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# DEPICTIONS OF A LUNAR ECLIPSE AND THE DAWN OF ASTROPHYSICS IN VAN GOGH'S PAINTINGS

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**Abstract:** When visiting the Museum of Modern Art's special exhibit "van Gogh and the Colors of the Night" (New York, USA, 2008) I was impressed by the artist's effort to paint and write about landscapes and life scenes at night. At the same time a clear contrast emerged between the colorful *Starry Night* painting and the darkness or twilight in his earlier productions. Since then, while revisiting van Gogh's paintings and reading his letters, I have come to the conclusion that his later work was not only driven by the poetry of the night but also by his awareness of the dawn of astrophysics in the nineteenth century. A change in the way the artist conceived the sky after his stay in Paris is evident, with the skies becoming more dynamic and rich in colors.

In this paper I present and discuss elements in van Gogh's masterpieces that refer to astronomical events visible from France in 1889 and 1890, such as a lunar eclipse and planetary conjunctions. I analyze emergent astrophysical concepts that may have inspired the depiction on canvas of stars with different structures and colors, as well as the large central swirl in the *Starry Night* painting. The general impression is that the artist had a fascination with and a profound attention to celestial phenomena, in addition to some knowledge of new wonders and discoveries of astrophysics in the nineteenth century.

**Keywords:** Vincent van Gogh; art; spiral nebulae; stellar classification; lunar eclipse; planetary conjunctions; meteorites.

## 1 INTRODUCTION

There is nothing more compelling than the stars in a night sky to fulfill the human mind's need to go and explore, just as there is nothing more inspiring than a starry night for an artist to visualize the invisible. The relationship between these two different sides of cultural heritage, arts and astronomy, is long lasting and it is enhanced by the use of images from both disciplines to communicate. Before the end of the nineteenth century, when the first photographs of celestial objects became available, astronomers used hand drawings to convert telescopic views into printed images. This exercise required the ability to transfer onto a piece of paper or a canvas the relative position of point-like objects, like stars and planets, but also the shape and morphology of more diffuse objects such as nebulae. Artists, like Étienne Léopold Trouvelot (1827–1895; Corbin, 2007) for example, were engaged by astronomers to use telescopes and produce detailed astronomical illustrations.

However, artwork may not be illustrative of the real world or a faithful reproduction of what eye can see. Artists can distort the vision of a material world to transfer for example emotions or scientific discoveries into their works. They can use imagination, and dare to go beyond what we see and know. Although many artistic works might have been inspired by the night sky and astronomical discoveries, in the case of van Gogh there has been a reciprocity of information (Boime, 2008), as his visualizations seem to have been precursors of more modern scientific concepts (Leshan and Margenau, 1982; Ma et al., 2024; Tremaine, 1992).

In this framework I analyze some of the world-renowned artistic masterpieces by the Dutch artist Vincent van Gogh (1853–1890; Figure 1) related to night skies. Evenings and nights have been constant sources of inspireation to many artists, including van Gogh, who painted masterpieces with scenes and landscapes at night and during twilight, beginning with his early work, *The Potato Eaters*. There have been papers and artistic exhibitions focusing on the feelings that have driven the recurrent night scenes in van Gogh's artistic production, such as religious, philosophical, and poetic thoughts (see, for example, the ex-

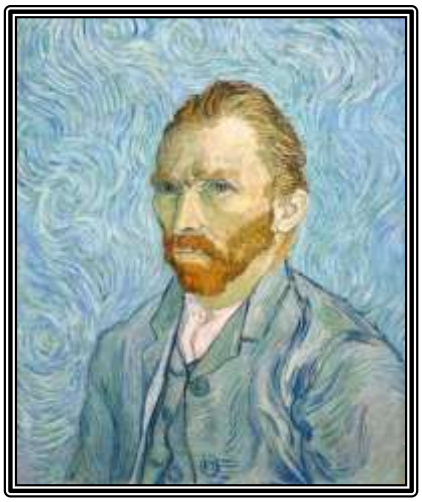


Figure 1: Self-portrait by Vincent van Gogh, Saint-Rémy-de-Provence, September 1889. Exhibited in the Musée d'Orsay, Paris (from Wikimedia Commons, in public domain).

hibit *van Gogh and the Colors of the Night,* van Heugten et al., 2008). Here I would like to focus on new additional elements that might have played a key role in driving some of his latest artistic production: the artist's awareness of celestial phenomena and his knowledge of scientific discoveries at the heart of astrophysics, a new discipline that was emerging in the nineteenth century, aimed at understanding the physical nature of stars and other celestial bodies.

In the past a few art historians and professional astronomers suggested that astronomy may have influenced van Gogh's life and artistic production, given the artist's effort to display on his artistic canvas specific observations of the night sky. The historian Boime asserted that although van Gogh never mentions astronomy or Camille Flammarion, the author of popular astronomy books, in his letters he must have been aware of Flammarion's illustrations and ideas. In his paper (Boime, 1984) and subsequently in his book, Boime (2008) described the great influence that Flammarion could have had on van Gogh's thoughts and particularly in relating the cosmos to religion and to the possibility of space travel. He suggested that spiral nebulae and the tails of comets reproduced in Flammarion's books may have inspired the central swirl in van Gogh's *Starry Night*. These were photographed for the first time in the 1880s and published in *Harper's Weekly* magazine, which van Gogh regularly read. Whitney (1986) agreed with this possibility and believed that van Gogh attempted to reproduce what he observed in the night sky. Whitney estimated the dates of some of van Gogh's paintings by comparing the positions of astronomical objects in his works with real locations in the sky. Following Whitney, Olson et al. (2003) reported the results of an expedition they made to southern France to date van Gogh's *Moonrise* by comparing the Moon's position in the painting with the observed position in the sky.

In this paper I point out elements present in van Gogh's paintings that reveal the artist's constant attention to celestial events as well as his possible knowledge of progress in astrophysics during the nineteenth century. After providing some brief remarks on the historical and geographical context of the artist's life, I analyze well-known paintings that might be illustrative of the strong connection between art and science in van Gogh's production.

## 2 A FEW FACTS ABOUT VAN GOGH'S LIFE AND THE HISTORICAL CONTEXT

By reading books and journal articles dedicated to van Gogh's life and artistic production (e.g. Callow, 1990; Hulsker, 1980; Naifeh and Smith, 2012; Scherjon and de Gruyter, 1937; Stone, 1934) as well as the letters he wrote to his brother, Theo, to family members, and friends (for these I refer to the English translation and on-line collection listed as Bakker et al., 2009),[1] one realizes that the artist had a very humble yet cultured personality. Having worked as a book-seller in Dordrecht for a few months in 1877, he had the opportunity to read many books and publications and to translate passages from the Bible into English, French and German.

His relation with art started in 1869 when he obtained a position in the Hague branch of the art dealers Goupil & Compagnie. After a training period he moved to London and later to Paris, and worked for other Goupil branches until 1876. I stress this because by age 23 he had already travelled across Northwestern Europe (i.e. to Ramsgate, Isleworth, Dordrecht, Amsterdam, Brussels, Drenthe, Nuenen and Antwerp) and would continue to do so for the next decade.

We recall here that van Gogh spent about two years in Paris, between 1886 and 1888, before moving to Arles in southern France. In Paris he first lived with his brother, Theo, at 54 Rue Lepic in Montmartre, where he was introduced to the work of the impressionists. The area was an artist's quarter with lots of cafés, and entertainment places like Le Chat Noir. It was here that van Gogh met artists and writers, and became friends with Émile Bernard, Paul Signac and Paul Gauguin. Gaugin illustrated one of Cros' poems. Charles Cros was a major figure at Le Chat Noir and one of Flammarion's closest friends, and he was well-known to Impressionist painters. Astronomy was already becoming popular thanks to Flammarion's various books (such as *Astronomie Populaire*, *Les Étoiles*, *La Pluralité des Mondes Habités*) and the reproduction of nebulae in magazines such as *L'Astronomie*, *L'Illustration*, *Harper's Weekly* and *Harper's* magazine, etc.

