

Amelia Carolina Sparavigna

Politecnico di Torino

# **Archaeoastronomy and Gardens**

## **Sun and Moon**



**Torino, January 2021**

*A garden is a planned space, that is, a controlled space incorporating both natural and man-made materials. In it, sometimes, it is evoked the Garden of Eden, the Paradise on Earth, such as in charbagh gardens.*

*Here it is proposed a discussion of alignments of the designs of gardens along the directions of sunrise on solstices and moonrise on lunistics. We will start from the Gardens of Taj Mahal.*

*Amelia Carolina Sparavigna*

*5 January 2012*

*The Gardens of Taj Mahal and the Sun (2013)*

*The Taj Mahal Mausoleum and the Moon (2'16)*

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# The Gardens of Taj Mahal and the Sun

Amelia Carolina Sparavigna<sup>1</sup> 

<sup>1</sup>Department of Applied Science and Technology, Politecnico di Torino, Italy

**Abstract:** The Taj Mahal is a splendid mausoleum in Agra, Uttar Pradesh, India, built by the Mughal emperor Shah Jahan. It is the best known and famous example of the Mughal architecture, which combines elements from Islamic and Indian architectural styles. Here we discuss the planning of the Taj Mahal gardens and their orientation with sunrise/sunset azimuths on solstices.

**Keywords:** Satellite Maps, Solar Orientation, Archaeoastronomy

## 1. Introduction

One of the subjects of archaeoastronomical researches is that of understanding the role the sky had in ancient cultures. A source of information for these researches is the analysis of the alignments of archaeological sites towards an astronomical target, such as the rising sun, the moon or some stars [1-5]. This alignment is given by measuring the azimuth, the angle from North on the horizontal plane. To compare it with sunrise or sunset azimuths, we can use several tools freely available on the Web: one of them is provided by Sollumis.com and allows observing the direction and altitude of the sun on each day of the year, represented by a diagram on a satellite Google map. Using it, we were able to find that the Lion Rock complex in Sri Lanka is oriented with the sunset on the day the sun reaches the zenith, that is, the altitude of 90 degrees [6].

Besides the cases of some prehistoric sites, we observed a solar alignment in the planning of ancient Chinese towns, such as Shangdu, the summer capital of Kublai Khan, Xi'an and Khanbalik [7]. These towns have their main axis aligned in the North-South direction, but some elements of their planning are given according to the sunrise and sunset azimuths on solstices. Even in the planning of the buildings of the Forbidden City of Beijing, we find such a solar orientation [7]. Here, we will discuss another example, where the architectural complex is aligned in the North-South direction, but it containing also an orientation with the Sun. It is the garden of

the Taj Mahal, the finest example of Mughal architecture.

## 2. Taj Mahal

The Taj Mahal, the Crown of Palaces, is a splendid white mausoleum in Agra, Uttar Pradesh, India. The Mughal emperor Shah Jahan built it in memory of his third wife, Mumtaz Mahal. The Taj Mahal is the best known and famous example of the Mughal architecture, which combined elements from Islamic and Indian architectural styles [8,9]. The mausoleum is one of the components of a quite large complex of structures, composed by buildings and gardens, including subsidiary tombs, waterworks infrastructure, the small town of Taj Ganji and a Moonlight Garden, north of the River Yamuna. The construction began in 1632 AD and was completed around 1653 AD. A board of architects under imperial supervision worked to the Taj Mahal, among them there were Abd ul-Kari, Ma'mur Khan, Makramat Khan, and Ustad Ahmad Lahauri [10]. Lahauri is generally considered the principal designer of the complex. In the Figure 1 we can see a satellite image from Google Earth of the site and below a plan of it. On the left, we find the Moonlight Garden, north of River Yamuna. Then we have the Mausoleum, with a Mosque and a Jawab. After, we find the Charbagh gardens: a gateway is connecting the gardens with the Taj Ganji. The mausoleum is the central focus of the entire complex, a large, white marble structure.

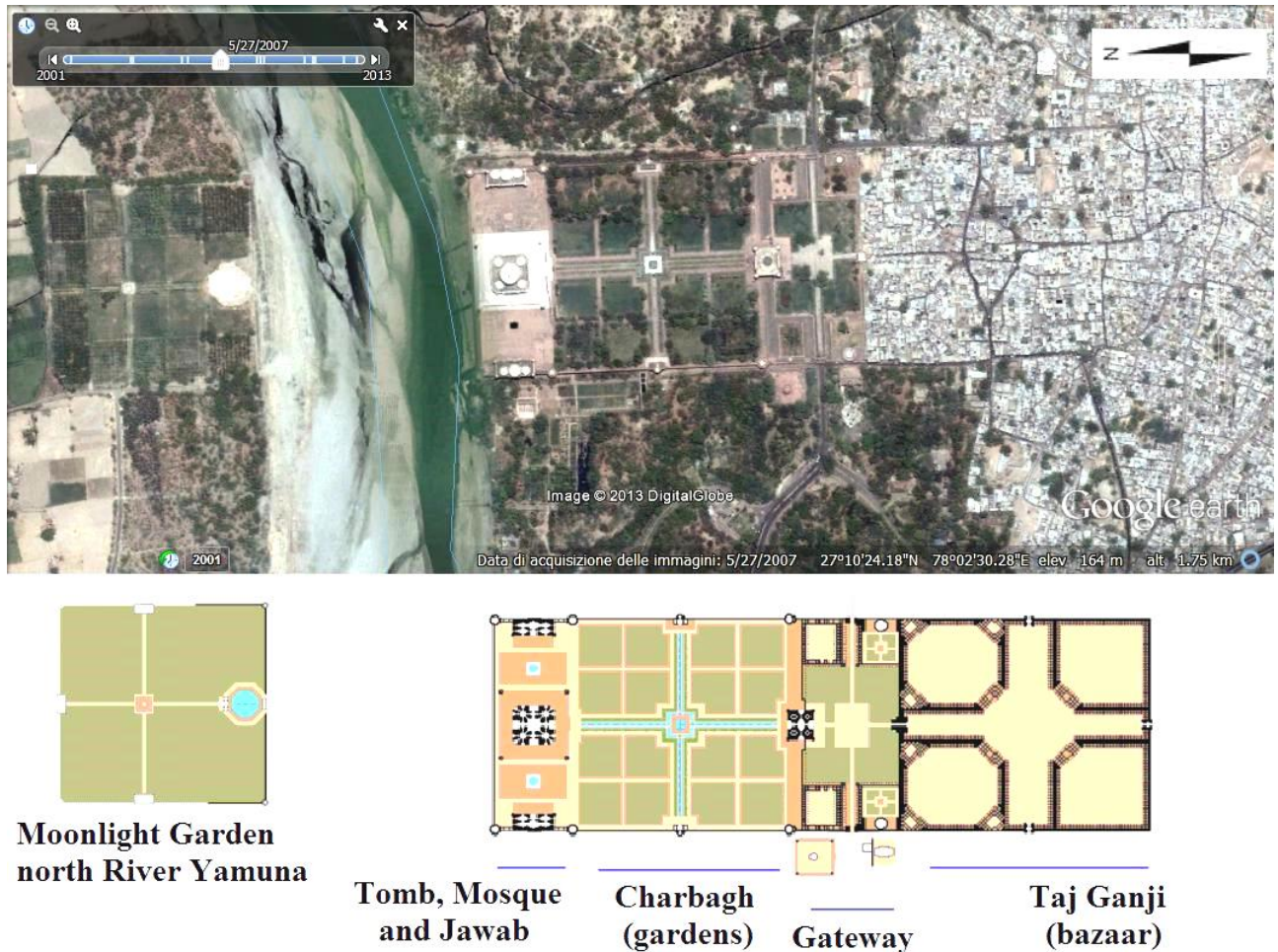


Amelia Carolina Sparavigna (Correspondence)

d002040@polito.it, amelia.sparavigna@polito.it

+39-011-564-7360





**Figure 1** – The Taj Mahal complex. It is aligned in the North-South cardinal direction. Courtesy: Google Earth and Wikipedia.

### 3. The Paradise Gardens

The “charbagh” is the Mughal garden, composed by raised pathways that divide the garden in four parts and each of these four quarters into sixteen sunken parterres or flowerbeds (Figure 2). A marble water tank at the center of the garden, halfway between the tomb and gateway, along the North-South axis, reflects the image of the mausoleum. The charbagh garden is modeled on the Persian gardens: it was introduced to India by the first Mughal emperor, Babur [10,11]. Its planning symbolizes the Paradise, the “Garden of Eden”. The word “paradise” is coming from the Latin “paradisus” and from the Greek “paradeisos”, however it has an Iranian source “pairidaeza”, which indicates a park in an enclosure,

that is, a walled garden [12]. In mystic Islamic texts of Mughal period, the Paradise is described as an ideal garden of abundance with four rivers flowing from a central spring or mountain along the four cardinal directions [10]. In their ideal form then, the charbagh gardens were laid out as a square or rectangle subdivided into four equal parts; the rivers were represented by shallow canals which separate the garden by flowing towards the cardinal points. However, it is necessary to remark that the cross axial garden also finds independent precedents within South Asia in the royal gardens of Sigiriya in Sri Lanka [13,14,6]: in this case, the orientation of the garden is not coincident with cardinal directions [6].





**Figure 2** – The Taj Mahal Gardens. Note that the image is rotated: the mausoleum, gardens and gateway are aligned in the North-South cardinal direction.

According to Ref.10, most Mughal charbaghs are rectangular with a tomb or pavilion in the center. The Taj Mahal garden is unusual because its main element, the white Mausoleum, is located at the end of the garden. This fact created a debate amongst scholars regarding the reasons why the traditional charbagh form had not been used. Ebba Koch suggests that a variant of the charbagh was employed; that of the more secular waterfront garden found in Agra, adapted for a religious purpose [10,14]. However, after the discovery of the Moonlight Garden, on the other side of the River Yamuna, the Archaeological Survey of India proposed that the Yamuna itself was incorporated into the planning of Taj Mahal, to be seen as one of the rivers of Paradise. In this case, the Taj Mahal complex, as shown in the Figure 1, becomes the traditional charbagh [10].

#### 4. The Garden and the Sun

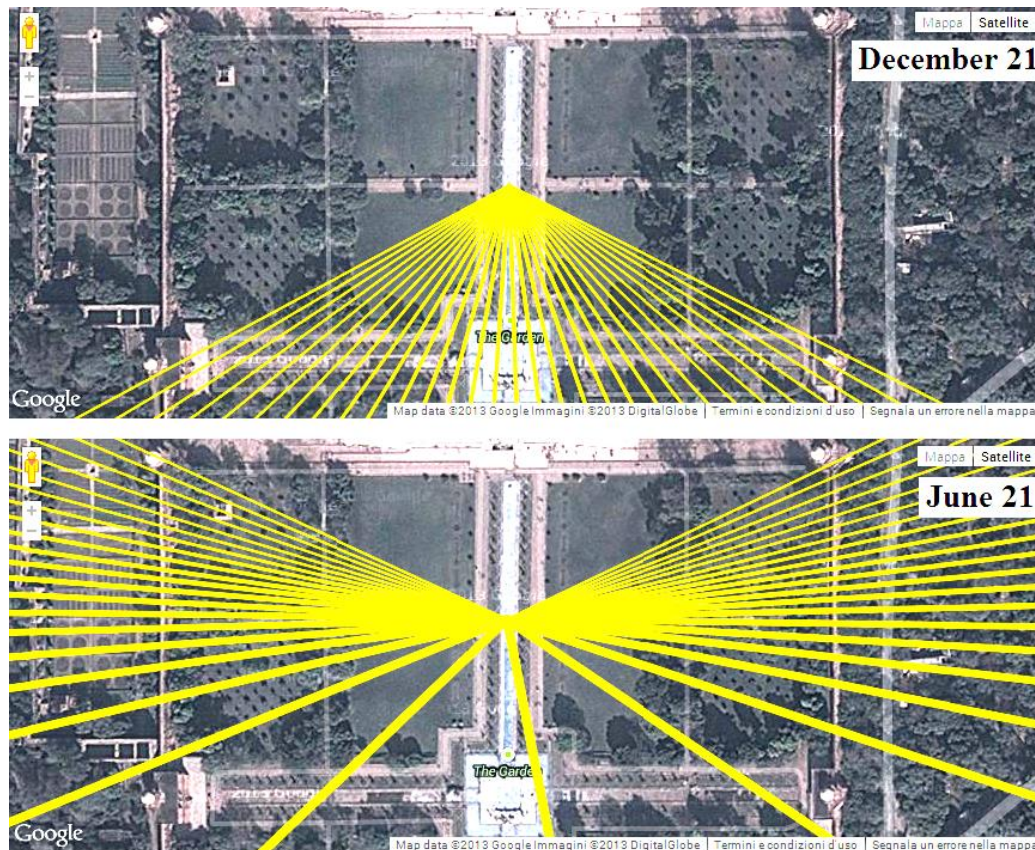
In Ref.15, a detailed discussion of the symbols involved in the architectural planning of the Taj Mahal garden and in its decorative elements is proposed. Here, we want to show another possible interpretation of the planning of the garden, according to sunset and sunrise azimuths.

As we have discussed in the Ref.7, some ancient Chinese towns are aligned in the cardinal North-South direction, the projection on the horizontal plane of the “axis mundi”, the axis about which the world is rotating. However, in planning them, architects used some elements aligned in the

directions of sunrises and sunsets on solstices. Another example discussed in [7], is a court of the Forbidden City in Beijing, that having at its centre the Hall of the Central Harmony, between the Halls of Preserving Harmony (North) and Supreme Harmony (South). This court is aligned in the North-South direction, but, from the Hall of the Central Harmony, we can see the sun rising and setting exactly at the corners of the northern edge on the summer solstice, and at those of the southern edge on the winter solstice. In such a manner, this enclosure becomes a symbolic horizon, aligned in the direction of the “axis mundi”, at the corners of which the sun is rising and setting on solstices.

This is the same for the garden of the Taj Mahal. Let us observe the Figure 3, showing the northern part of the garden and the direction of the Sun, viewed from its centre, as depicted by the diagrams of Sollumis.com. Note that at the corners of this rectangular part of the garden, we have white pavilions. On the winter solstice, the sun rises and sets at the southern corners of the garden (upper image). On the summer solstice, the sun rises and sets exactly at the northern corners (lower image). The same happens to the southern part of the garden. We can then repeat what we observed about the court of the Forbidden City: the enclosure of the garden becomes a symbolic horizon, where we have an alignment of the planning in the direction of the “axis mundi”, and the corners are placed in such a manner that we can see, from the centre of the enclosure, the sun rising and setting there on the solstices.





**Figure 3** – The northern part of the garden of Taj Mahal. We can see the direction of the sun during the winter and summer solstices, given by Sollumis.com (<http://www.sollumis.com/>). This site provides a polar diagram, overlaying a satellite map, showing the directions of the sun for any day of the year. The lines on the drawing show the direction and height (altitude) of the sun. Thicker lines mean the sun is higher in the sky. Longer and thinner lines mean the sun is closer to the horizon.

## 5. Conclusion

The Taj Mahal complex was created with some symbolic meanings. The Gardens for instance are representing the “Garden of Eden”, according to the mystic texts of the Mughal period, with four canals flowing from a central spring in the four cardinal directions. Here, we have shown that these gardens could have been planned according to the sunset and sunrise azimuths on solstices too. We have already discussed in a previous paper an example of a court having such a design, that of the Hall of the Central Harmony in the Forbidden City of Beijing [7]. The same happens to the gardens of Taj Mahal, so that the enclosures of them become a symbolic horizon. This horizon has the main alignment in the direction of the axis of the world, and its corners located in such a manner that it is possible to see the sun rising and setting there on the solstices.

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Sparavigna, A.C. (2016). The Taj Mahal Mausoleum and the Moon. PHILICA Article number 611.

## The Taj Mahal Mausoleum and the Moon

Amelia Carolina Sparavigna

Politecnico di Torino

**Abstract:** Here we are proposing an astronomical analysis of the Taj Mahal mausoleum made by means of a modern ephemeris, the Photographer's Ephemeris, a well-known software used for planning outdoor photography. A remarkable alignment with moonrise and moonset azimuths on minor lunar standstill is observed for the four pavilions at the corners of the platform of the mausoleum. Some reference to the moon can also be seen in the gardens.

