by Sheehan, Brasch, Cruikshank and Baum in the *Journal of the British Astronomical Association*, Vol. 124, No. 4, pp. 213–214 (2014). In dismissing the validity of existing photographs claiming to have recorded the Ashen Light, the authors note that "none of the putative images of the actual AL [Ashen Light] can be regarded as convincing. They appear to be due to filter leakage, crescent glare and excessive image processing used to bring out dark-side detail. It is, of course, difficult to prove a negative."

[13] 1873, *Handbuch der allgemeinen Himmelsbeschreibung: Vom Standpunkte der kosmischen Weltanschauung*, Braunschweig: Friedrich Vieweg & Son, 69.

around the edge of the entire disk" of Venus from his home in Uckfield, Sussex, on both the 25th and 30th September 1863.[14] Sir William Herschel (1738–1822), the famed Anglo-German discoverer of the planet Uranus, made a remarkable series of observations of the Ashen Light at Observatory House in Slough, Berkshire, in April 1793. "The light of Venus is brighter all around the limb, than on that part which divided the enlightened, from the unenlightened part of the disk," he wrote in his notes for the evening of 9 April.[15] Later in the same night, the planet's limb showed "a luminous margin . . . like a bright bead, of nearly an equal breadth all around." On the night of the 20th Herschel saw "a narrow luminous border all around the limb, and the light afterwards diminishes pretty suddenly." During an April 1876 meeting of the Royal Astronomical Society, William Noble (1828–1904) recounted seeing on an unspecified date "some years back . . . unmistakably the whole body of Venus, with the illuminated crescent like a hair of light around it."[16] Each such account clearly suggests limb brightening at work.

So it would seem at first glance that the mystery is solved: Venus must be surrounded by some kind of translucent material that is faintly self-luminous, explaining both the overall phenomenon of the Ashen Light as well as the observed limb brightening. And while Venus is very clearly possessed of a substantial atmosphere, it has been shown to emit no considerable quantity of light to which human eyes are especially sensitive. A uniformly luminous medium enveloping Venus therefore can't be the right answer.

The picture is further clouded by the existence of not one but *two* broad manifestations of the Ashen Light in the historical record, one seen in daylight and the other against a distinctly darker night sky. In the former case, observers describe some variety of discoloration of the planet's disc, making it stand out against the sky background by way of color contrast, or the appearance of the portion of the disc not directly illuminated by the Sun in such a shade of deep blue that it seems darker than the sky (Figure 15). These instances have been labeled "negative Ashen Light", to differentiate them from their "positive" kin in which the night side of the planet seems brighter than the surrounding sky and is typically only seen when the sky is astronomically dark (or nearly so).

[14] 1863, Observations of Venus at the Inferior Conjunction, *Monthly Notices of the Royal Astronomical Society*, 24, 25.

[15] 1793, Observations on the planet Venus, *Philosophical Transactions of the Royal Society of London*, 83, 209–213.

[16] 1876, *The Astronomical Register*, 14, 110. Noble stated clearly that he *didn't* note this effect during any of his previous observations of Venus. On 26 September 1870, for example, he "quite failed to see the dark body of the planet, which under analogous conditions has always been visible enough before in a constricted field." (1871, *Monthly Notices of the Royal Astronomical Society*, 32, 17)

Patrick Moore was clear about his distaste for applying 'Ashen Light' to any daytime observation, which he labeled "obviously a contrast effect." Although Moore noted that there clearly exist observations of more than one type, "the term 'Ashen Light' should properly be restricted to the faint luminosity of the night part of the disk, and should not be extended to cover reports of the night side being seen as darker than the background."[17] Moore held that the nighttime version of the effect was likely a true glow of some kind in the atmosphere of Venus, while the daytime version could be explained away as a trick of light and optics.

Figure 15: An artistic impression of the "negative" form of Ashen Light, seen exclusively against the daytime sky, in which the unlit portion of the Venus disc appears darker than the sky background.

What about an explanation that is a little closer to home, in a manner of speaking? An obscure German astronomer evidently known only to history as "F. Schorr" published a treatise in 1875 called *Der Venusmond: Und Die*

[17] 1962, *Journal of the British Astronomical Association*, 72(6), 265.

Untersuchungen Uber Die Fruheren Beobachtungen Dieses Mondes ('The Moon of Venus: And The Investigations On The Earlier Observations Of This Moon') in which he argued strongly that Venus must have an undiscovered natural satellite that accounts for some occasional oddities of its appearance. Although this putative moon was no more real than the Martian *canali*, its existence might have explained the Ashen Light in a very straightforward way: just as the Earth reflects sunlight to the night side of the Moon, which is then reflected back to the Earth and seen as a similar 'ashen' glow, an adequately large natural satellite on the night side of Venus might reflect sunlight to the cloudtops of Venus, which then reflect the same light back in the direction of Earth.