Van Gogh was excited about maps in general and he used to draw maps as gifts for his friends and family members (e.g. see Van Gogh's letter to Theo 638 reported in Section 6). He may have been aware of the International Astronomical Congress that took place in April 1887 at Paris Observatory, which had as its main resolution the use of photographic techniques to create a chart of the heavens (Flammarion, 1907; cf. Turner, 1912). That said, Van Gogh disliked photography. Referring to portraits he wrote to his sister:

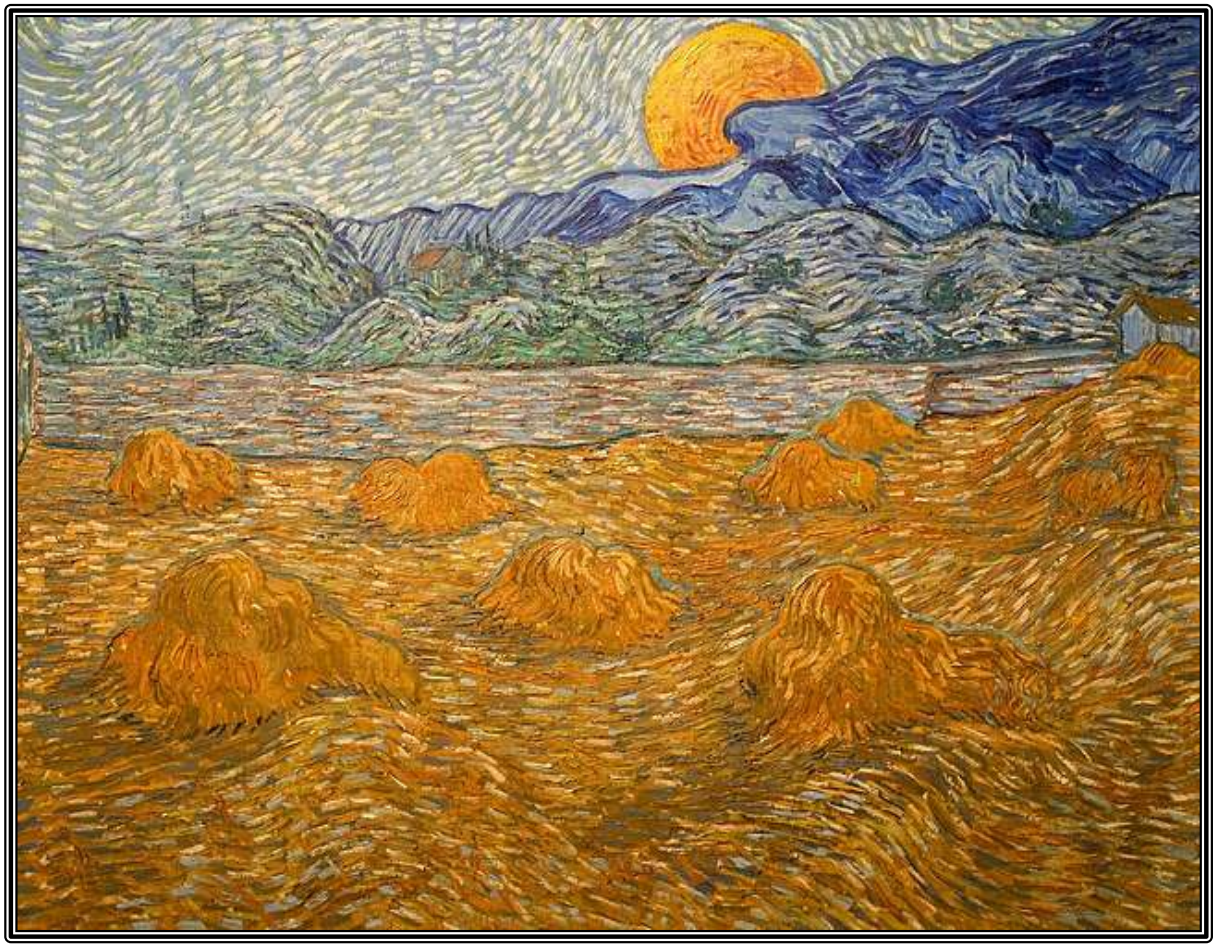


Figure 2: *Evening Landscape at Moonrise*, V. van Gogh, Saint-Rémy-de-Provence, July 1889. Exhibited in the Kröller-Müller Museum, Otterlo. We have shown in this paper that this masterpiece reproduces a rising Moon during a lunar eclipse visible in Southern France on 12 July 1889 (Creative Commons Attribution-Share Alike 4.0 International license).

> I myself still find photographs frightful and don't like to have any, especially not of people whom I know and love. These portraits, first, are faded more quickly than we ourselves, while the painted portrait remains for many generations. (Van Gogh, 1889, Letter to Willemien, 804).

His attempt to paint stars in the sky with care for their colors, position and luminosity, as we will see in this paper, might have been an attempt to show that artists can create beautiful and interesting charts of the heavens that remains for many generations.

## 3 MOONRISE: FRAMING THE 1889 LUNAR ECLIPSE

The painting *Evening Landscape at Moonrise* (hereafter referred to as *Moonrise*) shows wheat stacks in a field enclosed by a mountain ridge in the twilight sky, with a prominent orange disk partly hidden behind the mountains (see Figure 2). Van Gogh often looked at the sky from his window on the East side of the Saint Paul asylum in Saint-Rémy-de-Provence, as he mentions to his brother:

> Through the iron-barred window I can make out a square of wheat in an enclosure, a perspective in the manner of Van Goyen, above which in the morning I see the sun rise in its glory. With this – as there are more than 30 empty rooms – I have another room in which to work. (van Gogh, 1889, Letter to Theo, 776).

From this it is clear that his window faced East while it is not clear what the orientation of the additional working room was. Jacob-Baart de la Faille (1928), a Dutch art historian and writer, compiled the first critical catalogue of van Gogh's works and he referred to this work (F735) as *Sunset*. However, in their catalog Scherjon and de Gruyter (1937) changed the title of the work, identifying the scene as the *Rising Moon*, in agreement with the field being towards the East as seen from van Gogh's window. When he revised and updated his catalog in 1939 de la Faille corrected the title

of the painting.

Dating the *Moonrise* work has been a long and debated issue. The Scherjon and de Gruyter (1937) catalogue placed this canvas in August or September 1889 but the later edition of de la Faille's (1970) catalogue, published by a team of experts after the author's death, lists 6 July 1889 as the date of the *Moonrise* painting. This confusion arose because apparently the date is missing on the letter where the *Moonrise* work is described:

> I have one in progress of a moonrise over the same field as the sketch in the letter to Gauguin, but with wheat stacks replacing the wheat. It is dull yellow ochre and violet. Anyway, you will see it sometime soon. (van Gogh, 1889, Letter to Theo, 789, now dated as Sunday 14 or Monday 15 July 1889).

Hulsker (1980), working on van Gogh's correspondence, suggested that the letter was written much earlier than August or September, as previously stated, and dated the letter to 6 July. To narrow the uncertainties, in 2002 Olson et al. journeyed to Saint-Rémy-de-Provence, France, and observed the Moon rising for several days. Using astronomical calculations and deductive reasoning, they concluded that van Gogh's painting *Moonrise* depicted the Full Moon at 9:08 p.m. local mean time on 13 July 1889 (Olson et al., 2003).