**Keywords:** Archaeoastronomy, Satellite Images, Architecture, Modern Ephemerides

In some recent papers we have discussed the Mughal gardens, beautiful forms of landscape architecture of Mughal Dynasty, and the alignments along sunrise and sunset azimuths on solstices that some of them are showing [1-3]. These gardens, which had been heavily influenced by the Persian gardens of carbagh structure, have a rectilinear layout within walled enclosures [4-6]. Rich of flowers, plants and waters, they became the representation of an earthly paradise. And in fact, it is a word of an Iranian language, 'pairidaeza', meaning 'walled garden', that passed into the Ancient Greek 'paradeisos', and then rendered into the Latin 'paradisus'. In this manner, the "Garden of Eden" became the "Paradise on Earth".

Using satellite images, we can easily see that some of the Mughal gardens are oriented to the cardinal directions, that is, that they have axes aligned to north-south and east-west directions. The Gardens of Taj Mahal, such as all the monumental complex, have this orientation.

The Taj Mahal is the best known and famous example of Mughal architecture, a splendid white mausoleum in Agra, Uttar Pradesh, India. Mughal emperor Shah Jahan built it in memory of his third wife, Mumtaz Mahal [7,8]. The mausoleum is one of the components of a large complex composed by buildings and gardens, including subsidiary tombs, waterworks infrastructure, the small town of Taj Ganji and a Moonlight Garden, north of the River Yamuna.

In [1,3], we have discussed that alignments along sunrise and sunset azimuths on solstices are present in the garden of this complex, so that its enclosure becomes a symbolic horizon representing the world, where its axis is the 'axis mundi' (the axis of the world) and, on solstices, the sun is rising and setting at its four corners.

Since the garden is dimensioned according to the sun and its azimuths, we could expect also some alignments with the moon. More precisely, we want to search alignments along moonrise and moonset azimuths on lunar standstills. Let us note that the azimuth – that is the direction - of moonrise and moonset changes during the moon's nodal period (about 27 days), while the azimuth variation, during each nodal period, varies with the lunar standstill period (18.613 years) [9]. On standstills, the moon is making the narrowest and widest arcs across the sky. We can easily calculate the moonrise and moonset azimuths, that are depending on latitude, from the formula given by Jürgen Giesen at his web site [www.geoastro.de/sunmoonpolar/index.html#Mondwenden](http://www.geoastro.de/sunmoonpolar/index.html#Mondwenden). The reader can find detailed discussion and apps for simulating the moon apparent motion there.

However, for an astronomical analysis of alignments along moon azimuths, we can use a more evident approach: we can apply a software showing these azimuths on the satellite



maps. This software is the Photographer's Ephemeris, a well-known software used for planning outdoor photography.

Wikipedia tells us that on October 2015 we had a minor lunar standstill and that on April 2025, there will be a major lunar standstill. So let us use Photographer's Ephemeris for these periods.

Here in the following figures the results of simulations for the complex of Taj Mahal. In the Figure 1 we can see a very interesting result. If we consider the pole on the mausoleum, we see that the four pavilions at the corners of the platform are aligned along moonrise and moonset on the minor lunar standstill. But the satellite image is not orthogonal and then the pole seems not coincident to the center of the mausoleum. Therefore, let us compare Figure 1 to Figure 2, where the view of the complex is orthogonal. The angles are the same, as given by the two images superimposed (Figure 3). Therefore, the center of the mausoleum and the pavilions are aligned along the lunar azimuths. In the Figure 4 we can see the mausoleum and one of this pavilions.

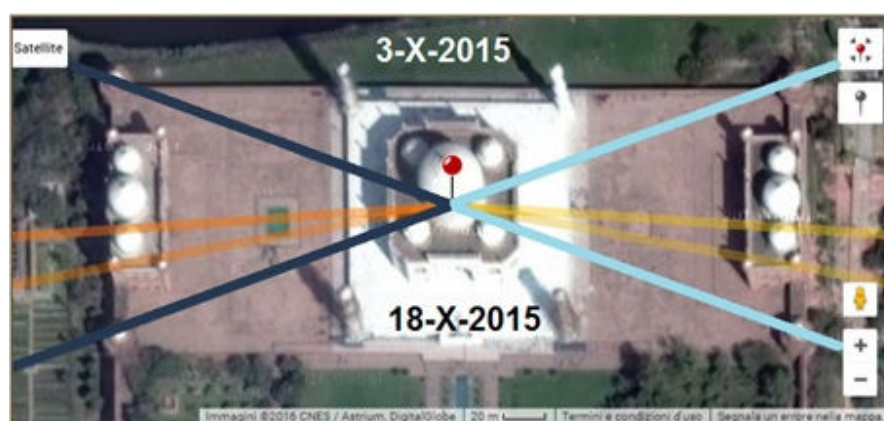


Figure 1: The moon on a minor lunar standstill (moonrises in pale blue lines and moonsets in dark blue lines, sunrises and sunsets in yellow and orange lines, for the dates of 3 October 2015 and 18 October 2015) from the Photographer's Ephemeris.

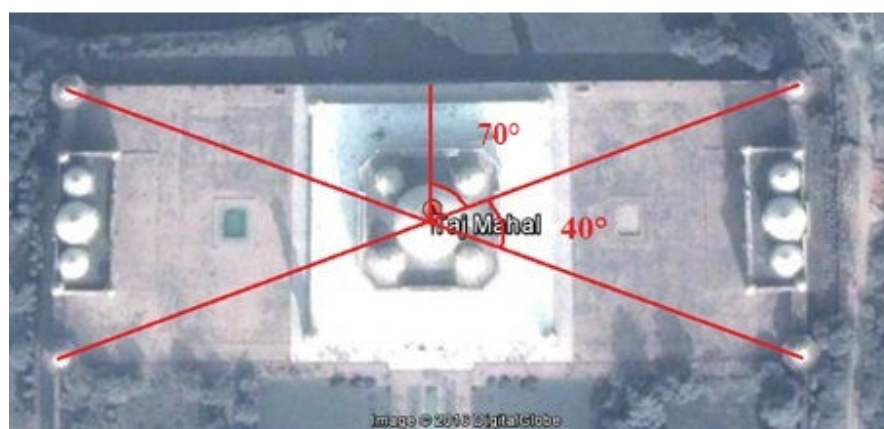


Figure 2: Measured angles are the same as those in the Figure 1, in this orthogonal view of Google Earth.

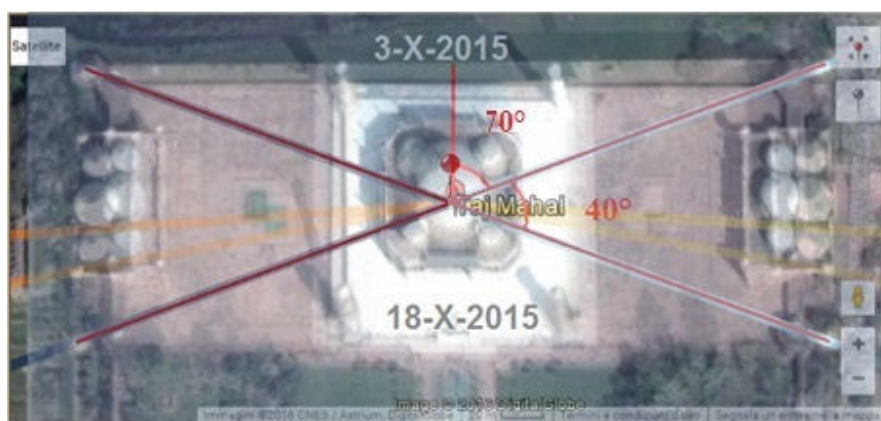


Figure 3: Figures 1 and 2 are superimposed for comparison. The angles are the same.



Figure 4: Here a view of the Mausoleum and its platform with one of the pavilions at the corner (Image courtesy: David Castor, Wikipedia).

Some other alignments can be seen in the gardens, for instance, as those given in the Figure 5, where we can see the moonrise and moonset azimuths on a major lunar standstill. Another interesting alignment is displayed by the Moonlight Garden on the minor lunar standstill. The Moonlight Garden is the charbagh complex which lies north of the Taj Mahal complex on the opposite side of the Yamuna River. However, the alignment which is more evident is that of the Figure 1.

As a conclusion we have that, in the Taj Mahal complex, the apparent path of the sun had been used for the garden whereas that of the moon was specifically linked to the tomb complex.

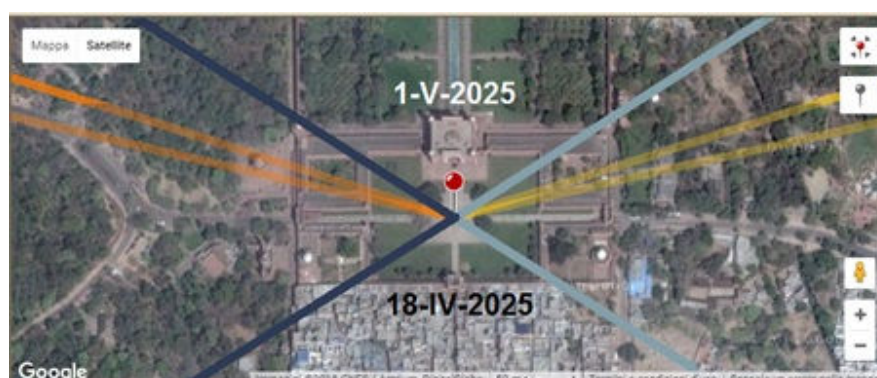


Figure 5: Moonrise and moonset azimuths on a major lunar standstill.

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## Solar Azimuths in the Planning of a Nur Jahan's Charbagh

Amelia Carolina Sparavigna<sup>1</sup> 

<sup>1</sup>Department of Applied Science and Technology, Politecnico di Torino, Italy

**Abstract:** A charbagh garden, the Dilkusha Charbagh, located near the town of Shahdara Bagh in Lahore, Pakistan, was created by the Mughal empress Nur Jahan. At the center of the garden, it was built the mausoleum of her husband, the emperor Jahangir. The paper discusses this charbagh and its planning according with solar azimuths.

**Keywords:** Satellite Maps, Solar Orientation, Mughal Architecture, Charbagh.

### 1. Introduction

In a recent paper [1], we have discussed the gardens of Taj Mahal and their planning according with the azimuths of sunrise and sunset on solstices. The Taj Mahal is the mausoleum built in 1632-1648 at Agra by Shah Jahan as a tomb for his wife, Mumtaz Mahal. Shah Jahan (1592-1666), the King of the World, was the fifth Mughal Emperor who reigned from 1628 until 1658; he is credited of many splendid monuments, so that the period of his reign is considered as the golden age of Mughal architecture [2,3]. Among these monuments, there is the mausoleum of his father Jahangir, the Conqueror of the World. The mausoleum is located near the town of Shahdara Bagh in Lahore, Pakistan. Placed at the centre of a walled garden, the Dilkusha Charbagh, the mausoleum was built ten years after the death of Jahangir. The garden was laid out previously by the empress Nur Jahan (1577-1645), the Light of the World, with the typical structure of a Mughal garden. Like that of the gardens of Taj Mahal, the planning of the Dilkusha Charbagh shows an agreement with the solar azimuths on solstices, as we will discuss in this paper.

### 2. Jahangir and Nur Jahan

Nur-ud-din Mohammad Salim, known as Jahangir (1569-1627), was the fourth Mughal emperor who ruled from 1605 until his death in 1627. As reported in [4], his reign was characterized by political stability, a strong economy and impressive cultural achievements. Jahangir was fond of art, science and architecture. He was a naturalist as well: in his

Tuzuk-i-Jahangiri, Memoirs of Jahangir, he recorded his observations on plants and animals.

Under the influence of his Persian empress, Nur Jahan, he promoted the Persian culture throughout his empire. As previously told, the owner of the Dilkusha garden was this empress [5]. In the Reference 5, we read that a local tradition is claiming that "the design and construction of Jahangir's tomb were in Nur Jahan's hands" too. However, in Muhammad Salih's Shah Jahan Nama (The History of Shah Jahan, completed in 1659-1660), the tomb is primarily attributed to Shah Jahan. The name of the architect is not known, but it seems that Chandar Bhan, a historian and writer, served as a supervisor of the site for some time [6].

The walled tomb-garden is entered from the Akbari serai on the west side (see Figure 1). The serai has gateways on the North and South and a pre-Mughal period mosque on the West [6]. At the centre of the garden lies the tomb which rests on a high podium, surmounted with tall minarets on all four corners. The square garden was divided into four parts in the Charbagh pattern, with water canals. There were fountains and water flowing. The water for the garden was lifted from eight wells located immediately outside the enclosure wall to an aqueduct running on top of the wall. Some terra cotta pipes were feeding fountains and tanks [6]. Every intersection in the garden was marked by octagonal and square tanks [7].



Amelia Carolina Sparavigna (Correspondence)

d002040@polito.it, amelia.sparavigna@polito.it

+39-011-564-7360



**Figure 1** - The Jahangir's Tomb is located near the town of Shahdara Bagh in Lahore, Pakistan. The mausoleum is at the centre of a walled garden, the Dilkusha Charbagh.

### 3. The Sun on the garden

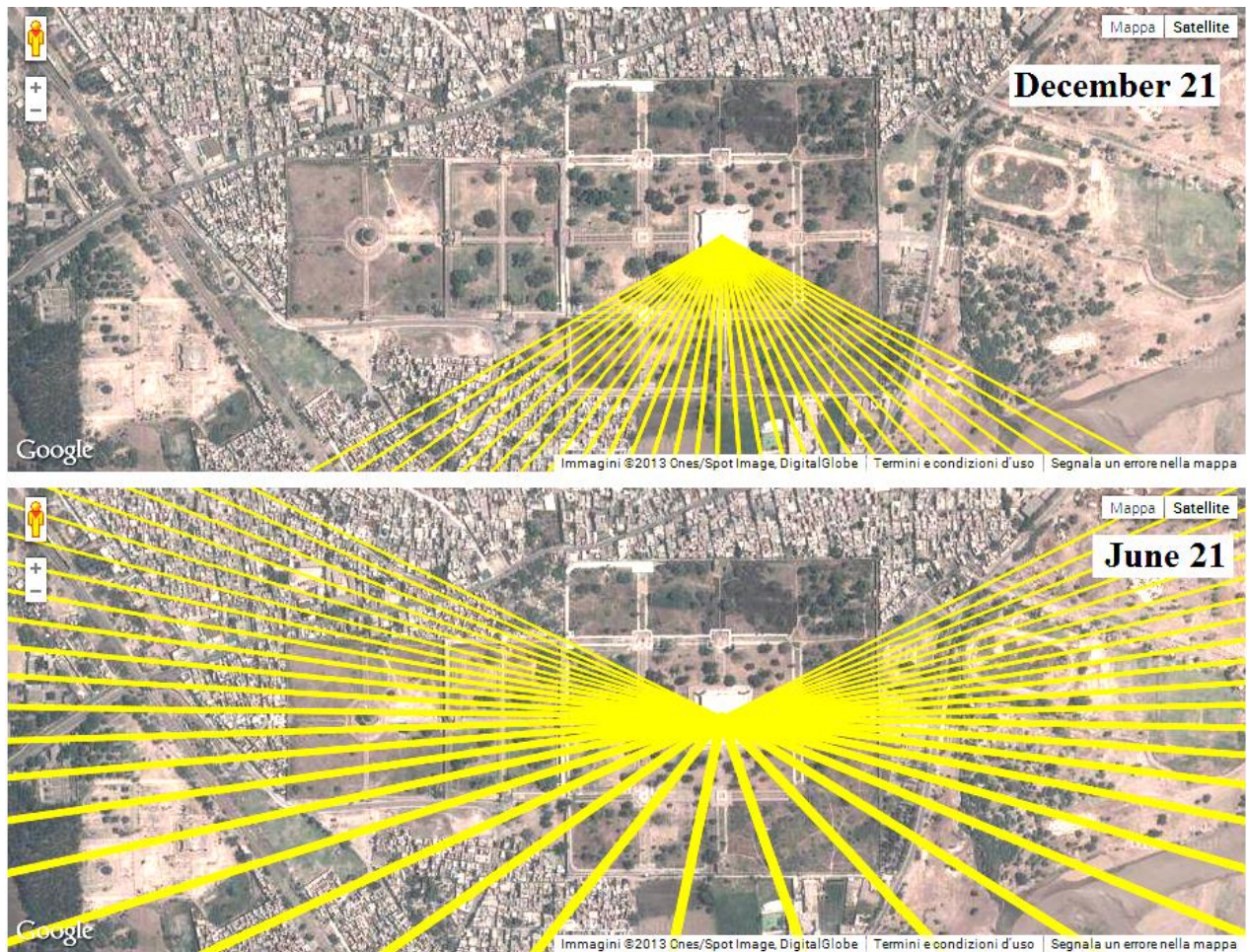
As discussed in [1], the “charbagh”, which means “four gardens”, is the Mughal garden modelled on the Persian gardens, with a planning which symbolizes the Paradise, the “Garden of Eden”. Let us also remember that the word “paradise” is coming from the Iranian word “pairidaeza”, which indicates a park in an enclosure, that is, a walled garden [1]. The Paradise is a garden of abundance with four rivers flowing from a central spring along the four cardinal directions. Therefore, in their ideal design, the charbagh gardens were laid out as a square or rectangle subdivided into four equal parts; the rivers were represented by canals which separate the garden by flowing towards the cardinal points. According to Reference 8, most Mughal charbaghs are rectangular with a tomb or pavilion in the centre. In the case of the Nur Jahan's Charbagh in Shahdara Bagh, the centre of it was occupied by the tomb quite after the garden was created.