To support his argument, Schorr undertook an analysis of as many published accounts of the Ashen Light as he could find. "The perception of the dark side of Venus," he wrote, "can be classified, according to observations, into those in which the whole night-side was visible, and in others in which only a part of it was visible in the light peculiar to this phenomenon." His four categories were:

(i). The entire night side is visible;

(ii). The entire night side is visible during a (total) solar eclipse;

(iii). Partial visibility of the night side; and

(iv). Unequal brightness of the two horns of the crescent Venus.

Schorr also looked for some connection between appearances of the Ashen Light and other physical circumstances of Venus and the Earth on the days and times of the observations. Of the few dozen reports he analyzed, he concluded that they "prove sufficiently that the perception of the secondary light is not bound to any time of day or evening; solar eclipses have no influence on them, only they are dependent on the time of inferior conjunction." The latter term refers to the circumstance in which Venus makes its closest approach to Earth during one orbit around the Sun (Figure 16), appearing so close to the Sun in terrestrial skies that visual observers must take extreme caution to shield their telescopes from the direct light falling into their open apertures in order to avoid eye damage.

At inferior conjunction Venus is nearest the Earth in its current orbital cycle, so it appears to us at its greatest angular size. At the same time, the lit crescent shrinks to its thinnest, and Earth is presented with the greatest view of the planet's night side. From his own observations of the Ashen Light in early 1806, the German astronomer Johann Hieronymus Schröter (1745–1816) concluded that the phenomenon could *only* be seen near inferior conjunction, arguing that a typical combination of observational circumstances prevented its appearance otherwise:

> [T]he only possible observations [of this phenomenon] are limited to relatively few days around the crescent phase of Venus under otherwise favorable conditions, and that even for the most diligent observer this is therefore a coincidence, because twilight and the very dim light of the night side of Venus do not permit such an appearance. It is therefore limited only to certain elongation angles of the planet.

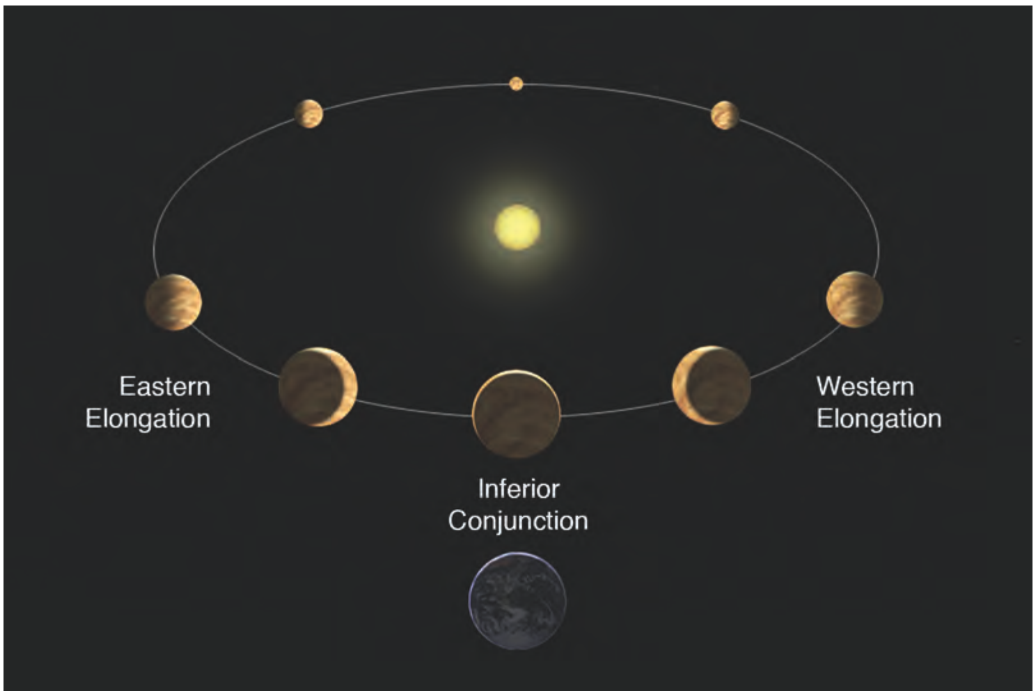

Figure 16: Venus goes through a series of phases, as seen from Earth (bottom), which depend in appearance on where the two planets are situated with respect to one another. This diagram is labeled in order to illustrate the meanings of the terms "eastern elongation," "western elongation," and "inferior conjunction." Adapted from the original work of Wikimedia Commons user Vzb83 and licensed under CC-BY-SA-3.0.