I have always been puzzled by the reddish color of the Moon in that painting which appears on one side only, and which was one of the unusual elements that generated confusion for decades between the Moon and Sun on that canvas. I therefore searched the NASA Eclipse Web Site for lunar eclipses between 1801 and 1900[2] and found that lunar eclipse number 09393 that occurred on 12 July 1889 was visible from southern France. This was a partial lunar eclipse (Saros 137) with a duration of 142 minutes and an umbral magnitude of 0.48. Using Stellarium[3] it can be easily seen that in Saint-Rémy-de-Provence the penumbral phase of this eclipse started soon after the Moon rose above the horizon in a Southeasterly direction. The umbra shadow moved over the Moon's surface when the Moon's elevation was 3.3º and 127° degree in azimuth, around 20:05 local time.[4] It is likely that the Moon and the eclipse became visible from van Gogh's room a few minutes later, as the Moon rose above the cliff of the alpine ridge. Since the cliff is higher in altitude towards the south (see Figure 2), van Gogh presumably saw the Moon rise after the eclipse had already started, and he was able to watch the eclipse through-out its full duration. The umbral phase of the lunar eclipse at Saint-Rémy-de-Provence was visible until 22:25 and had its maximum around the 21:12 local time, when the Moon was about 12° above the horizon and 140° in azimuth. The archive with weather conditions[5] on the evening of 12 July 1889 for the Aix-en-Provence station reports excellent sky conditions and clear skies. The eclipse phenomenon, with the color of the Moon becoming reddish, must have impressed van Gogh who was a careful and frequent observer of the sky.

Inspired by the lunar eclipse, it is likely that Vincent van Gogh started the *Moonrise* painting the day after, on 13 July 1889, with the intention of depicting on canvas the particular color of the Moon that he clearly noticed the day before. On 13 July 1889 at about 21:08, the Moon was at 126° in azimuth and 4.5° in altitude, and it crossed the cliff as painted on the canvas (Olson et al., 2003; the Moon's coordinates have been confirmed by Stellarium). Remarkably, the time corresponding to the depicted position of the Moon in the sky on 13 July is the same as when the maximum umbral eclipse magnitude occurred the day before. According to Stellarium the reddish side of the Moon was first located towards East, then it moved to the North. However, as can be seen in Figure 2 van Gogh seems to show as reddish the Southwestern part of the Moon, emerging from the cliff. It is possible that he did not remember this detail the following day. But, being aware of the fact that an eclipse occurs when the Earth's shadow covers our satellite, he may have purposely painted the reddish part of the Moon behind the cliff, so as to mimic a shadow, as artificially created by sunlight from the opposite direction.

During the nineteenth century, the German astronomer Friedrich Bessel (1784–1846) developed a method (that is still in use) to facilitate the calculation of local circumstances and conditions of visibility of a solar eclipse. All these developments were mainly possible due to ever-improving knowledge of the distance between the Earth and the Moon and Earth and the Sun since the seventeenth century. The popular magazine *L'Astronomie* (which at that time was also the *Bulletin de la Société Astronomique de France*) reported in the June 1889 issue that a partial lunar eclipse would happen in France on 12 July, underlining that the Earth's shadow would start covering the Moon's surface 7 minutes before sunset. We do not know if van Gogh received and read this magazine and if he was aware that a lunar eclipse was about to happen on 12 July 1889, but as pointed out in Section 6, below, the canvas *Road with Cypress and a Star* sug-

gests that he might have been aware of upcoming celestial phenomena. The artist knew about the existence of lunar eclipses, although he confused these with the Moon's phases. I report a sentence referring to the canvas *Road with Cypress and a Star* painted when the Moon was a crescent, in the absence of a lunar eclipse (see, also, Section 6):

> I still have a cypress with a star from down there, a last attempt – a night sky with a moon without radiance, the slender crescent barely emerging from the opaque shadow cast by the earth. (van Gogh, 1890, Letter to Paul Gauguin, RM23).

If van Gogh was aware of the lunar eclipse before it occurred, he might have started the canvas the same night he observed the phenomenon. This would imply a mismatch between the Moon's position on the canvas and the dating computed by Olson et al. (2003) due to artistic license or to an inaccurate match between the cliff and the Moon's azimuthal position (because trees today cover the cliff view from van Gogh's asylum window, as mentioned by Olson and witnessed personally during my visit to Saint-Rémy-de-Provence in September 2024). Weather records reported a partially cloud sky on 13 July and surely observing the Moon was less spectacular than during the eclipse the day before. Eclipses have always been associated with legends, myths and symbols which constitute a rich source of inspiration in different cultures and epochs relating humanity to the Earth, the Moon, the Sun and to the cosmos. For these reasons, van Gogh may have been particularly inclined and driven to immortalize this unique event.

## 4 STARRY NIGHTS AND THE COLORS OF THE STARS

Van Gogh arrived in Arles in February 1888 and made a number of paintings of the city, communicating at the same time through his letters his strong will to paint the night sky. In April he wrote to his brother Theo: "... I need a starry night with cypresses or maybe above a field of ripe wheat, there are some really beautiful nights here ..." (van Gogh, 1888, Letter to Theo, 594). And around the same time he wrote to the painter Emile Bernard:

> A starry sky, for example, well – it's a thing that I'd like to try to do, just as in the daytime I'll try to paint a green meadow studded with dandelions. (van (Gogh, 1888, Letter to Emile Bernard, 596).

And

> But when will I do the starry sky, then, that painting that's always on my mind? (van Gogh, 1888, Letter to Emile Bernard, 628).

*Starry Night over the Rhone*, shown in Figure 3, was one of three paintings made during September 1888 that incorporate the night sky and stars (the other two being *Cafe Terrace at Night* and a portrait of his friend Eugene Boch). While walking near home along the bank of the Rhone River in the city of Arles van Gogh discovered a suitable place from which to represent the starry night. This night scene was prompted by a genuinely moving experience in the endless darkness, an experience that van Gogh describes in a letter: "Once I went for a walk along the deserted shore at night. It was not cheerful, it was not sad – it was beautiful." (van Gogh, 1890, Letter to Theo, 619). And to his friend Eugène Boch he wrote:

> I am working ... on a study of the Rhone, of the city illuminated by gas lamps reflected in the blue river. Above, the starry sky with the Big Dipper, a glimmer of pink and green on the cobalt blue field of the starry sky, where the lights of the city and its cruel reflections are red gold and bronze green ... (van Gogh, 1888, Letter to Eugène Boch, 693).

In the *Starry Night over the Rhone* the artist paints stars that form the Big Dipper in the constellation of Ursa Major. For this canvas there has also been an unpublished study in which the astronomers Masi and Basso[6] attempted to reconstruct the time and date of *Starry Night* over the Rhone. They estimated that it was painted at 10.30 pm some time between 20 and 30 September 1888.

Added to this detail is also the discovery of a major example of artistic license where Ursa Major is depicted in the wrong area of the sky, in a Southwestern direction rather than towards the North (see, also, Whitney, 1986 for a discussion on star positions in this canvas). Van Gogh mentions this painting several times in his letters to Theo, to whom he also sent a sketch of the painting. Van Gogh also sent the original painting to Paris, along with a second work, *Irises*, to be shown in the Independent Artists' Exhibition of 1889.

Was van Gogh satisfied with this work? Between Sunday 9 September and Friday 14 September 1888 he wrote to his sister describing the colors of the stars and casting some doubt that the stars painted in the *Starry Night over the Rhone* matched the reality:

Figure 3: *Starry Night over the Rhone*, V. van Gogh, Arles, September 1888. In the Musée d'Orsay, Paris. The position of the bright stars in the center of the night sky depicts the Big Dipper in Ursa Major (from Wikimedia Commons, in the public domain).

> I definitely want to paint a starry sky now. It often seems to me that the night is even more richly coloured than the day, coloured in the most intense violets, blues and greens. If you look carefully you'll see that some stars are lemony, others have a pink, green, forget-me-not blue glow. And without labouring the point, it's clear that to paint a starry sky it's not nearly enough to put white spots on blue-black. (van Gogh, 1888, Letter to Willemien, 678).