In the Reference 1, we discussed the charbagh of Taj Mahal. The garden, such as all the complex of the mausoleum, is aligned in the North-South cardinal direction. Using a tool able to determine the solar azimuths, we were able to see how, on winter and summer solstices, the sun rises and sets at the corners

of the garden. In [1], we concluded that the enclosure of the garden of Taj Mahal is a symbolic horizon, where we have the alignment in the North-South cardinal axis, representing the axis of the world, and the corners placed in such a manner to represent the path of the Sun over the year. Another example of such a symbolic enclosure is a court of the Forbidden City in Beijing, that having at its centre the Hall of the Central Harmony, between the Halls of Preserving Harmony (North) and Supreme Harmony (South) [9].

The Jahangir's mausoleum complex is aligned in the East-West direction. However, the Dilkusha Charbagh, which was built before the tomb, can be considered aligned in the North-South direction, as the gardens of the Taj Mahal. In the Figure 2, we can see the direction of the sun on the winter and summer solstices, given by Sollumis.com (<http://www.sollumis.com/>). The images are polar diagrams overlaying a satellite map. Let us note that the subdivision of the charbagh is obtained according with the sunrise and sunset azimuths on solstices. It is possible then that this garden, with its references to solar azimuths, had been used as a model for the gardens of Taj Mahal.





**Figure 2** – The Dilkusha Charbagh complex is aligned in the cardinal directions. In the two images we can see the direction of the sun during the winter and summer solstices, given by Sollumis.com (<http://www.sollumis.com/>). This site provides a polar diagram, overlaying a satellite map, showing the directions of the sun for any day of the year. The lines on the drawing show the direction and height (altitude) of the sun. Thicker lines mean the sun is higher in the sky. Longer and thinner lines mean the sun is closer to the horizon.

#### 4. Conclusion

The Mughal Gardens are representing the “Garden of Eden”, according to the mystic texts of the Mughal period, with four canals flowing from a central spring in the four cardinal directions. Here, we have seen that one of these gardens, the Dilkusha Charbagh, could have been planned in agreement with the sunset and sunrise azimuths on solstices, like the gardens of Taj Mahal. Their enclosures are symbolic horizons, which have the alignment in the North-South cardinal direction, representing the axis of the world, and the corners located according to the sunrise/sunset azimuths on solstices, to represent the path of the Sun over the year.

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Courtesy: Dheerendra.photography for Wikipedia

# Observations on the Orientation of Some Mughal Gardens

*Amelia Carolina Sparavigna*

*Department of Applied Science and Technology, Politecnico di Torino)*

## Abstract

The Mughal gardens are a typical form of landscape architecture developed by the Mughal Dynasty. These gardens had a style heavily influenced by the Persian gardens of charbagh structure, with a use of rectilinear layouts within walled enclosures. Here we propose some observations on the typical layout of these gardens and on the orientations and alignments of a few of them.

**Keywords:** Landscape Architecture, Solar Orientation, Solstices, Urban Planning, Satellite Images, Google Earth.

## Introduction

Respect and reverence for water and trees which, as told in a recent paper [1], were so strong in many ancient civilizations, assumed in Persia the architectural form of beautiful gardens, the Persian gardens. Their design influenced the layout of other gardens in the world, from those of Al-Andalus to the magnificent gardens of the Mughal Dynasty [2].

The oldest Persian garden that has been discovered dated to the Achaemenid Era (500-300 BC) [1]. It is that of Pasargadae, built around 500 BC, the outline of which is still visible today in satellite images. Under the influence of Zoroastrianism, the religion of Achaemenid, Parthian and Sasanian empires, the emphasis on the role of water constantly increased and the gardens were enriched with fountains and ponds [3]. During the Sasanian Era (AD 226-641), the Mandala design of the garden appeared [4]. In any case, it was from the time of the Achaemenid Dynasty that the garden was connected to the idea of an earthly paradise. This influenced other cultures, such as the Hellenistic gardens of Seleucid and Ptolemaic Dynasties in Alexandria [3]. In this manner, the Avestan word 'pairidaeza', meaning 'walled garden', passed into Ancient Greek 'paradeisos', which was rendered into the Latin 'paradisus', and the Garden of Eden became the Paradise on Earth.

After the advent of Islam in Persia, basic concepts of garden design were developed and refined; the aesthetic aspect of the garden increased in importance, overtaking utility [3]. As told in [1], 'Heaven' became an important concept that modified the garden. Several heavenly features, highlighted by the Quran, were used to make the Persian garden a successfully combination of artificiality and naturalness [1]. In this manner, many gardens assumed the form of a charbagh, which is representing the Eden with four rivers and quadrants that are the four corners of the world.

In two recent papers [5,6], we have proposed the use of satellite images to investigate the layout and orientation of charbagh gardens. We can easily see that some of them are oriented to the cardinal directions, that is, they have axes aligned to north-south and east-west directions. Since the architecture of ancient civilizations is showing, sometimes, alignments to the directions of sunrise and sunset on solstices, we can investigate if they are shown by charbagh gardens too. In fact, we had found them in the Gardens of Tal Mahal and in the Nur Jahan charbagh [5,6]. These gardens have such alignments besides the cardinal orientation. Here, we continue our observations with satellite images of Mughal gardens and show, besides the abovementioned cases, some other examples of charbagh gardens discussing their orientations.

## Babur's gardens

The charbagh gardens had their origin in Persia, and was Babur, the first Mughal emperor, that introduced them to India [7]. Babur (1483-1530), direct descendant of Timur through his father and of Genghis Khan through his mother, was coming from the Central Asia. Moving from Farghana, the present-day Uzbekistan, he succeed in establishing the Mughal Empire. Babur was greatly influenced by the Persian culture, which affected both his own actions and those of his successors in the Indian subcontinent [8]. In particular, during his tenure in Samarqand, the city's impact upon him was so profound that the city shaped his attitude toward architecture and, even more significantly, toward landscape [7]. In fact, "Samarqand, embellished by Timur and his immediate successors, with splendid charbagh gardens, mosques and other buildings, was one of the wonders of the fifteenth century" [7].

Samarqand is most noted for its central position on the Silk Road between China and the West. In the 14th Century, it became the capital of Timur's empire. As told in [9], Timur "evidently wished to surpass all known precedents while he created his capital par excellence Samarqand". Perhaps, he desired to recreate in a suburban environment the summer life of his people, building several gardens in which it was possible to move at caprice from one to the other, staying either in tents, or in small garden pavilions, with the urban civilization close at hand [9]. In fact, Ref.9 observes that an entire 'necklace' of garden settlements encircling Samarqand existed, with gardens named after the renowned cities of the Muslim world, which Timur had conquered in the course of his expeditions.

Babur too preferred to camp in gardens than in palaces: he created several gardens which were as campsites, situated at a day's or half-day's horse ride from one another, in the manner that other rulers built serais [7]. Locations of many of these gardens are known from Babur's writings and from those of Zain Khan, but today none of these gardens exists in their original state and of others is even lost the location [7].

One of the Babur's gardens/serais is the Aam Khas Bagh. The structure was extended and almost rebuilt by Mughal Emperor Shah Jahan. It is along the Mughal military road between Delhi and Lahore. The complex was famous for a perfect air-conditioning system called Sarad Khana [10]. We can see it in the Figure 1. Let us note that the garden has a rectangular shape with a north-south axis.

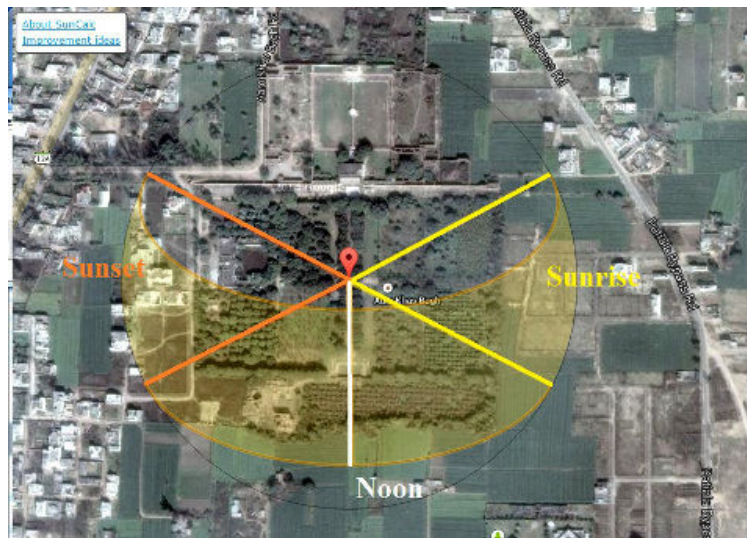


Figure 1: One of the Babur's gardens/serais is Aam Khas Bagh. The structure was extended, and almost rebuilt, by Mughal Emperor Shah Jahan. Note that the garden has a rectangular shape, and has a north-south axis (noon). In the image, it is also shows the angle between the directions of sunrise on solstices (yellow lines) and the angle between those of sunset (orange). Note that these lines are passing rather close the corners of the garden. The image was obtained using SunCalc (suncalc.net).

As remarked in Ref.7, "the manipulation of natural untamed landscape into a rational, ordered creation was for Babur a metaphor for his ability to govern". Babur contributed also to the urban processes in the Indian subcontinent by the development and extension of the 'garden city' concept, having as a model the cities of his homeland, particularly Kabul, Herat, Ferghana, Samarqand and Bukhara [9].

## Humayun's Garden Tomb



The second Mughal emperor was Humayun. His tomb is located just south of the Din-Panah citadel. A contemporary Mughal source indicates that the tomb was finished in 1571 after eight or nine years of work [7]. Its Timurid appearance must be credited to its Iranian architect, known from contemporary texts as both Mirak Sayyid Ghiyas and Mirak Mirza Ghiyas [7]. This architect was from Herat and worked extensively in Bukhara, where he excelled at buildings and landscape architecture [7]. Around 1562, he returned to India to work to the design of Humayun's tomb. The tomb complex is centrally situated in a charbagh (Figure 2). Each of the four garden plots is further subdivided by narrower waterways. Ref.7 explains that this garden was "based on the charbagh types established in Iran and more fully developed in Babur's own concept of the ideal garden".

Humayun seems to have been rather obsessed with the idea of perceiving the cities as 'zones of peace', adopting the mentality of his father Babur, of establishing places of 'rest and order' within disorder [7,9]. He makes also the first attempt of using a monument as the organizational center of the city and of delineating a grid for the development of the urban structure [9]. In [9], it is supposed that the form and position of the Humayun's mausoleum within the urban structure was already conceived to some extent by the emperor himself before his death.



Figure 2: Humayan's Tomb inside the charbagh garden. Note that the axis of the garden is not perfectly aligned to north-south direction.

In [11] it is told that, towards the south-east corner, within the charbagh garden, lies a tomb known as Nai-ka-Gumbad, that is, the Barber's Tomb, datable to 1590-91 CE. Its proximity to the main tomb and the fact that it is the only other structure within the complex suggests a certain importance; however, there are no inscriptions telling the names of the persons interred therein or giving other information. We can ask ourselves if this building had a specific position or alignment in the garden.

In the previous papers [5,6] we used sollumis.com software to investigate alignments to the rising sun; here, we apply SunCalc, a software used in Ref.12. In the Figure 3, we can see that, on the summer solstice, the south gate of the garden and the Barber's Tomb are along the direction of sunrise. In the image, the yellow line is showing sunrise and the orange the sunset. Of course, this could be an unintentional result of the garden layout.

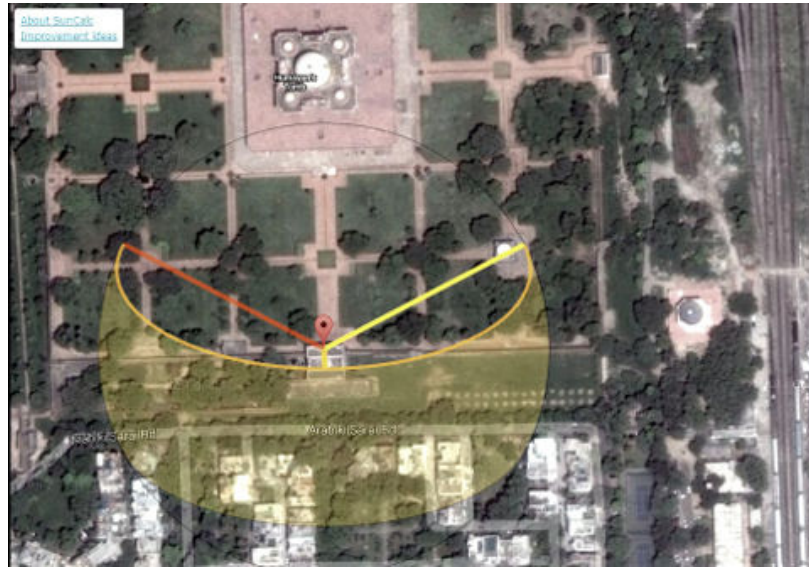


Figure 3: On the summer solstice, the south gate of the garden and the Barber's Tomb are aligned to the direction of sunrise. The image is obtained using SunCalc, where a yellow line is used for sunrise, orange line for sunset.

### The Gardens of Taj Mahal

The best known and famous example of Mughal architecture is the Taj Mahal, the Crown of Palaces, a splendid white mausoleum in Agra, Uttar Pradesh, India. Mughal emperor Shah Jahan built it in memory of his third wife, Mumtaz Mahal [13,14]. The mausoleum is one of the components of a quite large complex of structures, composed by buildings and gardens, including subsidiary tombs, waterworks infrastructure, the small town of Taj Ganji and a Moonlight Garden, north of the River Yamuna (Figure 4). The construction began in 1632 AD and was completed around 1653 AD. A board of architects under imperial supervision worked to the Taj Mahal, among them there were Abd ul-Kari, Ma'mur Khan, Makramat Khan, and Ustad Ahmad Lahauri [15]. Lahauri is generally considered the principal designer of the complex.

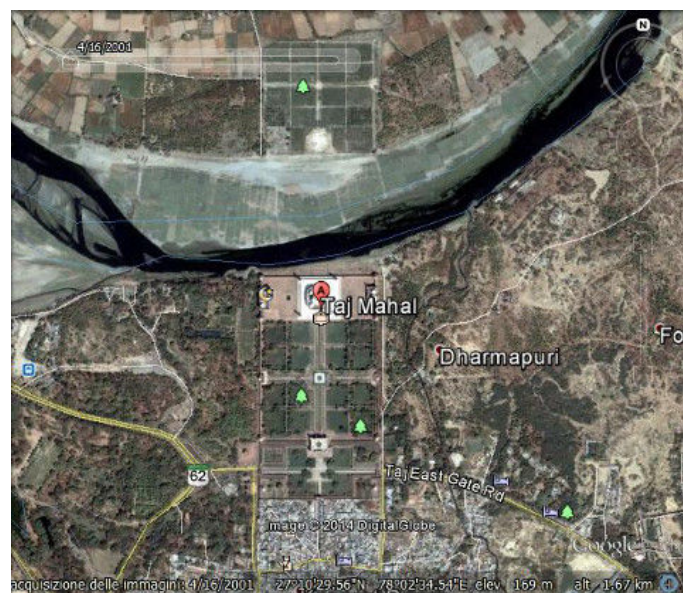


Figure 4: The complex of the Taj Mahal as shown in the Google Earth images. Besides the white huge mausoleum and the garden, we can see the small town of Taj Ganji and the Moonlight Garden, north of the River Yamuna.