It is true that the influence of reflected light from a moon illuminating the Cytherean cloud tops would be greatest when Venus and Earth approached each other most closely. And while at face value the 'planetshine' hypothesis seems promising, all searches have failed to turn up evidence for a large moon. It's now accepted that any natural satellites of Venus must be so small as to have escaped detection altogether, one consequence of which is that there exists no natural sunlight reflector of sufficient size that can account for any faint glow emanating from the night side of the planet.

But what about the original notion underpinning Schorr's idea: are Ashen Light sightings more common near inferior conjunction than at other times?

In other words, is an observer more likely to see it as Venus slips past the Sun than in other instances during which the planet is in some other part of its orbit? It turns out the the Ashen Light *is* significantly more likely to be seen in the few weeks ahead of inferior conjunction than shortly afterward. Figure 17 illustrates this effect. It presents the same set of observations sorted by decade in Figure 13, but this time the histogram bars represent the number of observations of the Ashen Light in the weeks before and after inferior conjunction. And the distribution is distinctly lopsided.

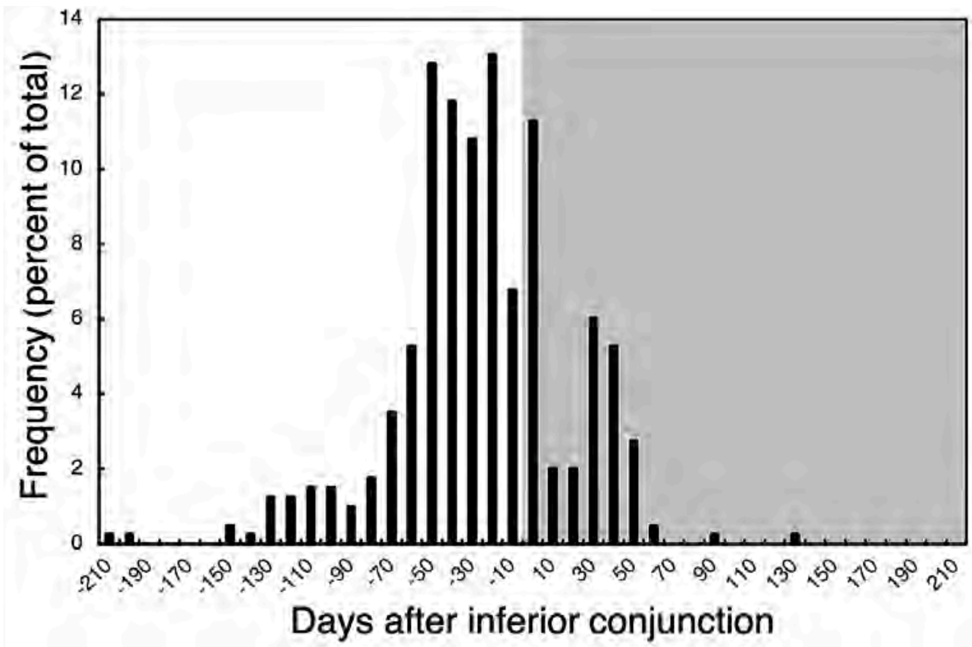

Figure 17: A histogram, using the same database of observations used to make Figures 13 and 14, showing the frequency of reports of the Ashen Light with respect to the number of days before or after the inferior conjunction at which it was observed. The gray shaded area separates observations after inferior conjunction from those before. This naturally divides the histogram into two regions: one in which Venus is most readily visible in the evening (unshaded) from another in which observations are most conveniently made during the hours before sunrise (shaded).

Far from conjunction, when the angular size of the disc of Venus is small, its phase relatively large and its location close in the sky to the Sun, there are few historical records of the Ashen Light; it's just not an easy observation to make under the circumstances. As Venus approaches Earth, its disc becomes larger and the phase smaller, showing progressively more of the side of the planet not directly illuminated by the Sun. It also 'elongates' east or west of the Sun in the sky, depending whether it is approaching the Earth or receding from it around the time of inferior conjunction, making it generally easier to observe.

The figure shows that Ashen Light sightings peak about a month before inferior conjunction and drop off quickly thereafter; a secondary peak follows about one month later as the planet heads for its greatest elongation west of the Sun. Whatever controls the distribution of sightings with respect to the date of inferior conjunction can’t be the apparent size of the planet’s disc or the phase, which are otherwise more or less equal at a given number of days on either side of conjunction. Rather, the answer seems to be simply that observers prefer the convenience of observing Venus in the early evening hours rather than waking up early to spot it before (or after) sunrise. Here we have the second suggestion of an observational bias in historical records of this phenomenon.