It seems that he felt this was not his final work for a starry night but only a first try because an artist can do more than simply placing white spots on blue-black to paint a starry night. Fascinated by the night sky and having been in the lively city of Paris, where he heard the echoes of the discoveries of the nature, diversity and structures of the stars (in magazines, books circles and cafes), he may have had the will to dare and go further in his mission to communicate the beauty and secrets of a starry night through art. Artists and astronomers, such as Étienne Léopold Trouvelot and William Parsons the 3rd Earl of Rosse (1800–1867), produced illustrations of the sky seen through new, more powerful telescopes. But an artist like van Gogh could use the power of his imagination, i.e. arts, to go beyond what eyes could see, and depict feelings as well as perceptions of new astronomical discoveries. For example, in a letter to Theo he defines himself as an 'arbitrary colorist', and while describing the atmosphere in Arles he also gives his thoughts about the cosmos:

> Because instead of trying to render exactly what I have before my eyes, I use colour more arbitrarily in order to express myself forcefully … And still to feel the stars and the infinite, clearly, up there. (van Gogh, 1888, Letter to Theo, 663).

Stellar colors are also mentioned in a letter to Theo from Les Saintes-Maries-de-la-Mer:

> The sky, a deep blue, was flecked with clouds of a deeper blue than primary blue, an intense cobalt, and with others that were a lighter blue – like the blue whiteness of milky ways. Against the

> blue background stars twinkled, bright, greenish, white, light pink – brighter, more glittering, more like precious stones than at home – even in Paris. So it seems fair to talk about opals, emeralds, lapis, rubies, sapphires. (van Gogh, 1888, Letter to Theo, 619).

Van Gogh lived in the scientific climate of the second half of the nineteenth century after his visit to Paris. In the *Astronomie Populaire* star colors are clearly described:

> The star light, which glimmers sometime vividly, sometime feebly, in intermittent gleams, sometime white, green or red, like the flashing fires of a limpid diamond ... Spectral analysis applied to the double stars have proved that the beautiful colors are not due to contrast but are real. (Flammarion, 1907: 606, 612).

Stellar spectroscopy, the study and classification of spectra, was born early in the nineteenth century when the German scientist Joseph von Fraunhofer (1787–1826) discovered dark lines in the spectrum of the Sun. Following Fraunhofer, other astronomers in the second half of the nineteenth century, such as Gianbattista Donati (1826–1873) and Angelo Secchi S.J. (1818–1878; Chinnici and Consolmagno, 2021) in Italy, analyzed stellar spectra and developed classification schemes (Hearnshaw, 2014). Supported by his observations, Secchi was able to publish *Le Stelle* in 1877 in which he reported the classification of at least 4,000 stars into five groups according to their spectral characteristics. He wrote that Type 1, Type 2 and Type 3 stars comprise bluish-white, yellow and reddish-orange stars respectively. In the French edition (Secchi, 1880) a figure labelled "Etoiles Colorées" shows several stars with their intrinsic color. Stellar classification schemes as well as the description of the colors and spectra of a few known stars and double stars are reported in the chapter of Flammarion's *Popular Astronomy* dedicated to the light of the stars:

> ... instead of being white the stars often shine with colored light, showing in their strange couples admirable association of contrasts where the astonished eye sees the fires of the emerald united with those of the ruby, of the topaz with those of the sapphire, of the diamond with the turquois, or the opal with the amethyst, thus sparkling with all the tints of the rainbow. (Flammarion, 1907: 630).

The concept that our Sun is similar to other stars in the heavens and therefore that stars have a structure is also well underlined in Flammarion's book. In *The Starry Night* (see Figure 4) stars are depicted not merely as little yellow dots against a dark sky. They exhibit a structure, and become non-uniform in color going from their centers to their edges. Colors change from one star to another.

However, we cannot exclude the likelihood that van Gogh observed stars close to the horizon and noticed the scintillation phenomenon, i.e. stars changing color according to their properties and the Earth's atmosphere, as described by Flammarion in his *Popular Astronomy* before he introduces stellar spectra:

> … star light … glimmers sometime vividly sometime feebly, in intermittent gleams, sometime white, green or red, like the flashing fire of a limpid diamond, seems to animate the interstellar solitudes ... we divine better the distant life which is in motion round each of these brilliant fires burning in Infinitude. (Flammarion, 1907: 606).

Van Gogh's first reference to the famous *Starry Night* painting is in an undated letter to Theo: "I have a landscape with olive trees, and also a new study of a starry sky." (van Gogh, 1889, Letter to Theo, 782). In the same letter a reference to Theo's letter dated 16 June, indicates that Vincent van Gogh's letter was written after 16 June 1889. Evidence for dating van Gogh's works primarily stems from his correspondence with relatives and colleagues. Art historians have long agreed that van Gogh painted *The Starry Night* between 16 and 18 June 1889, while in Saint-Rémy-de-Provence in Southern France. Elements that astronomers can use to discover the execution date of the *The Starry Night*, are the relative positions of the Moon and Venus, and the Moon's phase, assuming that the painting refers to a precise sky view as seen from van Gogh's window.

The planet Venus, described by van Gogh as "… the morning star …", was the most luminous object in the sky at the time this masterpiece was painted. He writes:

> This morning I saw the countryside from my window a long time before sunrise, with nothing but the morning star, which looked very big. (van Gogh, 1889, Letter to Theo, 777).

Positioned to the right of the cypress tree, Venus is portrayed with a prominent white envelope surrounding a small yellowish core. According to Stellarium, the planet, with an apparent magnitude of −4.6, reached its peak luminosity during June 1889. The starry night is

Figure 4: *The Starry Night*. Oil on canvas by Vincent van Gogh, Saint-Rémy-de-Provence June 1889, in the Museum of Modern Art, New York. It depicts the view from the East-facing window of his asylum room just before sunrise, with the addition of an imaginary village and a large swirl in the sky (from Wikimedia Commons in the public domain).

reported just before dawn, looking East in Saint Remy de Provence; this is what the artist could see from his window. The relative positions of the Moon and Venus correspond to a sky view between 18 and 23 June. Boime (1984) suggested that the painting depicted the early morning sky on 19 June, but at the same time he noticed an important difference concerning the phase of the Moon: on this date the Moon was between the half Moon and the third quarter, thus resembling more a rugby ball than the fine crescent depicted by van Gogh. The Moon in the canvas is a waning crescent, and its phase, together with the position of Venus indicates that the painted night sky is the view from van Gogh's window close to the summer solstice, between 21 and 23 June, just before dawn (approximately 3:00–3:30 am CET or 41 min earlier according to van Gogh's local time, as suggested by the simulated sky by Stellarium). However, weather records for Aix-an-Provence indicate a cloudy sky with some rain during the proposed period. Weather conditions were better during the early mornings of 18 or 20 June but in this case we have to conclude that the Moon's phase has been depicted arbitrarily. We cannot exclude the possibility that van Gogh started painting the canvas on 23 May 1889. On this date Venus was only a few degrees above the horizon before dawn, the Moon had already started its waning crescent phase, and weather records indicate clear sky conditions. It is also plausible that van Gogh spent multiple nights working on the painting, thus extending the execution of *The Starry Night* across the summer solstice, with possible corrections to the Moon's phase. Alternatively, as pointed out by Whitney (1986), the artist may have assembled his own sky from impressions gathered over an interval of a month or so.