According to Ref.15, since most Mughal charbagh gardens are rectangular with a tomb or pavilion in the center, the Taj Mahal garden is unusual because its main element, the white Mausoleum, is located at the end of the garden. This fact created a debate amongst scholars regarding the reasons why the traditional charbagh form had not been used. In [16], it is suggested that a variant of the charbagh was employed.

The Taj Mahal complex has a north-south axis. As we have discussed in [17], when an architectonic structure is aligned in this manner, it is aligned to the projection on the horizontal plane of the 'axis mundi', the axis about which the world is rotating. However, in their planning, architects could also use some elements aligned in the directions of sunrise or sunset [17,18]. In fact, architects have six main directions: two are joining cardinal points (north-south, east-west) and four are those given by sunrise and sunset on summer and winter solstices.

Alignments to solstices are present in the garden of Taj Mahal, as we can see in the Figures 5 and 6. In the Figure 5, the yellow and orange lines of solstices are bisecting the sides of the garden. In the Figure 6, these lines are passing through the pavilions at the corners of the garden. About this image, we can repeat what we have observed when we discussed a court of the Forbidden City in Beijing [17]. The enclosure of the garden is a symbolic horizon, where its axis is representing the 'axis mundi'. On the solstices, from the centre of the rectangular enclosure, we can see the sun rising and setting at its four corners.

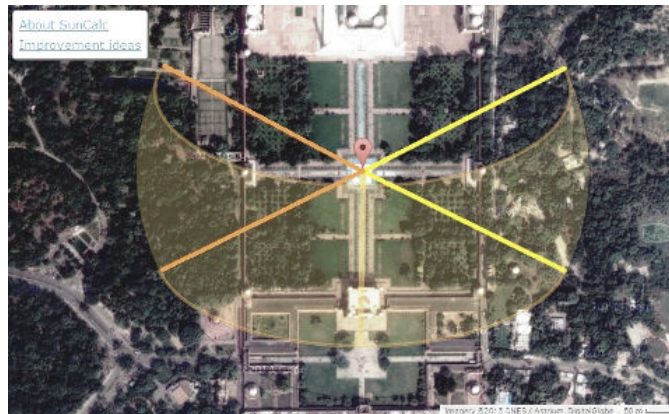


Figure 5: Here we can see, using SunCalc, the gardens of Taj Mahal and the directions of sunrise (yellow) and sunset (orange) on the winter and summer solstices.

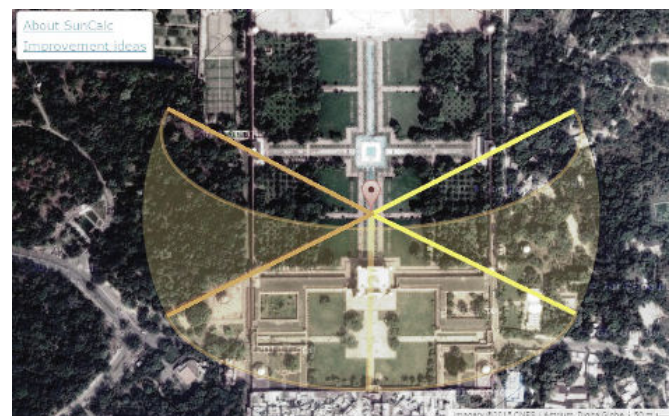


Figure 6: If we use the reference point at the center of the southern part of the garden, we see that the directions of sunrise (yellow) and sunset (orange) on winter and summer solstices are passing through the pavilions at the four corners of the garden.

### The Dilkusha Charbagh

Among the monuments of the golden age of Mughal architecture, we find the mausoleum of Shah Jahan's father. He was Jahangir, the Conqueror of the World. Jahangir (1569-1627), was the fourth Mughal emperor who ruled from 1605 until his death in 1627. His reign was characterized by political stability, a strong economy and impressive



cultural achievements [19].

The mausoleum is located near the town of Shahdara Bagh in Lahore, Pakistan. Placed at the centre of a walled garden, the Dilkusha Charbagh, the mausoleum was built ten years after the death of Jahangir. The garden was laid out previously by the empress Nur Jahan (1577-1645), the Light of the World, with the typical structure of a Mughal garden. Like that of the gardens of Taj Mahal, the Dilkusha Charbagh shows alignments on solstices.

It seems that a local tradition is claiming "the design and construction of Jahangir's tomb were in Nur Jahan's hands" [20]. But in Muhammad Salih's Shah Jahan Nama (The History of Shah Jahan, completed in 1659-1660), the tomb is primarily attributed to Shah Jahan. The name of the architect is not known; it seems that Chandar Bhan, a historian and writer, served as a supervisor of the site for some time [21].

The walled tomb-garden is entered from the Akbari serai on the west side (Figure 7). At the centre of the garden lies the tomb which rests on a high podium, surmounted with tall minarets on all four corners. The square garden was divided into four parts in the charbagh pattern, with water canals. There were fountains and water flowing. The water for the garden was lifted from eight wells located immediately outside the enclosure wall to an aqueduct running on top of the wall. Some terra cotta pipes were feeding fountains and tanks [21]. Every intersection in the garden was marked by octagonal and square tanks [22].



Figure 7: Jahangir's Tomb is located near Shahdara Bagh in Lahore, Pakistan. The mausoleum is at the centre of a walled garden, the Dilkusha Charbagh.

The Jahangir's mausoleum seems having an east-west axis. However, the Dilkusha Charbagh, built before the tomb, can be considered aligned in north-south direction. Has this garden, like that of Taj Mahal, some references to solar azimuths? The answer is positive, as we can see in the Figure 8.

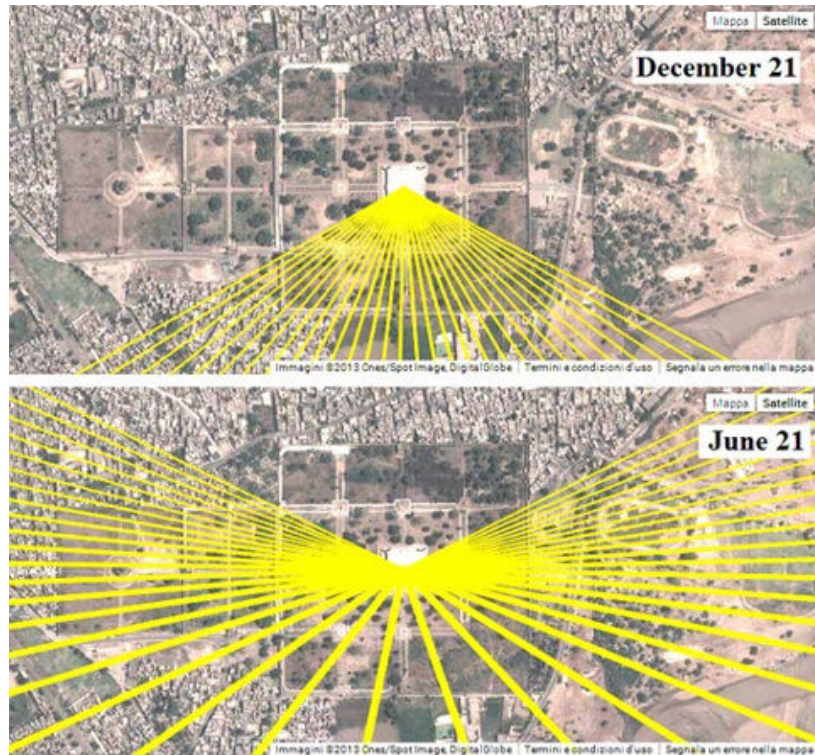


Figure 8: The Dilkusha Charbagh is shown in the two images where we can see the direction of the sun during the winter and summer solstices, given by Sollumis.com (<http://www.sollumis.com/>). This site provides a polar diagram, overlaying a satellite map, showing the directions of the sun for any day of the year. The lines on the drawing show the direction and height (altitude) of the sun. Thicker lines mean the sun is higher in the sky. Longer and thinner lines mean the sun is closer to the horizon.

Even the tomb of Nur Jahan, which is located not far from the tomb of Jahangir is showing interesting alignments, as shown in the Figure 9. The whole mausoleum was surrounded by the garden. Today, only the western part exists.



Figure 9: The Tomb of Nur Jahan and the directions of sunsets on solstices, given by Sollumis.com.

### The Charbagh of Akbar

Akbar the Great (1542-1605), was Mughal Emperor from 1556 until his death. Akbar succeeded his father, Humayun. Akbar gradually enlarged the Mughal Empire to include nearly all of the Indian Subcontinent north of the Godavari river [23]. His tomb is an important Mughal architectural masterpiece, built 1605–1613, in Sikandra, a suburb of Agra, Uttar Pradesh, India. As we can clearly see in the Figure 10, Again, we find the layout and the solar alignments already observed for the gardens of Taj-Mahal and the Dilkusha.



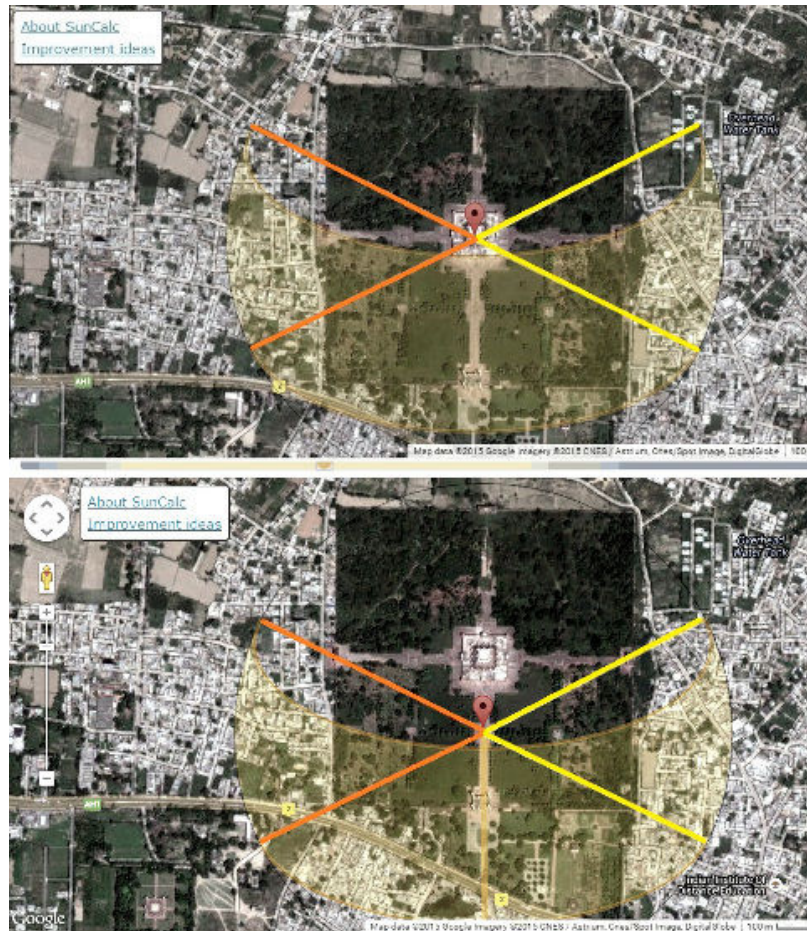


Figure 10: The Garden of Akbar Tomb and the sun on summer and solstices as given by SunCalc (yellow lines are the sunrise, orange the sunset). Again, we find the layout and the solar alignments already observed for the gardens of Taj-Mahal and the Dilkusha.

### Toward Persia

Let us note that the Mughal gardens can have a different orientation too; examples are the tomb of Itimad-ud-Daulah and the Rambagh in Agra and the Pinjore Garden. Let us discuss them and their relevant alignments.

The tomb of Itimad-ud-Daulah is also known with the name of 'Baby Taj', being regarded as a draft of the Taj Mahal. As discussed in [24], the tomb, built between 1622 and 1628 represents a transition between the first phase of monumental Mughal architecture, which was built from red sandstone with marble decorations, as in Humayun's and Akbar's Tombs, to its second phase, based on white marble and pietra dura inlay, such as in the Taj Mahal.

The mausoleum was commissioned by Nur Jahan, for her father Mirza Ghiyas Beg, who was originally a Persian Amir in exile. He had been given the title of Itimad-ud-Daulah, Pillar of the State. In the Figure 11 we can see the mausoleum at the center of the charbagh garden. Looking at the satellite images with SunCalc, we can guess that the charbagh was oriented toward Persia, in a symbolic return of Mirza Ghiyas Beg to his homeland. We can also find an alignment to sunrise on the summer solstice too.



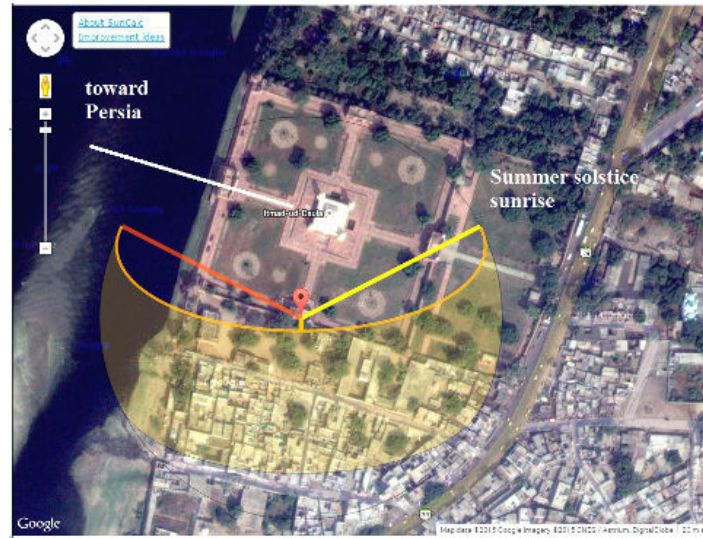


Figure 11: The mausoleum of Itimad-ud-Daulah, Pillar of the State. He was originally a Persian Amir in exile. Looking at the satellite image with SunCalc, we can guess that the charbagh was oriented toward Persia, in a symbolic return of Mirza Ghiyas Beg to his homeland. In this garden, however, we can also find a solar orientation because two gates are aligned to the direction of sunrise on the summer solstice.

### Rambagh Garden and the Qibla

The Rambagh Garden has the distinction of being the very first garden of the Mughals that was built in India [25,26]. Some scholars are of the opinion that the original name of Rambagh was Aram Bagh. It was built in AD 1528 by Babur. It is also said that the tomb of Babur was constructed there, but after a few years was shifted to Kabul [26]. The Rambagh Garden is in Agra, 3 km away from the Itimad-ud-Daulah's tomb. It lies on the banks of Yamuna River.

In the Figure 12, we see the garden. The straight white line determined by the two pavilions of the garden has the direction of the Qibla, the 'direction' toward Mecca, as given by <http://www.qibla.com.br>.



Figure 12: The Rambagh garden. The white line is coincident to the Qibla given by site <http://www.qibla.com.br>.

### Pinjore Garden

The Pinjore Garden, (Figure 13), is located in Pinjore, Panchkula district in the Indian state of Haryana. It was built under the Patiala Dynasty Rulers, and created in the 17th century by architect Nawab Fidai Khan, during the early reign of his foster brother Aurangzeb, from 1658 to 1707. It has been renamed as 'Yadavindra Garden' in the memory of Maharaja Yadavindra Singh. The garden has been laid in seven terraces with the main gate of the garden opening into the highest first terrace which has a palace built in Rajasthani-Mughal style [27]. This garden is interesting

because its axis is parallel to the direction of the sunrise on summer solstice.