More than perhaps any other aspect of the Ashen Light, observers describing it often struggle to find the right words to capture its apparent color as seen through the telescope eyepiece. “Soon after inferior conjunction, when the crescent of Venus is very narrowly illumined, the night side of this planet becomes visible to us in a special shade of color,” Schorr wrote. “It is probably impossible to describe exactly this hue, but it almost resembles that of the night side of our Moon when it becomes visible to us.” Eyewitnesses through the centuries employed all manner of poetic descriptions in attempting to capture the ‘impossible’ hue. To William Derham, at the dawn of the eighteenth century, it was a “dull and rusty colour.” In 1866, Friedrich Wilhelm Rudolf Engelmann found it “a lighter, grayish-greenish tone than the background sky.” Carl Venceslas Zenger (1830–1908) noted its “peculiar coppery hue” in 1883, while Henry MacEwen described “a beautiful golden light” in 1896. Not to be outdone, the English amateur astronomer Richard Baum wrote first of a “a ghastly, grey effulgence,” one memorable night in 1953, followed later by “a purplish hue.” The disagreement among the reported colors tells us something about either the physical mechanism that produces the light, the human visual perception of color at low light intensities, or both. This is worth a side trip into the strange world of psychophysics, discussed in further detail in Chapter 8.

Finally, there are many instances in which observers report distinct surprise at seeing the Ashen Light at all. In fact, when encountered these accounts tend to jump off the page at the reader. That’s particularly true of cases in which the observer already had extensive experience in Venus work, implying many nights on which nothing of the sort was seen. One finds innumerable notes to the effect of “Ashen Light not seen” or “Ashen Light not suspected,” clearly indicating that observers were aware of the phenomenon, but that they saw on any given night nothing that led them to think they might have detected it.

One may reasonably suspect that some instances of positive detections were caused by observers ‘primed’ to sense something they might believe to be real almost as an article of faith, such that failing to sense the Ashen Light was considered evidence of a defect, real or imagined, in their perceptive abilities. "If one contemplates the few observations of the secondary light of Venus . . . made in the space of two centuries, it will certainly be admitted that this must be a most rare phenomenon," Schorr wrote in 1875. However,

> if one can deduce the cause of it, however one chooses, then nevertheless several circumstances must co-operate at the same time in order to cause the visibility of the same. However, it can be added that all observers of this phenomenon discovered it only incidentally and were surprised by this perception, initially believing it to be deception. But if they had known beforehand that the night side of Venus must be visible at any time, they would have observed it more often, and we would find a greater number of observations of it recorded.

Primed belief in the existence of the Ashen Light — or, at least, awareness of the sightings claimed by other observers — therefore may not exert an undue influence on the probability that a given Venus observer will see it during his or her career. If the phenomenon is purely psychological, other factors must also be in play.

And what can we make of the very first recorded instance of the Ashen Light, in 1643, by an observer whose perception can't possibly have been influenced by the previous accounts of other people? It's especially noteworthy that the observer carefully noted the presence of an aberration in his instrument that could affect his perception, and yet still indicated positively that he had seen something peculiar in regard to many years of Venus observations. Maybe the crescent Venus reminded Riccioli a little too much of the Moon when in its crescent phase, its night side glowing faintly in sunlight reflected from the Earth. Did his brain simply fill in the missing information from an analogous memory?

At the same time, what is the value of *any* particular Ashen Light observation when taken by itself? Roger Cheveau, a French planetary astronomer working in Paris during the interwar period, cautioned about the appraisal of such anecdotes — immediately after reporting his own: "A single observation cannot lead to a serious conclusion on this subject."[18] Yet, still, we have to consider the very real possibility that nothing like a physical "Ashen Light" exists, other than in the minds of those who convinced themselves, one way or another, of its objective reality.

More than 80 years after Cheveau wrote those words, and 400 years after Galileo Galilei became the first human to get a close-up look at Venus, there is still no universally accepted explanation for the Ashen Light. As Julius

[18] 1933, La Lumière Cendrée de Venus, *L'Astronomie*, 47, 69.

Benton, Coordinator of the Venus Section of the Association of Lunar and Planetary Observers, put it, “in spite of all the recent arguments against it, the Ashen Light mystery just won’t go away,” and highly experienced visual observers of Venus insist steadfastly that their impressions of faint light radiating from the night side of Venus are “not illusory.”[19] The purpose of the following pages is to examine its history, determine what it is decidedly *not*, pursue some promising leads, and get at the heart of the question of what our eyes really reveal when the brain can very easily tell the heart and mind the wrong story.

[19]2010, ALPO Observations of Venus During the 2007-2008 Western (Morning) Apparition, *Journal of the Association of Lunar and Planetary Observers*, 53(1), 37.