On the upper side of the canvas, just above Venus and the swirl, three stars might represent the constellation Aries. Aries, the first sign of the zodiac, is van Gogh's own zodiac constellation. Stellar halos in *The Starry Night* are broken concentric circles that sur-

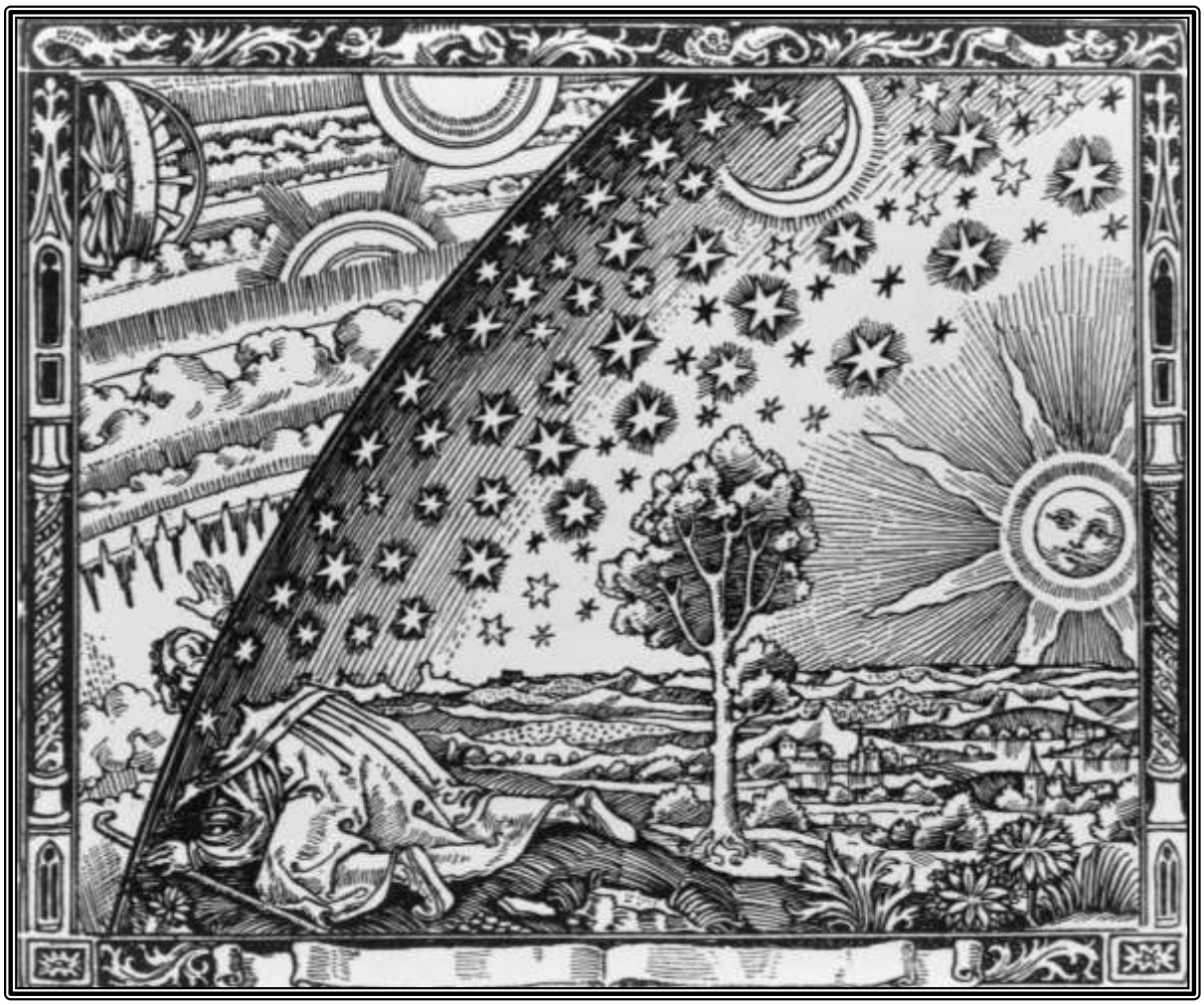


Figure 5: The Flammarion engraving. This is a wood engraving by an unknown artist, included in the book *L'Atmosphère: Météorologie Populaire*, by Camille Flammarion (1888). The missionary is leaving behind a sky where stars are fixed and eternal and is entering a new sky no longer static but in movement, as indicated by the wheels, with the Sun and the stars exhibiting internal structure (from Wikimedia Commons, in the public domain).

round the ten stars and the planet Venus. They may symbolize eternity or they were just used to mimic different luminosities of celestial objects. I underline again that this echoes Flammarion's illustrations, where stars, like the Sun, have structures and atmospheres: stars are no longer shining dots in a dark sky. The resonance with stellar classification, which highlighted intrinsic differences between stars, is reflected in this masterpiece. Van Gogh employed diverse palettes to emphasize the varied properties of each star, illustrating their unique characteristics through a harmonious blend of colors.

## 5 THE DYNAMIC AND SWIRLING SKIES

In his last work on the starry night (*The Starry Night*, Figure 4) van Gogh represents the sky with swirling movements. The swirling, and more generally turbulent shapes that characterize some of van Gogh's latest landscapes and skies have often been interpreted as symptoms of the psychological distress that he experienced during the one year that he spent in the Saint-Paul Asylum at Saint-Rémy-de-Provence. However, astronomical reconstructions reveal that the sky visible from his window was quite similar to the one depicted on the canvas proving some realism in the painting. Looking at other masterpieces, we see that van Gogh's brush-strokes often take us on a journey around the painting as they twist, turn and swirl around the subject. This gives a sense of movement and vibration. This technique makes the sky dynamic, reminiscent of the new sky in Flammarion's engraving shown in Figure 5. The concept of the sky as a dynamic entity was a widespread notion in Paris during the years van Gogh resided there. The dynamic sky is also present in other van Gogh works from the 1889–1890 period, such as *Cypresses*, *Road with Cypress and Star*, *Olive Trees* and *Wheat Field with Cypresses*.

Van Gogh transfigured reality into geomet-

ric forms, using a 'fluid' geometry, which becomes more evident by the comparison between his paintings and the images produced by recent scientific visualization technologies. By analyzing the swirls in *The Starry Night* scientists found turbulent properties matching the physical law that governs turbulent flows, as observed for example in molecular clouds that give birth to stars (Ma et al., 2024; Wright, 2019). While this might suggest the artist's careful observation of real flows, it does not explain the reason for placing a large swirl at the center of this canvas.

Van Gogh's art has always been particularly attentive to the metamorphoses of nature, but it also leaves freedom to communicate feelings and concepts (e.g. Whitney, 1886). The large swirl at the center of *The Starry Night* might have no real counterpart but just be part of the artist's attempt to represent a dynamic sky i.e. a sky that evolves, filled with movement and color. Swirls might represent van Gogh's understanding of the cosmos as a living, dynamic place.

For the rest of this Section I will discuss other possibilities for the large swirl placed the center of the canvas: if this was done to give relevance to a subject represented by the swirl, or if there was a celestial object in that part of the sky that inspired van Gogh's painting.

Boime (1984) interpreted the swirling figure in the central portion of the sky in *The Starry Night* to represent either a spiral galaxy or a comet, since photographs of these types of objects were published in popular media. He emphasized that van Gogh was familiar with the history of science, and suggested that his interest in astronomy grew through the reading of illustrated popular works—and in particular those by Camille Flammarion (as reported earlier in this paper). The artist Benson agreed that van Gogh's interest in astronomy led him to be the first artist to depict a spiral nebula. By 1879 a reproduction of the print of M51 based on Lord Rosse's drawing had made its way into a best-selling French book on astronomy, Camille Flammarion's *Astronomie Populaire* (*Popular Astronomy*) a copy of which may have been acquired by the Saint-Paul de Mausole Asylum in Saint-Rémy-de-Provence. It is widely believed that van Gogh, when a patient at the Asylum, was intriged by Flammarion's reprint of Lord Rosse's drawing, seeing it either at the Asylum, or earlier, when he was in Paris (Benson, 2014).