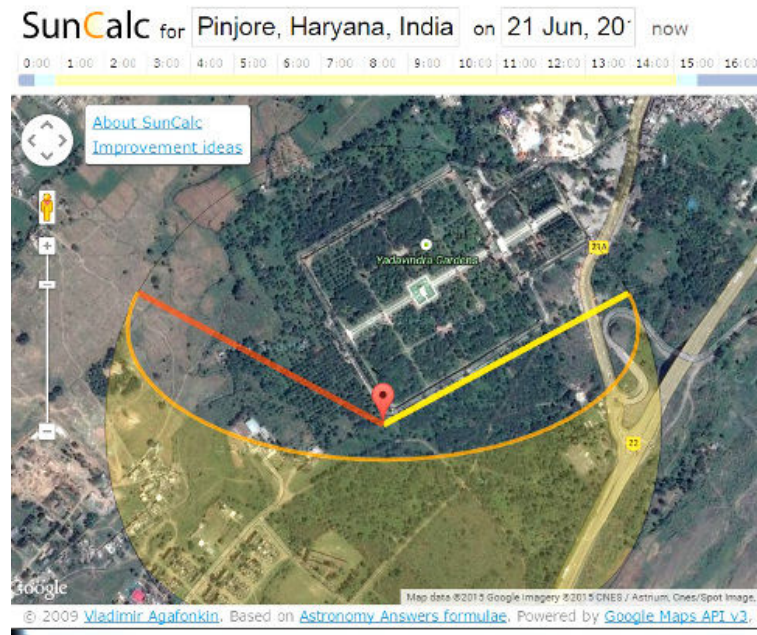


Figure 13: The Garden of Pinjore and the sun on summer solstice as given by SunCalc (yellow line is the sunrise, orange the sunset).

### And many other charbagh gardens

Of course, there are many other charbagh gardens to examine, several are beautiful and well preserved, others look like faint images of their past. Let us show just one of them as it appears in satellite image of Google Earth (Figure 14). It is near the Bhangarh Fort, a 17th-century fort built by order of King Prabhush Rajguru in Rajasthan, India. It seems that ghosts are haunting the old city, as a local lore is telling [28].

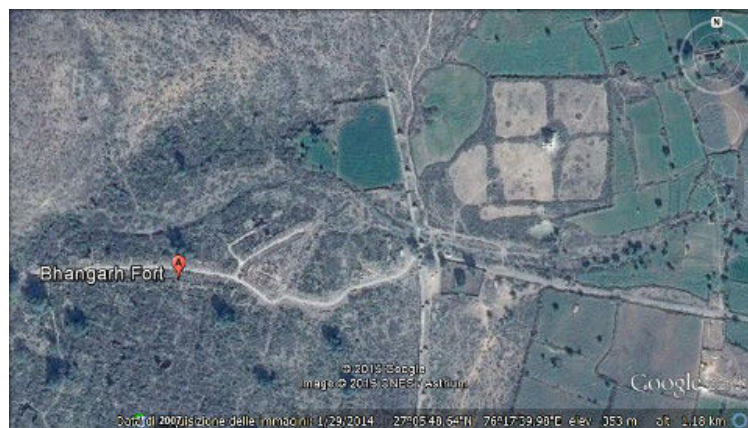


Figure 14: A charbagh garden near the Bhangarh Fort.

### Conclusion

It is well known that the Mughal gardens were created with the symbolic meaning of Gardens of Eden, with the four main canals flowing from a central spring to the four corners of the world. Here, we have shown that some of these gardens could have elements of their layouts, oriented to the directions of sunrise and sunset on solstices. However, other orientations are possible, as shown by the examples given in this discussion.

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<http://www.livescience.com/49660-taj-mahal-gardens-align-solstice-sun.html>



**Author comment added 2nd November, 2015 at 13:21:13**

This paper is reported in: "The Taj Mahal's gardens align with the SUN: Four corners of Indian complex were built in line with the winter and summer solstices" By JONATHAN O'CALLAGHAN FOR MAILONLINE  
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# The Sun, the Moon and the Mughal Emperors

**Amelia Carolina Sparavigna**

Politecnico di Torino, Torino, Italy  
Email: [amelia.sparavigna@polito.it](mailto:amelia.sparavigna@polito.it)

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## Abstract

**This paper aims collecting some excerpts from literature to evaluate the importance that the sun and the moon had for the Mughal emperors, and consequently for arts and architecture of the Mughal period. This is a preliminary survey for a future more extensive work on the subject.**

**Keywords:** Mughal Empire, Arts, Architecture.

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## Introduction

In some previous papers, we have discussed the Mughal gardens and the alignments observed in some of them, along the sunrise and sunset azimuths on solstices [1-3]. These gardens, beautiful forms of landscape architecture of the Mughal Dynasty, had been heavily influenced by the Persian gardens of charbagh structure, which had a rectilinear layout within walled enclosures [4-6]. Rich of flowers, plants and waters, they became the representation of an earthly paradise. And in fact, it is a word of an Iranian language, ‘pairidaeza’, meaning ‘walled garden’, that passed into the Ancient Greek ‘paradeisos’, and then rendered into the Latin ‘paradisus’. In this manner, the "Garden of Eden" became the "Paradise on Earth".

By using satellite images and software for ephemeris, we can easily see that the Mughal gardens, which have their main axes oriented to the cardinal directions, can have alignments along sunrise and sunset azimuths on solstices. The Gardens of Taj Mahal are an example of a garden having such alignments [1,3]. In this manner, these green enclosures become a symbolic horizon representing the world, where their north-south axis is representing the ‘axis mundi’ (the axis of the world) and the alignments along sunrise and sunset on solstice are rendering the apparent motion of the sun in the sky. For the Taj Mahal complex, let us note also that the pavilions of the platform of the mausoleum are displaying an orientation along moonrise and moonset azimuth on minor lunar standstill, and the gardens some alignments to major lunar standstill [7].

In this article we show that, besides these analysis of the astronomical alignments in architectures, based on satellite images and ephemeris, strong evidences of the role of sun and moon in the life of Mughal emperors exist and that we can find them in the literature about arts and architecture of Mughal period. Here a collection of excerpts from literature.

## About the Akbar's tomb

Of the Akbar's tomb, we discussed in [3]. Akbar the Great (1542-1605), was a Mughal Emperor from 1556 until his death. Akbar succeeded his father, Humayun. His tomb is an important Mughal architectural masterpiece, built from 1605 to 1613, in Sikandra, a suburb of Agra, Uttar Pradesh, India. As we can see in [3], the garden that is containing the tomb has the layout possessing the solar alignments observed for the gardens of Taj-Mahal and for the Dilkusha. The Dilkusha Charbagh, near Shahdara Bagh in Lahore, Pakistan, is the garden that contains the mausoleum of Jahangir (1569-1627), the

Conqueror of the World. The empress Nur Jahan (1577-1645), the Light of the World, laid out this garden [2].

Beside the solar alignments that we find in the garden, the Akbar's tomb has clear astronomical elements too. As told in [8], the "tomb's upper story remains open to the sky. In the center is a magnificent carved white marble cenotaph; at its north end is a lamp stand, also rendered in finely carved white marble. ... an uncovered cenotaph is the grave-type that meets orthodox approval and many have been the reasons for the open top story of Akbar's tomb. But this is only a partial explanation. Considering the Mughal fascination with light and light symbolism, the placement of this cenotaph directly under the sun and moon follows especially the interests of Akbar and Jahangir. Underscoring this interpretation is the final verse of the Persian inscription on the tomb's entrance gate that reads: "May his [Akbar's] soul shine like they rays of the sun and the moon in the light of God".

An inscription of the North facade of the gate of Akbar's complex confirms that "the visual metaphors on the Mughal tombs are indeed references to paradise" [8]. "Hail, blessed space happier than the garden of Paradise / Hail lofty buildings higher than the divine throne / A paradise, the garden of which has thousands of Rizwans as servants / A garden of which has thousands of paradises for its land / The pen of the mason of the Divine Decree has written on its court / These are the gardens of Eden, enter them and live forever. (Smith, Akbar's Tomb, pp.31-35 [9]).

In fact, it is clear from the inscription that it is the charbagh, that is the garden, not the tomb, a metaphor of paradise.

### **Akbar' syncretic religion**

The Din-i Ilahi, the Religion of God, was a syncretic religion propounded by Akbar in 1582 AD. Akbar had the intent of merging elements of the religions of his empire, aiming to a reconciliation among the creeds. The elements were primarily drawn from Islam and Hinduism, but some others were also taken from Christianity, Jainism and Zoroastrianism. In fact, Akbar promoted tolerance of other faiths [10]. As told in [11], of the initiation to the Din-i Ilahi which was a secret rite, not many details are known. It seems that it had been usually performed on Sundays, because of the Zoroastrian and Hindu reverence to the Sun. Abul Fazl (1551 - 1602), vizier of Akbar, told that "At the time of initiations some words of advice were given to the disciple: he must not ... [indulge in] sectarian quarrels, but must follow the rule of universal peace with regard to religions; he must not kill any living creature with his own hand and must not flay anything. the only exceptions are in battle and the chase ... Honour the luminaries (the Sun, Moon, etc.) which are manifesters of God's light, according to the degree of each, and recognize the power and the existence of Almighty God at all times and seasons. Be careful indeed that whether in private or in public you never for a moment, forget Him ". The honoring of luminaries is important, and this reinforcing the fact that the Mughal planning of landscape, which we find in the Mughal gardens is also including alignments to sun and moon.

### **The Mughal emperors like the sun**

For the Mughals, their emperors were like the sun. Let us discuss this fact using a very interesting paper, which is explaining the symbolism of the Mughal thrones. The reference [12] is providing a general analysis of the form, decoration and surroundings of the Mughal thrones as the seats of the emperors, regarded to be the "Embodied Suns". Reference 12 is showing, in great detail, how the decoration of the Mughal thrones with solar motives and images of those animals, traditionally believed to be heavenly and solar, was creating the celestial space for the Emperor, as if he were the sun in the universe. As told in [12], the solar symbolism was a leitmotiv of the Mughal Empire, so that the ruler was regarded as the sun. In fact, the Great Mughals traced back their lineage to the "shining" sons of Princess Alanquwa and subsequently back to the sun [12].





**Figure 1:** Nur-ud-din Mohammad Salim, known by his imperial name Jahangir "conqueror of the world", was the fourth Mughal Emperor. Note the aura radiating from his head.

From the Hindu tradition were derived the practices of the Mughal sun worship, which included the ceremony of the darshan, when the emperors appeared in the jharokha [13] at the moment of the sunrise [12]. Another source of the Mughal solar symbolism was an ancient Persian concept of the divine glory. Abul Fazl, vizier and chronicler of Akbar's reign, tells: "Kingship is a light emanating from God, a ray from the sun, the illuminator of the universe, it is the argument of the book of perfection, the receptacle of all virtues". The divine light was visible as an "aura" radiating from "the blessed face of the ruler"; this aura was represented as haloes encircling heads of the monarchs in the Mughal art [12] (see examples Figures 1-3). On the halo surrounding the head of emperors see also [14].

As a consequence, we have that Akbar was "His Majesty the Sun", "The Sun of Mighty Power", "Lamp of the Court of Dominion of Taimur's Dynasty", "Visible God". And the favored wife of Jahangir was "Nur-e-Jahan", which means "The Light of the World". Mumtaz Mahal, the beloved spouse of Shah Jahan, was "The Sun of Modesty" and the Princess Jahanara "The Light of the Imperial Chamber" [12].



**Figure 2:** Portrait of Humayun. Note the aura, the divine effulgence, surrounding the head of the emperor (Image Courtesy Wikipedia)

As told in [12], "The solar symbolism gained a particular importance during accessions and enthronements of the Mughal emperors. Humayun was obsessed by cosmic symbolism and occult sciences, was enthroned in pavilions and tents that were adorned with the zodiac signs and that obviously

imitated heavens for the solar emperor. Undoubtedly celestial connotations were also included in Humayun's famous "Mystic House". It was a building with an octagonal room which housed the imperial jeweled throne". It is possible, as told in [12], that the octagonal form of this throne room echoed the concept of an octagonal alignment of the cosmic space, which was already known to the Turkish ancestors of the Mughals, linked to the eight directions of the world, the four corners of the earth and the four intermediate directions. "The emperor was thus enthroned at the crossing of these cosmic directions, in the center of the universe" [12].

The Reference 12 continues discussing the symbols of sun used in the Mughal Thrones, the sunburst, the parasol, and the peacock. "A peacock was the most important of all solar creatures that feature among the decorative motives on Mughal thrones. ... Peacocks, just as ducks, were associated with paradise, and some Muslim poets, like for example Shams-i-Tabasi, spoke of *tavus-e-sidrat al-muntaha* which was the peacock of the uppermost level of paradise. ... Because of these paradisiac and solar connotations, the peacock was depicted as the custodian of the tree of life and of the solar disc. ... The most famous of all Mughal thrones symbolizing the glory of the dynasty and commonly described as the "heavenly like", that is Shah Jahan's Peacock Throne was also adorned with two jewelled figurines of peacocks" [12]. For more details, the reader is invited to see the paper [12].

### Inscription on a dagger

An important dagger with the blade inscribed to the Emperor Shah Jahan (reg. 1628-1657) is described in [15]. It is interesting for the inscription, because it contains reference to sun and moon, and for the emblem of the parasol depicted on it. Not only on the thrones then, but also on small objects the Mughals were using symbols connected to the sky. The inscription read 'The dagger of the king of kings, the defender of religion and conqueror of the world. The conqueror king, the second Lord of happy conjunction, Shah Jahan, is like the new moon, but out of its shining triumphs, it makes the world shine eternally like the rays of the Sun. Oh God! O the Ever-opener (of all gates)! O the Aider! O the Helper!' [15]. This dagger is a personal a Shah Jahan's personal objects. It contains the Emperor's name, his title, and the place and date of the dagger's manufacture.

Let us note in this inscription how the emperor is like the crescent moon, but, due to his triumphs, he is shining like the sun.



The blade is also depicting the parasol, an emblem found on blades from the imperial army and princes. The parasol signified the "dome of heaven", and which when carried above the head of a ruler, showing that he had an exalted state and his role between God and more ordinary mortals [15].

**Figure 3:** The Jahangir's dream. Mughal emperor Jahangir, on the right, and Shah Abbas, the Safavid ruler of the Persian empire. Note the iconography. They stand on top of the world, on a lion and a lamb, respectively, in peace and harmony. Note the angels holding up the crescent moon and the sun.

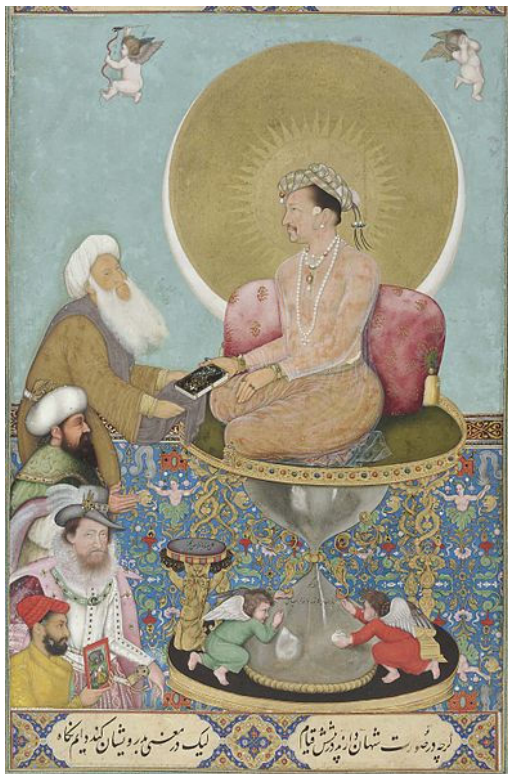
(Image Courtesy: Jungpionier, Wikipedia).

### Divine effulgence

In the Figure 3 we can see a Mughal emperor, Jahangir, and the Safavid ruler of the Persian empire in peace and harmony, in the sun and crescent. Of these two elements, sun and crescent together, we will write in the next paragraph. In the Figure, we can see the head of Jahangir radiating energy. This radiation was the “divine effulgence”, possessed by Mughal emperors (see the Figure 2 for Humayun) .

We find it in a letter of a Persian ruler [16]. Here a part of a letter from the Safavid ruler of Iran, Shah Tahmasb (r. 1524-1576), to his Ottoman rival, Sultan Sulayman (r. 1520-1566) [16].