Spiral nebulae were captivating objects in the late nineteenth century and paved the way for the discovery of extragalactic astronomy. The Harvard astronomer Charles A. Whitney (1929–2017) conducted his astronomical study of *The Starry Night* independently of Boime (who spent most his career at U.C.L.A.), and he also sees the depiction of a spiral galaxy in the sky, giving William Parsons, 3rd Earl of Rosse, credit for the original drawing.

The interpretation of the swirl representing a spiral nebula might be valid because van Gogh may have been aware of the scientific discussions around the nature and distances of spiral nebulae. The large swirl in *The Starry Night* brings to mind motion, as also underlined by Nasim (2009) in relation to the engraving of M51 by Lord Rosse (1850) shown in Figure 6. One certainly gets the impression of movement, which however was too difficult to measure in the mid-nineteenth century. Nasim (2009) reports that although many astronomical books and papers in the mid-nineteenth century connected the spiral shape to dynamical models, there have been different speculations favoring either the non-stellar nature and nearby distance of spiral nebulae (like converging cometary objects) or their connection to stellar systems and/or the formation of stars and planetary systems. The subsequent discovery by Huggins and Miller (1864) of emission-line spectra for planetary nebulae, showed that nebulae could be divided into two distinct classes: those that were clouds of luminous gas showing emission lines, and those that were stellar aggregations having only absorption lines. Huggins and Miller (*ibid*.) acquired a spectrum of M31 but found no indications of bright lines, although the spectrum was truncated in the orange and red parts due to the low luminosity of the nebula. At that time M31 was not known to be a spiral nebula, and no other spectra of spiral nebulae had been reported.

The discovery of M31's spiral structure was made by Roberts (1888) who succeeded in photographing its faint disk. The use of photographic plates after 1880 confirmed the spiral character of some nebula, leading to the publication of various theories on their formation. For example, Roberts (1889) refers to the formation of a vortex through the collision of streams of meteorites after observing the M81 spiral nebula. However, obtaining spectra of spiral nebulae remained difficult due to their faintness. At the time when van Gogh visited Paris astronomers were still wondering whether these were gaseous or stellar in nature. Another relevant question concerned the size of the Universe: were these systems located within the Milky Way or were they 'island universes' much further away, as Wright (1750) had suggested in his book *An Original Theory or New Hypothesis of the Universe*? The M51

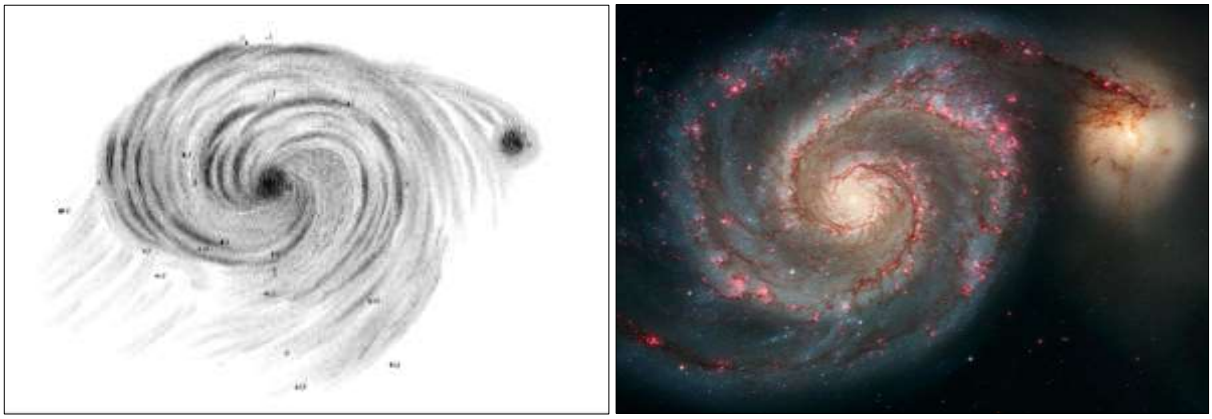


Figure 6 (Left): The engraving sketch of the Great Spiral (M51 or Whirlpool galaxy) by The Earl of Rosse in 1850. (Right): the M51 optical+Hα composite image taken in recent years with the Hubble Space Telescope (the left image is from Wikimedia Commons in the public domain, and right image courtesy: NASA, ESA, and the Hubble Heritage team).

engraving is reported in popular books such as Arago (1854) and Secchi (1877). Flammarion (1867) reproduced a similar sketch of M51. Van Gogh may have drawn a generic object with a spiral shape, much more extended than individual stars, inspired by the M51 sketches. He may have placed the swirl at the center of the painting to give relevance to this class of nebulae. The absence of colors of the swirl may symbolize a lack of information or understanding, reflecting the ongoing mystery about the true nature of these celestial objects.

In this paper I would like to introduce a new element in the analysis of the central swirl. The position of this in *The Starry Night* intriguingly aligns with the location in the sky of the radiant point of a meteor swarm called the Arietids. This swarm, active from mid-May to late June, is a significant meteor shower comparable in activity and duration to the Perseids and Geminids although less known due to its peak occurring in the very early morning hours. In a recent paper, Abedin et al. (2017) conducted numerical modeling of the Arietid stream to identify the parent body and to constraint its age. They concluded that the most plausible scenario for the formation of the Arietids is continuous activity of Comet 96P/Machholdz over an interval of 12,000 years. Therefore, the meteor shower would have been visible during van Gogh's observations. The connection between comets and shooting stars can also be found in *Astronomie Populaire.* Therefore, the earlier suggestion that the swirl might represent a comet gains significance due to the presence of the Arietids in that part of the sky. Van Gogh greatly admired Jean-Francois Millet who painted a *Starry Night* with some astronomical accuracy. He mentions Millet numerous times in his letters, e.g., "… to me Millet, is that essential modern painter who opened the horizon to many …" (van Gogh, 1884, Letter to Theo). Millet included part of the constellation of Orion and some shooting stars in his *Starry Night*, due to the Orionid meteor shower (Beech, 1988). The Arietid meteor shower, visible from the window of his asylum room at Saint-Rémy-de-Provence, must have provided further inspiration for van Gogh to paint *The Starry Night*, given his connection with Millet, and also to depict a large nebula in that part of the sky, as explained in the next paragraph.

One leading hypothesis on the formation of spiral nebulae in the late nineteenth century involved meteor showers. The concept is presented in Flammarion's *Popular Astronomy*, and outlined with a great sense of mystery and contemplation, that some nebulae might represent agglomerates of billions of stars, or else they could consist of cosmic matter that forms new stars, thus connecting the present to the past. These concepts can be found also in scientific papers and in magazines. For example, in his paper "Photograph of the Spiral Nebula M33 Trianguli", Roberts (1895) concluded that the spiral structure of M33 likely resulted from a collision between two swarms of meteorites moving in opposite directions, a hypothesis that he had suggested a few years earlier for M81 (Roberts, 1889). Meteorites and motion were considered to be responsible for the spiral shape of some nebula. In March 1889 *Harper's* magazine published an astronomical article "The Origin of Celestial Species" (Lockyer, 1889) where the author explained the role of meteorites in the formation of nebulae and of variable stars of different colors. Hence the presence of the Arietid meteor stream may have stimulated van Gogh's painting of a spiral nebula.

Whitney (1986) suggested also other inter-

pretations of the swirls in *The Starry Night*: they could represent wind, evoking the mistral that had such a profound effect on van Gogh during the 27-month period that he spent in Provence, and the large central swirl could represent the Milky Way, visible in that portion of the sky at an earlier time of the night. The largest object in the sky is indeed the Milky Way, although its spiral shape is not visible to us because we are located within it. Its disk lies in projection about 20° east of the Aries constellation. The swirl in van Gogh's painting could indicate his intuition or knowledge about the Milky Way's possible spiral structure. In 1852, Stephen Alexander (1852) proposed that the Milky Way might have a spiral form. As an artist and an avid reader who had worked in a bookstore, van Gogh may have encountered such hypotheses in the course of his reading.

Finally, it is worth mentioning that in the region of the sky where van Gogh places the swirl, there are two large spiral nebulae, M31 and M33, our closest and very extended spiral galaxies. Van Gogh may have been aware of (or have observed) M31 in that part of the sky and placed the large swirl there to represent the Andromeda Nebula. The photograph of Andromeda taken by Isaac Roberts in 1988 was inserted by Flammarion in the first article in the April 1889 issue of *L'Astronomie*, emphasizing the spiral structure of this nebula, like that drawn for M51 by lord Rosse. Due to its low surface brightness M33 instead needed extremely-clear sky conditions to be observed and its spiral shape was only definitively revealed later, in 1895, thanks to advances in photography (Roberts, 1895).

To summarize, the five hypotheses discussed here regarding the possible significance of the large swirl in *The Starry Night* are that it represents:

(1) a dynamic sky;
(2) a spiral nebula;
(3) a comet;
(4) the mistral wind; or,
(5) the Milky Way.

While these hypotheses provide strong arguments that the swirl is not a product of van Gogh's psychological distress, but of his cultural background, attention and fascination for the night sky, it remains challenging to draw a definitive conclusion given the complex role of imagination and realism in van Gogh's painting. Moreover, I propose that the object might have been placed in that portion of the canvas because:

(a) it is a central area and the artist would like to give great relevance to what it represents;
(b) the artist has been inspired by the presence of Andromeda and/or of the Milky Way in that area; and
(c) across that sky area the artist has observed the Arietid's meteor showers linked to comets and to the origin of spiral nebulae.

This last hypothesis is very appealing and does not exclude the previous ones: van Gogh may have noticed the Arietid meteor shower during that time of the year in the area of the sky where he placed the large swirl. At the same time he may have been aware of new emerging astronomical concepts, such as the dynamic nature of the cosmos, and the discovery of spiral nebulae, captivating objects often linked to collisions between swarms of meteorites and to the formation of new planetary systems. The shooting stars may have inspired van Gogh's painting of the central swirl in *The Starry Night*, to represent a spiral nebula, a comet or any symbolic object of the new dynamic sky, emergent concept in the second half of the nineteenth century.

## 6 CELESTIAL CONJUNCTIONS

Van Gogh's fidelity in reproducing the positions and characteristics of celestial objects as well as his keen attention to celestial phenomena can be seen in several of his artworks, particularly during the last years of his life. For instance, Olson and Doescher (2001) calculated that van Gogh painted *White House at Night* on 16 June 1890, based on the position of the 'star' depicted in the painting (see Figure 7). Their research suggested that this 'star' must be Venus, which was very bright in the evening sky during June 1890.

Astronomical phenomena such as planetary conjunctions are also present in van Gogh's masterpieces. On 17 June 1890, just one day after the date of the *White House at Night*, van Gogh wrote to Paul Gauguin from Auvers-sur-Oise describing his *Road with Cypress and Star* (see Figure 8):

> A night sky with a moon without radiance, the slender crescent barely emerging from the opaque shadow cast by the earth. One star with an exaggerated brilliance, if you like, a soft brilliance of pink and green in the ultramarine sky, across which some clouds are hurrying. (van Gogh, 1890, Letter to Paul Gauguin, RM23).

There was no lunar eclipse during that period and van Gogh appears to have been confused between the phases of the Moon and the phenomenon of a lunar eclipse. As Olson and Doescher (1988; 2001) have already point-

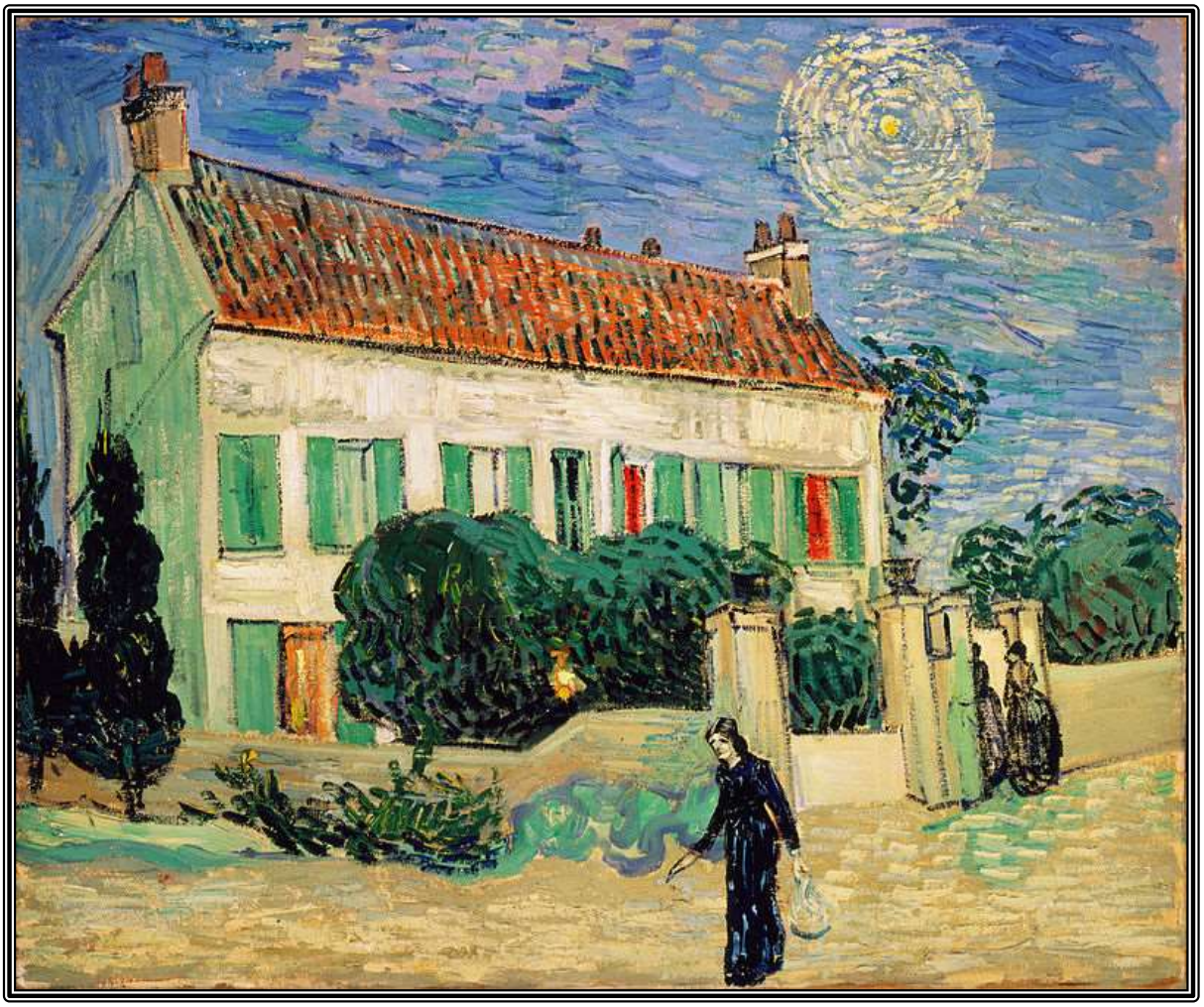
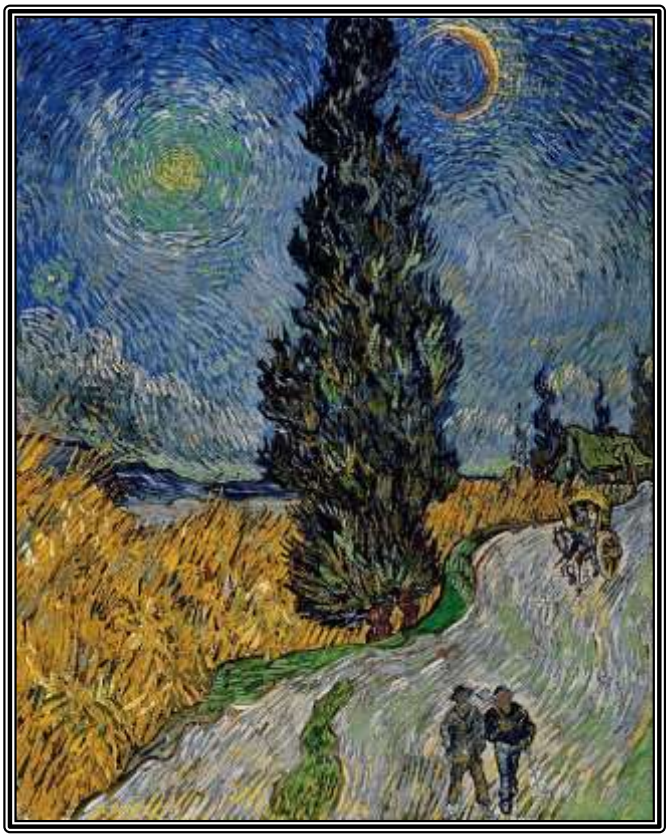