“Humayun, one of the greatest kings of the world, had five lac [100,000] troops and 12,000 elephants. Then ... he became so vain as claim divine powers. His occasional appearance to the people was described as divine effulgence. In his entire dominion and in his army, the Shari’at was abrogated and heresy and evil prevailed. One day he called a meeting of his notables, soothsayers and astrologers and said he had seen in a dream that the moon, the sun and the stars had come down to the foot of his throne. The soothsayers and astrologers said that the position of the heavenly bodies confirmed the purport of the dream and that the Sultan of Turkey, the Shah of Iran, the rulers of Turan and other kings would soon have to present themselves at his (Humayun’s) and accept his service, and their tenure of sovereignty will depend on his will” [16].



**Figure 4:** Jahangir receiving a mullah. 1620 ca. The artist was Bichitr, an Indian painter during the Mughal period, patronized by the emperors Jahangir and Shah Jahan.

### Sun and crescent moon

Here in the following a very interesting discussion is proposed, discussion which is given in [17]. “In India, after the Moghul conquest, some new iconographic elements were introduced and some styles changed. In particular, Islamic Persian influences are visible. The configuration of sociopolitical symbols underwent a slight modification in that the crescent as a symbol of state was introduced”.



In fact, in the Figure 3, we have noted the sun and the crescent together. Ref.17 is analyzing the image here reproduced in the Figure 4; [17] tells “In this picture the Mughal configuration of the empire, the state and the ruler is depicted, the empire symbolized by a sun radiant, the state by a crescent and the ruler by his image”. According to [17], the sun-and-crescent has its origins in ancient Mesopotamia and was the imperial state emblem of the Seleucid Empire (312-64 BC). Then, for the Mughals, the “symbol of the Empire was a sun. The Indian sun is of variable design. The oldest form, from the first years of the Mughal Empire shows a sun radiant, the rays thin and long. This form is for example on the imperial robes of Humayun ... As a symbol of state we meet the moon, like in many other cultures. The Indian moon is always depicted as a full moon and as a white or silver disc. ... The first Mughal emperors used the crescent as a symbol of State, thereby following the Hellenistic tradition” [17]. The full moon was used as emblem of Mughal governors. “It was displayed on a black circular screen borne behind the ruler. Sometimes it has a corona or is surrounded by stars. The full moon continues a Hindu tradition and was used by Hindu rulers”.

On the Figure 4, let us continue using Ref.18. The artist of the image was Bichitr an Indian painter during the Mughal period, patronized by the emperors Jahangir and Shah Jahan. In [18] it is told that Jahangir was fascinated by Renaissance art. The cupids depicted combine the Western world with the Eastern world. As in Jahangir’s Dream (Figure 3), we once again see that Jahangir’s head is in the center of the sun and the moon; he is the center of the universe and the giver of light. The rulers represented in this miniature are painted in order of importance: Jahangir is obviously the most important.

The sun and the crescent moon together could seem an iconography which is far from the European arts. However, we have them too. In the Figure 5, we can see the woman of the Apocalypse in an illustration of the Hortus deliciarum (c.1180). Another interesting example is Our Lady of Victory (1654), a statue which is showing a crescent moon and solar rays, on the portal of Schlögl monastery church.



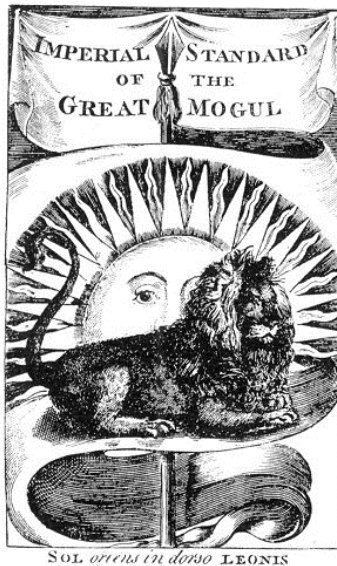
**Figure 5:** The woman of Apocalypse. Note the crescent moon (Image Courtesy Testus, Wikipedia).



In general, the iconography of Middle Ages in Europe used the crescent moon, which was a symbol already used by the late Hellenistic and early Roman period. We can find it on Byzantine coins, and in the Roman coinage, such as on this Hadrian coin.

### Persian Flags

The Mughal Empire had a number of imperial flags and standards. The principal imperial standard of the Mughals displayed a lion and sun. The Mughals traced their use of this flag back to Timur [19]. About the historical Persian flags, it can help us the Encyclopaedia Iranica website [20]. Both the Sun and Golden Lion are symbols of kingship and royalty.



**Figure 6:** An engraving from Edward Terry's *A Voyage to East-India* (1655) titled Imperial Standard of the Great Mogul.

“The sun (imagined as a male) had always been associated with Persian royalty”. It is interesting, in [20], a salutation of a letter from the “Persian king, the Sun of the East,” to the “Roman Caesar, the Moon of the West” and a quote of a hero-king saying: “I have heard from wise men that when the Moon of the Turks rises up it will be harmed by the Sun of the Iranians”. The references continues telling that the “Lion was also a very common symbol of royalty in the ancient and medieval world. Lion hunting scenes are somewhat common in Assyrian reliefs, showing the power of the Assyrian kings over nature. Persia was no different, and neither were the neighboring areas: Islamic, Turkish, and Mongol traditions also stressed the symbolic association of the lion and royalty. ... They likewise reaffirmed the charismatic power of the sun, and the Mongols re-introduced the veneration of the sun especially in its rising phase. As a result of these developments the heraldic use of the lion and sun symbol gained popularity and was extended, appearing on banners as well as on coins and textiles, metalwork, and luster tiles ... Clavijo (pp. 207 f.) describes a palace which Timur had seized from the former Chaghatay khans of Samargand, and states that the lion and sun symbol ornamented the gateway of the main building and the arches around the courtyard.”

### On the moon

As we have seen, references on the role of the sun in the Mughal culture can be easily found. For what concerns the moon, we have seen its role as symbol in the crescent form. Further work is requires to find other references to the moon, to be more specific. In any case, let us consider the words we find in the Ref.21, which is discussing the thought in Islamic India.

The author of [21] is invoking the “Saussure’s basic notion that meaning is created not simply as a result of a sign signifying something, but also through a play of differences and mediations between and among various signs, so that a sign can signify other signs .... For example ‘It might be said that the

moon shows man his true human condition; that in a sense man looks at himself, and finds himself anew in the life of the moon. That is why the symbolism and mythology of the moon have an element of pathos and at the same time consolation, for the moon governs both death and fertility, both drama and initiation. Though the modality of the moon is supremely one of change, of rhythm, it is equally one of periodic returning; and this pattern of existence is disturbing and consoling at the same time – for though the manifestations of life are so frail that they can suddenly disappear altogether, they are restored in the “eternal returning” regulated by the moon’.” Hence the significance of the new moon, and the Eid moon, the idea of the eternal renewal is shared by Muslim and Christian alike [21].

### The moon and the ghosts

For the moon and Mughal emperors, let me conclude with this story that we can find in a fiction book [22], about the Humayun’s Tomb. “The tomb was in a huge garden, with waterways and fountains all round, enclosed by high walls. Hardly anyone visited the tomb at that time of the evening. A couple of caretakers were supposed to be on guard but they used to go home, locking the main gate, afraid of the ghosts of Humayun and other Mughal kings who were known to freely roam the place as soon as the sun went down. It was rumoured that on every full moon night, Babur held a durbar, with all the Mughal kings who had ruled this vast empire for 400 years standing respectfully before him. It was said that they didn’t want outsiders to be present there after dusk” [22]. It is interesting this story, where the ghosts of kings, that during their life were like the sun, are meeting today on full moon.

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Humayun's Tomb seen from Char Bagh  
Courtesy: Udit Kapoor for Wikipedia

## The Solar Orientation of the Lion Rock Complex in Sri Lanka

Amelia Carolina Sparavigna<sup>1</sup>✉

<sup>1</sup>Department of Applied Science and Technology, Politecnico di Torino, Italy

**Abstract** This paper discusses the solar orientation of the archaeological complex of Sigiriya, the Lion Rock, in Sri Lanka. We can see that the axis of this complex is oriented with the sunset of the zenithal sun.

**Keywords:** Satellite Mas, Solar orientation, Archaeoastronomy

### 1. Introduction

Several ancient ceremonial structures are designed to align with the repeating patterns of sun or moon or even stars. We have the Stonehenge megalithic monument for instance, which has alignments with summer and winter solstices, and the Karnak temple in Egypt, aligned again with the sun on solstices [1,2]. Even the gothic cathedrals have a solar orientation [3]. These huge buildings have their axis aligned with the azimuth of the sunrise on a given day of the year, probably the day of their foundation.

At latitudes above the tropical zone, the sun reaches the highest noon altitude on the summer solstice and the lowest one on the winter solstice. In any case, this angle is below 90 degrees. But, when we are in the tropical zone the sun reaches the zenith, that is an altitude of 90 degrees. In this paper, we will show that, besides the alignment with the sunrise and

sunset azimuths on solstices, we can have in the tropical zone, an alignment with the zenithal sun, that is a design of the site with the sunrise or sunset azimuths of the day during which the sun reaches the zenith. An example of this alignment is the Lion Rock complex in Sri Lanka.

### 2. The Lion Rock complex

The ruins of a huge palace built by King Kassapa I (477–495 CE) are on the top of a granite rock, known as Sigiriya, the Lion Rock [4–8]. This site is in the heart of Sri Lanka, dominating the neighboring plateau, inhabited since the 3rd century BC, and hosting some shelters for Buddhist monks [4]. A series of galleries and staircases, having their origin from the mouth of a gigantic lion made of bricks and plaster, provide access to the ruins on the rock. In the Figure 1, it is possible to see the site surrounded by a wall and the rock inside.



**Figure 1** – The Sigiriya complex as we can see in the satellite maps. On the right the Lion Rock

Sigiriya is a unique witness to the civilization of Sri Lanka during the years of the reign of Kassapa [5]. The site is rich of frescoes, which originated a pictorial style used for many centuries. However, the fame of the site is mainly due to the fact that Kassapa

I established his capital there in a fortified palace. After the death of Kassapa, the site of Sigiriya returned to the monks, and then was progressively abandoned.



Amelia Carolina Sparavigna (Correspondence)

d002040@polito.it, amelia.sparavigna@polito.it

+39-011-564-7360



At the summit of the rock, there is the fortified palace with its ruined buildings, cisterns and rock sculptures. At the foot of the rock we find the lower city surrounded by walls. The eastern part of it has not yet been totally excavated. The western aristocratic part of the capital of Kassapa I was embellished by terraced gardens, canals and fountains.

The Gardens of the Sigiriya city are an important characteristic of the site. They are divided into three distinct forms: the water gardens, the cave and boulder gardens, and the terraced gardens [4]. The water gardens are in the central section of the western precinct. They were built according to an ancient garden form, of which they are the oldest surviving examples.

The water gardens are connected with the outer moat on the west and the large artificial lake to the south of the Sigiriya rock. All the pools are also interlinked by an underground conduit network fed by the lake, and connected to the moats.

### 3. Solar orientation

In the Ref.4 it is told that the water gardens are built symmetrically on an east-west axis. In fact, the design of the gardens is symmetrical, however the axis is not oriented on the cardinal east- west line: the site is inclined of 9 degrees, as we can measure from satellite maps (Figure 2).



**Figure 2** – Measurement of the angle using the GIMP compass.

Since this angle is not negligible, it can correspond to a specific azimuth of the sun.

Let us remember that the azimuths are formed by the vector from the observer to the sun rising or setting on the horizontal plane and a reference vector on this plane. There are several web sites that allow knowing the azimuth and the noon altitude of the sun and moon at a specific location on a given day of the year. For instance, one is the site in Ref.9. Using it, we can obtain at Sigiriya, the following data for the noon altitude and sunset azimuths given in the following table. We see that we have the zenithal sun on April 9 and on the First of September.

Date	Noon Altitude	Sunset Azimuth
April 8	89.4°	277.6°
April 9	89.6°	278.0°
April 10	89.5°	278.4°
August 30	88.9°	278.9°
September 1	89.2°	278.2°
September 2	89.1°	278.0°

We have that the azimuth is of 8 degrees with respect the cardinal east-west direction. There is then the difference of one degree with the measured angle of the axis of the gardens.

We can also obtain the data on azimuth and noon altitude from a web site that we have already used in some papers (see for instance Ref.10 and references therein): it is that of Sollumis.com [11]. This site allows drawing on the Google satellite maps some lines which show the direction and height of the sun throughout the day. Thicker and shorter lines mean the sun is higher in the sky. Longer and thinner lines mean the sun is closer to the horizon. Using Sollumis.com for instance, we can easily find solar orientations in the layout of some Chinese Pyramids burial complexes [10].

Let us use Sollumis.com on the site of the Lion Rock. The results obtained are shown in the Figure 3. Here we find a sunset azimuthal angle of 9 degrees with respect the cardinal east-west axis, in agreement with the measured angle (see the Figure 2).



# The orientation of the Kings Knot of Stirling Castle

*Amelia Carolina Sparavigna (Department of Applied Science and Technology, Politecnico di Torino)*

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## Abstract

In the satellite images of Google Earth we can easily see the King's Knot of the Stirling Castle, a knot garden made of earthworks with a geometric layout. Using SunCalc software, which is giving direction of sunrise and sunset on satellite maps, we can study the orientation of this Knot in relation to the apparent motion of the sun.

## The orientation of the King's Knot of Stirling Castle

**Amelia Carolina Sparavigna**

Department of Applied Science and Technology, Politecnico di Torino, Torino, Italy

**Abstract:** In the satellite images of Google Earth we can easily see the King's Knot of the Stirling Castle, a knot garden made of earthworks with a geometric layout. Using SunCalc software, which is giving direction of sunrise and sunset on satellite maps, we can study the orientation of this Knot in relation to the apparent motion of the sun.

**Keywords:** Satellite images, Google Earth, Orientation, SunCalc.

Stirling Castle is one of the most important locations in Scotland, relevant for its position, architecture and history. The castle is atop a hill, in a strong defensive position, so that it was an important fortification to control River Forth until the 1890s. Most of the principal buildings of the castle date from the fifteenth and sixteenth centuries [1]. Stirling Castle had a King's Park enclosed, of which today that part known as King's Knot still exists. In the Figure 1, we can see an image from Google Earth of the castle and of the garden.

The King's Knot is an octagonal stepped mound, standing in a double-ditched enclosure. It survives as a remnant of a wider garden, a description of which is given in the Rotuli Scaccarii Regum Scotorum, that is, the Exchequer Rolls of Scotland [2], Volume VIII, A.D. 1508-1513. At the beginning of XVI Century, the Castle had a "Great Garden" and a "Garden under the Wall". A "new park had been formed for the beasts, probably deer, boars, and the wild cattle which may still be seen in the parks of Cadzow and Chillingham, favourite pets of



James IV, as of other kings. It was in the Great Garden that the Round Table, or elevated plot of ground, sometimes called the King's Knot, had been laid out, of which the outlines may still be seen. Barbour refers to it, but the revival of the Arthurian romance by James IV (1473-1513), gave it a new significance in the chivalric and poetic traditions of Scotland" [2]. Let us remark that this reference gives that the King's Knot was also considered as a Round Table.



Figure 1 – Stirling Castle and its King's Knot as it is shown by Google Earth.

In [3], it is told that the earthworks we see of the King's Knot represent the final form created for Charles I, in 1627-9. In 1625, William Watts was despatched from London to be 'maister gairdiner to his Majestie at the Castell of Stirling' [4]. Probably, it was built for the king's Scottish coronation in 1633 [4-6]. "Viewed from the castle above, James IV had earlier created in the 1490s a landscape of leisure with his park, loch, fish ponds and great garden of fruit trees, flowers and hedges which came close to the garden ideal of the Italian Renaissance" [3]. Let us note that the King's Knot is defined a "knot garden", a garden of very formal geometrical design in a square frame (most Renaissance knot gardens were composed in such a manner [7]). However, as we will see in the following discussion, its layout could have an astronomic meaning too.

The archaeological investigation of the site proposed in [3] is very interesting. In this reference, it is told that aerial photographs taken in 1980, by the Royal Commission for Ancient and Historical Monuments of Scotland, made an important discovery: ditches in a trapezoidal form beneath and around the King's Knot mound suggested that an earthwork monument had preceded it. From the images of the archaeological surveying proposed in [3], it seems that earthworks changed their orientation. Here, we discuss what we can see today in the satellite images. In recent papers (see for instance [8-10]), we have compared the orientation of gardens with the direction of sunrise and sunset on solstices. This is quite easy to do by means of software, such as Sollumis.com or SunCalc.net (the use of this software was proposed in [11]). Software gives sunrise and sunset on satellite maps for any day of the year. In this manner, we observed that the gardens of Taj Mahal have specific orientations to solstices. These Mughal gardens, which had been planned to represent the Earth Paradise, seem being also representing a local horizon coherent with the apparent motion of the sun. Is this also possible for a knot garden? The answer can be positive, having these gardens a geometric layout too.

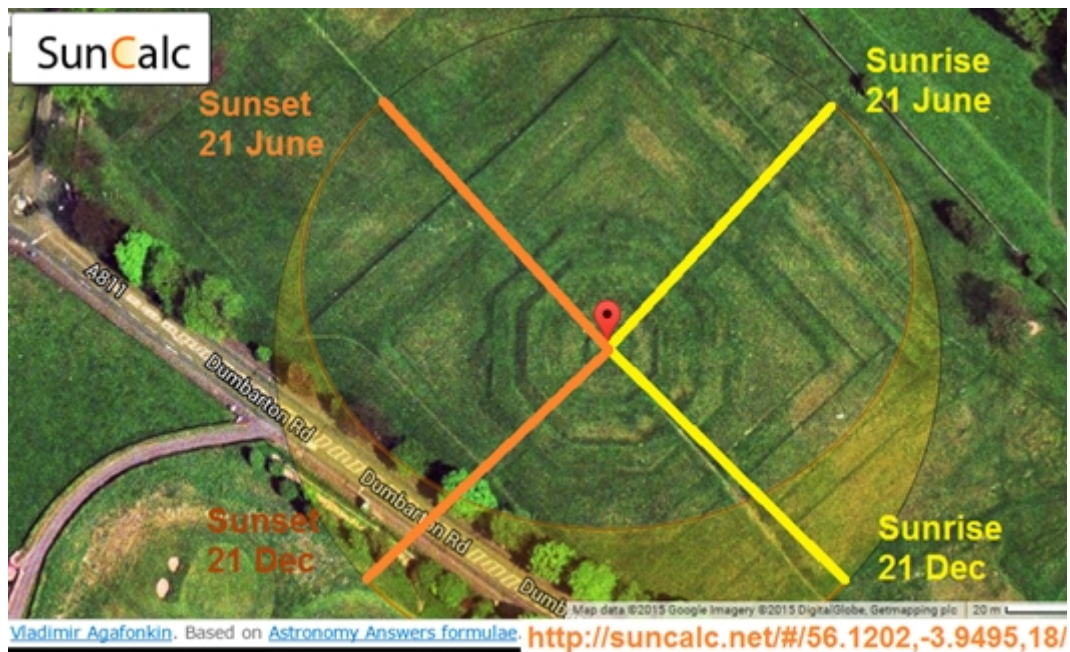


Figure 2 – Result of an analysis with SunCalc.net of the King's Knot.

In the Figure 2, it is shown the result of an analysis with SunCalc.net of the King's Knot. It is interesting that the orientation with the direction of the sunset on solstices is quite good. From the center of the knot, which is the most elevated part of these earthworks, the king could observe the azimuth spanned by sunrise and sunset throughout the year. Then, probably, the orientation of the garden is not accidental, but having an astronomical meaning. Let us conclude, remembering that the layout of this knot has an orientation which looks like that of the Roman Fort of Hardknott, of which we discussed in Ref.12.

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At the north-west side of the part of the Knot shown in the Figure 2, the garden has a layout resembling a giant board of "Nine Men's Morris" game. In Wikipedia ([https://en.wikipedia.org/wiki/Nine\\_Men%27s\\_Morris](https://en.wikipedia.org/wiki/Nine_Men%27s_Morris)), it is told that "giant outdoor boards were sometimes cut into village greens. In Shakespeare's 16th century work A Midsummer Night's Dream, Titania refers to such a board: "The nine men's morris is filled up with mud" (A Midsummer Night's Dream, Act II, Scene I)."



## The King's Knot of Stirling Castle and its astronomical orientation

Amelia Carolina Sparavigna

Department of Applied Science and Technology, Politecnico di Torino, Torino, Italy

**Abstract:** The Stirling Castle is one of the most important castles of Scotland. It is atop of a hill, in a strong defensive position for controlling the River Forth. Below the west side of the castle's hill, there is the King's Knot, a 16th-century formal garden. In the satellite images of Google Earth we can easily see this garden, that today consists of earthworks with a geometric layout. Using SunCalc software, which is a software giving the directions of sunrise and sunset on satellite maps, we can study the orientation of this Knot in relation to the apparent motion of the sun.

**Keywords:** Satellite images, Google Earth, Orientation, SunCalc.

Stirling Castle is one of the most important locations in Scotland, relevant for its position, architecture and history. The castle is atop a hill, in a strong defensive position, so that it was in the past an important fortification used to control River Forth. Most of the principal buildings of the castle date from the fifteenth and sixteenth centuries [1]. The Castle had a King's Park enclosed, of which today that part known as King's Knot still exists. In the Figure 1, we can see a view from Google Earth of the castle and of the garden.

The King's Knot is an octagonal stepped mound, standing in a double-ditched enclosure. It survives as a remnant of a wider garden, a description of which is given in the *Rotuli Scaccarii Regum Scotorum*, that is, the Exchequer Rolls of Scotland [2], Volume VIII, A.D. 1508-1513. At the beginning of XVI Century, the Castle had a "Great Garden" and a "Garden under the Wall". A "new park had been formed for the beasts, probably deer, boars, and the wild cattle which may still be seen in the parks of Cadzow and Chillingham, favourite pets of James IV, as of other kings. It was in the Great Garden that the Round Table, or elevated plot of ground, sometimes called the King's Knot, had been laid out, of which the outlines may still be seen. Barbour refers to it, but the revival of the Arthurian romance by James IV (1473-1513), gave it a new significance in the chivalric and poetic traditions of Scotland" [2]. Let us remark that this reference gives that the King's Knot was also considered as a Round Table, that is, it was built on the site of a medieval jousting arena - (see Appendix) - in imitation of the legendary court of King Arthur [1,3].

In [4], it is told that the earthworks of the King's Knot that we see today represent the final form created for Charles I, in 1627-9. In 1625, William Watts arrived from London to be the 'maister gairdiner to his Majestie at the Castell of Stirling' [5]. Probably, it was built for the king's Scottish coronation in 1633 [5-7]. "Viewed from the castle above, James IV had earlier created in the 1490s a landscape of leisure with his park, loch, fish ponds and great garden of fruit trees, flowers and hedges which came close to the garden ideal of the Italian Renaissance" [4]. Let us note that the King's Knot is defined a "knot garden", a garden of very formal geometrical design in a square frame (most Renaissance knot gardens were composed in such a manner [8]). However, as we will see in the following discussion, its layout could have a link to astronomic alignments too.

The archaeological investigation of the Knot proposed in [4] is very interesting. In this reference, it is told that aerial photographs taken in 1980, by the Royal Commission for Ancient and Historical Monuments of Scotland, made an important discovery: ditches in a trapezoidal form beneath and around the King's Knot mound suggested that a different earthwork monument had preceded it. From the images of the archaeological surveying proposed in [4], it seems that earthworks had a different orientation.



**Figure 1** – Stirling Castle and its King's Knot as it is shown by Google Earth.



**Figure 2** – The garden consists of two parts as shown by the Google Earth image. The south-east part is the King's Knot.





**Figure 3** – The castle and the garden as seen in the Google Earth Street View. Note, on the right, the earthworks of the King’s Knot.

As we can see in the Figure 2, the garden consists of two parts, the south-east one is the King’s Knot. At the north-west side of the Knot, as shown by the image, the garden has a layout resembling a giant board of “Nine Men’s Morris” game. In Wikipedia, about this game, it is told that “giant outdoor boards were sometimes cut into village greens”. In the William Shakespeare’s 16th century work *A Midsummer Night’s Dream*, Titania refers to such a board telling “The Nine Men’s Morris is filled up with mud” (*A Midsummer Night’s Dream*, Act II, Scene I, see Appendix). Then, from the octagonal stepped mound of the Knot, the King could play the game, moving on this giant board his pieces.

Let us consider what we can see today in the satellite images. In recent papers (see for instance [9-12]), we have compared the orientation of gardens with the direction of sunrise and sunset on solstices. This is quite easy to do by means of software, such as *Sollumis.com* or *SunCalc.net* (the use of this software was proposed in [13]). *SunCalc* software gives sunrise and sunset directions on satellite maps for any day of the year. In this manner, we had the opportunity to observe that the gardens of Taj Mahal have specific orientations to solstices. These Mughal gardens, which had been planned to represent the Earth Paradise, seem being also representing a local horizon coherent with the apparent motion of the sun. Is this also possible for a knot garden? The answer can be positive, having these gardens a geometric layout too.

In the Figure 4(a), it is shown the result of an analysis obtained by means of the *SunCalc.net* of the King’s Knot. It is interesting that the orientation with the direction of the sunset on summer solstice is quite good. From the center of the knot, which is the most elevated part of these earthworks, the king could observe the azimuths spanned by sunrise and sunset throughout the year (at least a large part of them, as given by the Figure 5). Then, probably, the orientation of the garden is not accidental, but having an astronomical meaning too. Also for the north-west part of the garden, the layout is showing the same orientation (see Figure 4(b)). Let us conclude, remembering that the layout of this knot has an orientation which looks like that of the Roman Fort of Hardknott, of which we discussed in Ref.14.



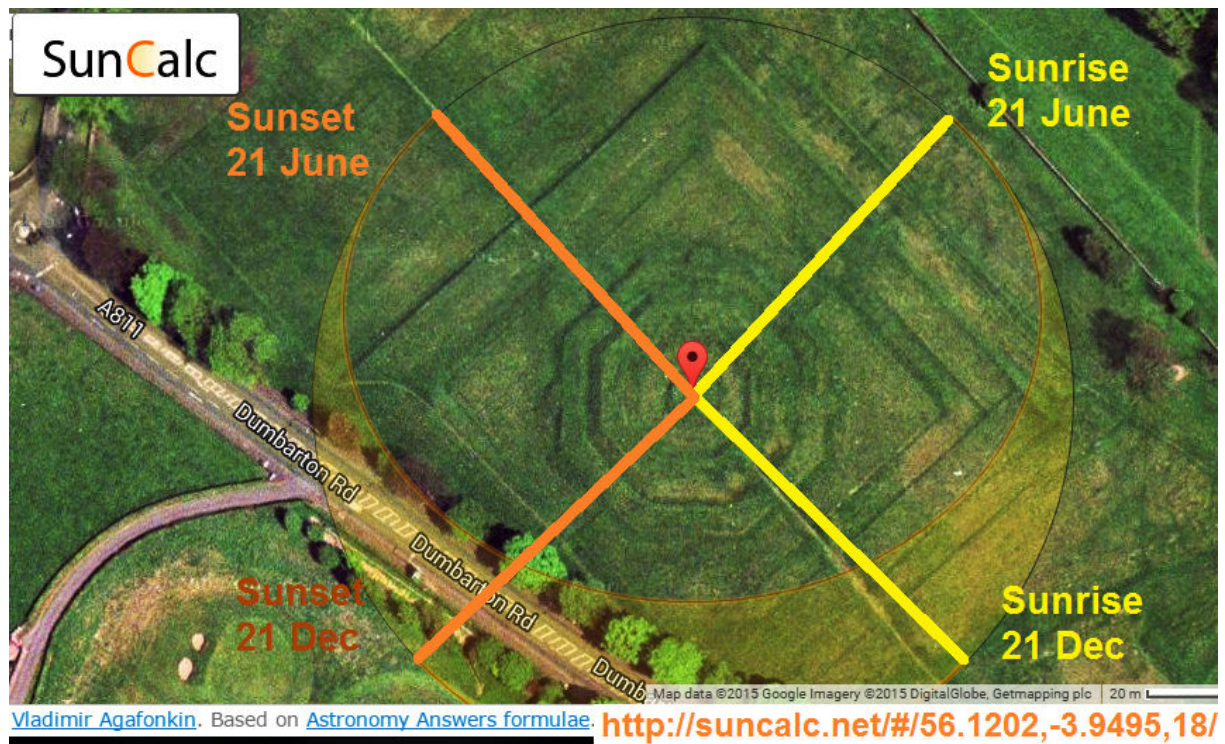


Figure 4 (a) – Result of an analysis with SunCalc.net of the King’s Knot.

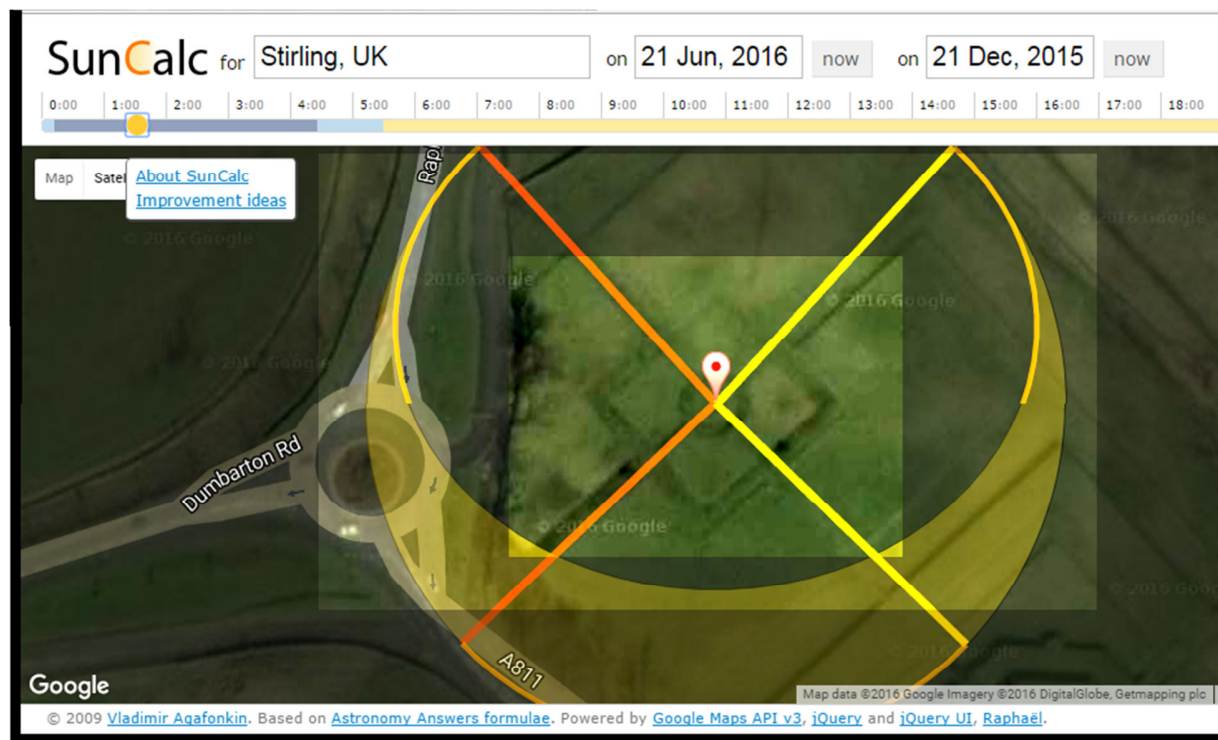
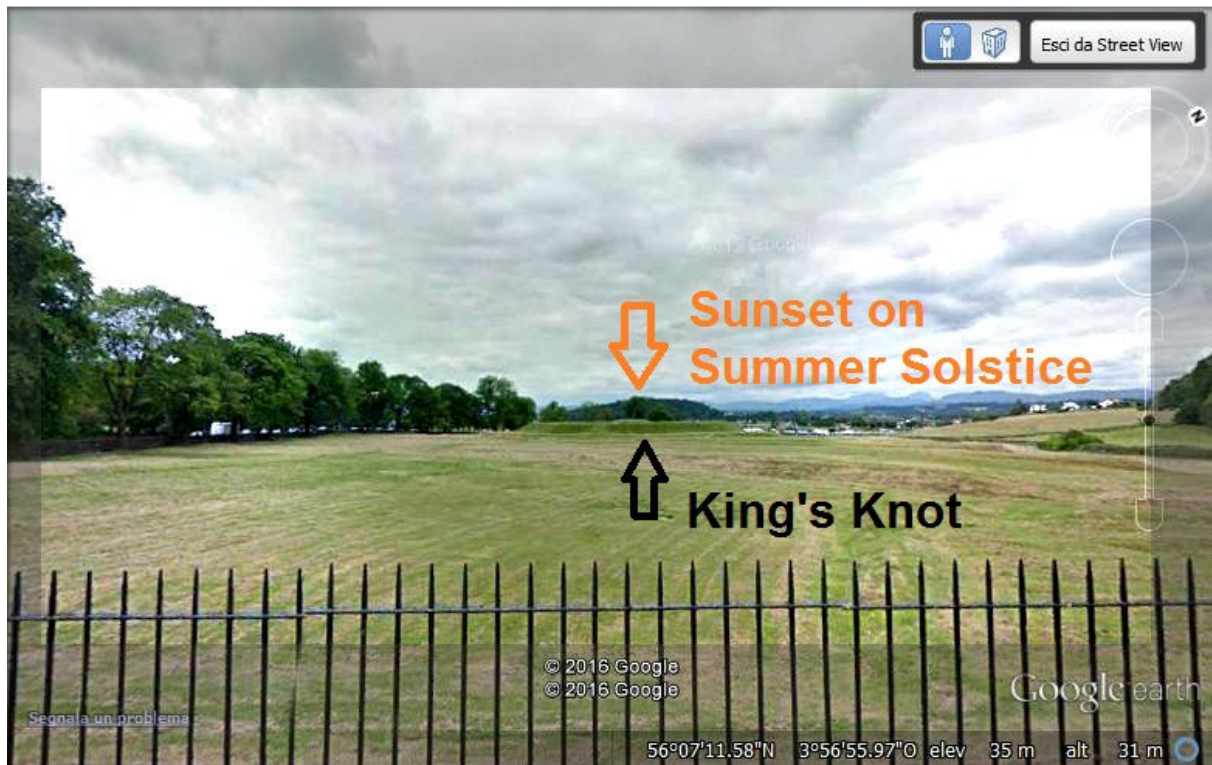


Figure 4 (b) - Orientation of the north-west part of the garden with respect to sunset and sunrise on solstices.