Figure 7 (above): *White House at Night*, an oil-on-canvas painting created on 16 June 1890 in the small town of Auvers-sur-Oise by Vincent van Gogh, six weeks before his death; it is displayed at the Hermitage Museum of St. Petersburg (from Wikimedia Commons in the public domain).



ed out, if the dim shining object at the bottom left of Venus represents Mercury, and the Moon was crescent and slightly higher than Venus, similar to what is depicted in the painting, the work might refer to a sky seen on the evening of 20 April 1890, around 8 pm CET (7:19 pm local time) toward west. There was a conjunction between Venus and the Moon on 20 April 1990, and a conjunction between Venus and Mercury on the morning of 25 April, as reported in the April 1889 issue of the magazine *L'Astronomie*. The planets were separated by only 2° in the sky after the sunset of 24 April 1890. During these evenings weather reports for Aix-en-Provence indicated only a few clouds and

Figure 8 (left): *Road with Cypress and Star*, by V. van Gogh and dated May 1890, in the Kröller-Müller Museum (the image is from Wikimedia Commons in the public domain).

Figure 9: *Wheatfield with Crows*, oil on canvas by Vincent van Gogh, in the Van Gogh Museum, Amsterdam (the image is from Wikimedia Commons in the public domain).

hence a possible visibility of the planets and of the Moon. In the sky the Moon has a very thin illuminated surface visible from the Earth, positioned at about 4° to the left of Venus, while Mercury was lower to the right of Venus. Interestingly, van Gogh's depiction of these three celestial objects appear to be mirrored compared to the Stellarium simulation (except for the Moon's illuminated part). Art historians (e.g. Erickson, 1998) suggested that this painting was created in May 1890. It is therefore likely that van Gogh mentally framed the planetary conjunction and later attempted to reproduce the view, albeit with some artistic license (similar to the license used for the Earth shadow in the *Moonrise* painting and the winding of the large swirl in *The Starry Night*, if interpreted as a reproduction of the M51 drawing).

In this context I would like to emphasize a possible new planetary conjunction present or inspiring what has often been claimed to be van Gogh's last work, *Wheatfield with Crows* created in Auvers-sur-Oise (see Figure 9). Van Gogh's letters suggested that this painting was completed around 10 July 1890. Around 10 July 1890, in fact, van Gogh wrote to his brother Theo stating that he had painted three large canvases since visiting Paris on 6 July. He described two of these as immense stretches of wheat fields under turbulent skies, emphasizing a sense of sadness, and later mentioning 'extreme loneliness'. One of these could potentially be *Wheatfield with Crows*. There have been claims that he may have finished other works, such as *Tree Roots*, even later, so it remains uncertain if this truly was his last painting. The artwork features a dramatic, cloudy sky filled with crows soaring over a wheat field, with a central path leading to nowhere. The flight of the crows merges with a dramatic blue and black sky, hinting that it is getting dark. Notably, two round whitish objects are clearly visible at the horizon. The larger whitish object towards the end of the path may represent a setting Sun or a luminous star at the end of the road, which is where the road is going. This idea resonates with what he wrote:

> For my own part, I declare I know nothing whatever about it, but looking at the stars always makes me dream, as simply as I dream over the black dots representing towns and villages on a map. Why, I ask myself, shouldn't the shining dots of the sky be accessible as the black dots on the map of France? Just as we take the train to get to Tarascon or Rouen, we take death to reach a star. (van Gogh, 1888, Letter to Theo 638).

The second whitish object might have been added later, as some of white/light blue paint spills over one of the crows. In the evening on 7 July 1890 a spectacular planetary conjunction of Saturn and Venus was visible with the two planets separated by less than 15 arcminutes (approximately half the size of the Full Moon). This conjunction was announced also in the magazine *l'Astronomie* (in the July 1889 issue) as the two planets were expected to reach a minimum separation of 6 arcsec (which happened during daytime). The object to the left of the setting Sun might represent this event. Van Gogh might have mentioned

the canvas before completing it and added the second celestial object near the horizon at a later time. According to Stellarium, on the evening of 17 July an extremely thin, barely visible crescent Moon was setting very close to the horizon where the Sun set. The Moon, Saturn and Venus were all setting around the same time on 19 July 1890. Although we cannot exclude the possibility that the largest object is a crescent Moon, the roundness of the object makes this hypothesis less likely. We underline that more generally we do not have enough elements to judge if the two whitish objects represent specific observed celestial objects, but the celestial Western horizon was very noteworthy during mid-July 1890. The presence of two whitish celestial objects close to the horizon—remarkably positioned at the end of the path—highlights the artist's keen attention to celestial phenomena and his deep connection to the sky as a physical, mystical and religious entity.

## 7 CONCLUDING REMARKS

In this paper I have analyzed van Gogh's paintings that suggested the artist's awareness of relevant new astrophysical concepts in the second half of the nineteenth century, and underlined the deep fascination felt by van Gogh for celestial phenomena, which he often depicted in his masterpieces. Previous analyses have already reported the link between van Gogh's art and astronomy and the correspondence of the positions of some celestial objects with what he may have observed at night.

I have added in this paper new elements, such as the 1889 lunar eclipse, visible in southern France and depicted in the *Moonrise* painting, and a planetary conjunction. I have also proposed that the structure and colors of stars in *The Starry Night*, mentioned explicitly in his letters, have been inspired by his awareness of new astrophysical concepts emerging at the end of nineteenth century such as stellar diversity and spectral classification. By analyzing the swirling skies in his famous *Starry Night* I speculated on additional possible correspondences and sources of inspiration. Emerging astronomical wonders at the end of the nineteenth century likely drove the creation of what was the most famous painting of the night sky and van Gogh's most popular masterpiece.

## 8 NOTES

1. https://www.vangoghletters.org/vg/letters.html
2. https://eclipse.gsfc.nasa.gov/LEcat5/LE1801-1900.html
3. Stellarium is an astronomy software that mimics a planetarium (https://stellarium.org/).
4. In 1889, as pointed out by Olson, Saint-Remy local time was 19 minutes later than Universal time and we shall use this time in the rest of this Section.
5. See the on-line *Portail des archives du climat de Meteo-France* (http://archives-climat.fr/).
6. http://www.bellatrixobservatory.org/cvaai/37/index.html

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