**Figure 5** – The King’s Knot and the direction of sunset on the summer solstice as seen in the Google Earth Street View.

### Appendix – The Round Table

This appendix is reporting the discussion on the Round Table of Ref.3 — “The joust, as a military pastime, is mentioned by William of Malmesbury, and said to have been practised in the reign of king Stephen.<sup>1</sup> During the government of Henry III. the joust assumed a different appellation, and was also called the Round Table game. This name was derived from a fraternity of knights who frequently jousted with each other, and accustomed themselves to eat together in one apartment, and, in order to set aside all distinction of rank or quality, seated themselves at a circular table, where every place was equally honourable. Athenaeus, cited by Du Cange, says, the knights sat round the table, bearing their shields at their backs : I suppose for safety sake. Our historians attribute the institution of the round table to Arthur, the son of Uter Pendragon, a celebrated British hero, whose achievements are so disguised with legendary wonders, that it has been doubted if such a person ever existed in reality. In the eighth year of the reign of Edward I, Roger de Mortimer, a noble man of great opulence, established a round table at Kenilworth, for the encouragement of military pastimes; where one hundred knights, with as many ladies, were entertained at his expense. The fame of this institution occasioned, we are told, a great influx of foreigners, who came either to initiate themselves, or make some public proof of their prowess. About seventy years afterwards Edward III erected a splendid table of the same kind at Windsor, but upon a more extensive scale. It contained the area of a circle two hundred feet in diameter; and the weekly expense for the maintenance of this table, when it was first established, amounted to one hundred pounds ; which, afterwards, was reduced to twenty pounds, on account of the large sums of money required for the prosecution of the war with France. This receptacle for military men gave continual occasion for the exercise of arms, and afforded to the young nobility an opportunity of learning, by the way of pastime, all the requisites of a soldier. The example of king Edward was followed by Philip of Valois, king of France, who also instituted a round table at his court, and by that

means drew thither many German and Italian knights who were coming to England. The contest between the two monarchs seems to have had the effect of destroying the establishment of the round table in both kingdoms, for after this period we hear no more concerning it. In England the round table was succeeded by the Order of the Garter, the ceremonial parts of which order are retained to this day, but the spirit of the institution ill accords with the present manners” [3].



**Figure 6** - A 13th century illustration in Libro de los juegos of the game being played with dice  
(Courtesy Wikipedia)

### **Appendix – Nine Men’s Morris**

This appendix is reporting the discussion on the Nine Men’s Morris from Ref.3. — “Merelles, or, as it was formerly called in England, nine men's morris, and also five-penny morris, is a game of some antiquity. Cotgrave describes it as a boyish game, and says it was played here commonly with stones, but in France with pawns, or men, made on purpose, and they were termed merelles; hence the pastime itself received that denomination. It was certainly much used by the shepherds formerly, and continues to be used by them, and other rustics, to the present hour (1800). But it is very far from being confined to the practice of boys and girls. The form of the merelle-table, and the lines upon it, as it appeared in the fourteenth century, is given upon plate thirty-three; and these lines have not since been varied. The black spots at every angle and intersection of the lines are the places for the men to be laid upon. The men are different in form or colour for distinction sake; and from the moving these men backwards or forwards, as though they were dancing a morris, I suppose the pastime received the appellation of nine men's morris; but why it should have been called five-penny morris, I do not know. The manner of playing is briefly this: two persons, having each of them nine pieces, or men, lay them down alternately, one by one, upon the spots; and the business of either party is to prevent his antagonist from placing three of his pieces so as to form a row of three, without the intervention of an opponent piece. If a row be formed, he that made it is at liberty to take up one of his competitor's pieces from any part he thinks most to his own advantage; excepting he has made a row, which must not be touched if he have another piece upon the board that is not a component part of that row. When all the pieces are laid down, they are played backwards and forwards, in any direction that the lines run, but only can move from one spot to another at one time: he that takes off all his antagonist's pieces is the conqueror. The rustics, when they have not materials at hand to make a table, cut the lines in the same form upon the ground, and make a small hole for every dot. They then collect, as abovementioned, stones of different forms or colours for the pieces, and play the game by depositing them in the holes in the same manner that they are set over the dots upon the table. Hence Shakespeare, describing the effects of a wet and stormy season, says: The folds stand empty in the drowned field, And crows are fatted with the murrain flock, The nine men's morris is filled up with mud” [3].



As told in Wikipedia - [https://en.wikipedia.org/wiki/Nine\\_Men%27s\\_Morris](https://en.wikipedia.org/wiki/Nine_Men%27s_Morris) - one of the earliest mentions of such game can be found in Ovid's *Ars Amatoria*. Ovid wrote: "There is another game divided into as many parts as there are months in the year. A table has three pieces on either side; the winner must get all the pieces in a straight line". According to [15], the game was probably well known by the Romans, who were introduced to it via trade routes. An old combined Nine Men's Morris and chess table. In the Figure 6 we can see a medieval illustration of the game.

**Note:** A previous version of this paper was proposed in [16].

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## Winter Solstice and Lunar Standstills in the Gardens of Villa d'Este

Amelia Carolina Sparavigna

Department of Applied Science and Technology, Politecnico di Torino, Torino, Italy

**Abstract:** The gardens of Villa d'Este are a masterpiece of the Italian Garden style. The villa and the gardens were created by the Cardinal Ippolito II d'Este, Governor of Tivoli, in the remarkable context of Tivoli itself, which includes the ruins of the ancient roman Villa Adriana. The Cardinal charged the architects Pirro Ligorio and Giovanni Alberto Galvani of the planning of his new monumental complex. In particular, Ligorio planned the gardens. In their layout, the architect largely used the mythological iconography, to which he added also an allusion to an astronomical event, the winter solstice. In fact, the orientation of an axis of the gardens is along the direction of the sunset on this solstice. In a subsequent rearrangement of the lower part of the gardens, another astronomical reference was also incorporated. It is a reference to the major and minor standstills of the moon about the winter solstice.

**Keywords:** Satellite images, Google Earth, Orientation, SunCalc.

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The gardens of Villa d'Este are a masterpiece of the Italian Garden style, included in the UNESCO world heritage list [1]. The gardens are framed by the remarkable context of Tivoli itself, which includes the important ruins of the ancient roman Villa Adriana. The Cardinal Ippolito II d'Este, Governor of Tivoli from 1550, was the person that wanted to recreate the splendour of the Villa Adriana in a valley known as Valle Gaudente. It was after 1560 that his architectural and iconographic program was planned by the architect and archaeologist Pirro Ligorio, and realized by the court architect Giovanni Alberto Galvani.

Ligorio (1510-1583) was an architect and a specialist in antiquity. He was born into a patrician family of Naples. He moved to Rome in 1534, working as a painter for the decoration of several palaces. At the same time, he began to write an ambitious work on antiquity. The first Ligorio's publication on this subject was *The Book of Circi, Theatres and Amphitheatres* [2]. He also prepared some maps of ancient Rome and a study of Villa Adriana [3]. From 1550, he entered the services of Ippolito II d'Este, accompanying the Cardinal to Tivoli. While the Cardinal spent his office of governor, Ligorio studied the local remains of old villas and temples. After 1560, the architect served as consultant for a planning of Villa d'Este in the framework of the iconography of ancient Rome. Besides Ligorio, the Cardinal had also Giovanni Alberto Galvani, who served as the main architect of the Villa, but Ligorio was the person who took charge of the villa's gardens [4].

Using Ligorio's knowledge of aqueduct engineering, the gardens were planned rich of waterworks and fountains, as well as of a collection of ancient sculpture. In the Figure 1, we can see a Google Earth image of the gardens. The elevation profile shows that the gardens are made by a series of terraces on the slope of the hill. In the Figure 2, the elevation profile of one of the terraces, the lower garden, is given too.

As described in [5] by David Coffin (Ligorio's most prominent biographer [4]), Pirro Ligorio employed three major themes in the gardens. First, the architect linked nature and art, so that

several of his waterworks and sculptures incorporated representations of flora and fauna. The second theme was geographic, with references to the local places. For instance, in the Fontana dell'Ovato of the upper garden, we find the representation of the falls of Tivoli and of the three rivers, Aniene, Erculaneo and Alburno, flowing into the Fountain of Rome, which represents the river Tevere. Finally, Ligorio used the mythological iconography, to create in the Villa of Ippolito d'Este a new Garden of the Hesperides. Many statues, some of them being original ancient statues, emphasized the mythological iconography.

From the 18<sup>th</sup> century, due to lack of maintenance, it started the decay of Villa d'Este and its gardens were slowly abandoned. The waterworks fell into ruin, and, the collection of ancient statues of the Cardinal Ippolito was disassembled and scattered [1]. This state of decay continued until the middle of the 19<sup>th</sup> century, when another cardinal launched a series of works of restoration. This Cardinal was Gustav Adolf von Hohenlohe Schillingfürst [6], who obtained the tenure of the villa from the Dukes of Modena. Between 1867 and 1882, the Villa became a cultural center where the Cardinal frequently hosted Franz Liszt [1]. In 1919, the villa became a property of the Italian State.

Let us consider again the gardens of Villa d'Este. If we observe the Figures 1 and 2, we can see that the gardens have axes oriented along NNW and WSW directions. This is in agreement to what Antonio Del Re told in his book of 1611 on the orientation of the monumental complex [7]: “Il Sole piglia la facciata, ovvero prospettiva principale verso Tramontana & Circio suddetti nel tempo del Solstizio estivo da Levante a Ponente; ma nel Solstizio hiemale (invernale) non lo prende da Levante, ma si bene alquanto da Ponente.” [8] The main view of the monumental complex is oriented about a NNW direction, that is, “verso Tramontana and Circio.” (Figure 3). Antonio Del Re is observing that, during the summer the sun hits this main view of the villa from Levante (sunrise) and Ponente (sunset). However, on the Winter Solstice, only the sunset hits the façade. If we use the SunCalc.net software, which is giving the directions of sunrise and sunset on a satellite image, we can easily verify what Del Re told. By SunCalc.net we prepared the image in the Figure 4, which is clearly illustrating the orientation of the façade of the villa.

Using this same software, we have that one of the axes of the gardens that we see in the Figures 1 and 2 is almost coincident to the azimuth of the sunset on the winter solstice (Figure 5). Therefore, it seems reasonable that, after surveying the local profile of the Valle Gaudente, Ligorio decided this specific orientation, along the direction of the sunset on the winter solstice, for his gardens. We can also use the Sollumis.com software, to have the result given in the Figure 6; we can see the directions of the sun throughout the day of the winter solstice and note easily the azimuth of the sunset coincident to the axis of the lower garden. Moreover, using Street View in Google Earth (as given in the Figure 7), we can also imagine how it would be the sunset on the winter solstice. Note the belvedere at the end of the perspective. From this belvedere, an observer has an unobstructed view of a large part of the horizon.

In the lower garden, it is possible to find another reference to an astronomical event. This event is the lunar standstill. In the image of the Figure 6 we can see two “sweating” fountains. They were made as the “Meta Sudans,” a famous fountain built by Emperor Domitian near the Colosseum and the Arch of Constantine. “Sudans” means sweating because the water flows on the surface of a natural rock as sweating from it. As told by Wikipedia, in the item on Villa d'Este (in English), these fountains were designed in 1568-1569 by Tomasso da Como; the two “Metae” were originally intended for being the giant guardians of the garden. These “Metae” were not executed until the second half of the 17<sup>th</sup> century, when they were set up in the garden.



In the 16<sup>th</sup> century the lower garden was quite different from that we see today. The center of the garden was divided into sixteen large squares, with a pergola in the center of each section (see the Figure 8). The main paths dividing the garden were covered with trellises. In the center of the garden, there was a large wooden pavilion, which contained four small fountains. The pergolas and pavilion were demolished during the beginning of the 17<sup>th</sup> century [6], and replaced by the Rotunda of the Cypresses, a circular alley, which originally contained sixteen cypress trees [9]. The “Metae Sudantes”, such as the Rotunda, can be seen in an engraving of 1685 by Giovanni Francesco Venturini [9], that we give the Figure 9.

If the axis of the garden represents the direction of the sun on the winter solstice, the two fountains could be used to represent the “guardians” of the apparent motion of the sun, and therefore, to represent the direction of the southern moonset on minor and major lunar standstills. Let us remember that the apparent behaviour of the moon is more complex than that of the sun. The sunrise direction oscillates between the solstitial positions during a year, whereas the moon does the same during a nodal period (about 27 days). Moreover, the moon has a period – the lunar standstill period (18.613 years) – on which the values of the extremal directions (standstills) are changing. In this manner, there are major and minor standstills. The direction of the sunrise or sunset on the solstice is between these two extremal directions of moonrise or moonset. Therefore, in the case of the lower garden of Villa d’Este, if its axis is representing the sunset direction on the winter solstice, it is possible that we can find in the garden two directions representing the moonset on major and minor lunar standstills too.

Using the Photographer’s Ephemeris (TPE) software, we can have, besides the direction of sunrise and sunset, also the directions of moonrise and moonset on a satellite image. In the Figure 10, we show the use of TPE for the lower garden with the reference point coincident to the Rotunda of the Cypresses. The blue directions are the southern azimuths of moonset on the minor lunar standstill (upper panel) and on the major lunar standstill (lower panel). The blue lines are passing where there are the two “Metae.” In this manner, these fountains are representing the “guardians” of the sunset on winter solstice.

After the use of software and satellite images, we can conclude that Ligorio determined the orientation of the gardens considering the direction of sunset on the winter solstice. In the following century, in a subsequent rearrangement of the lower part of the gardens, a reference to the major and minor lunar standstills was added too, by means of the positions of the two “Metae Sudantes” with respect to the Rotunda of Cypresses. Let us note that, besides the gardens of Villa d’Este, other gardens have astronomical references to the apparent motion of sun [10-14]. Of these gardens, those of the Taj Mahal are remarkable because they are showing alignments to both sunrise and sunset on solstices. Moreover, the mausoleum itself is showing alignments along moonrise and moonset directions on a minor lunar standstill [14].

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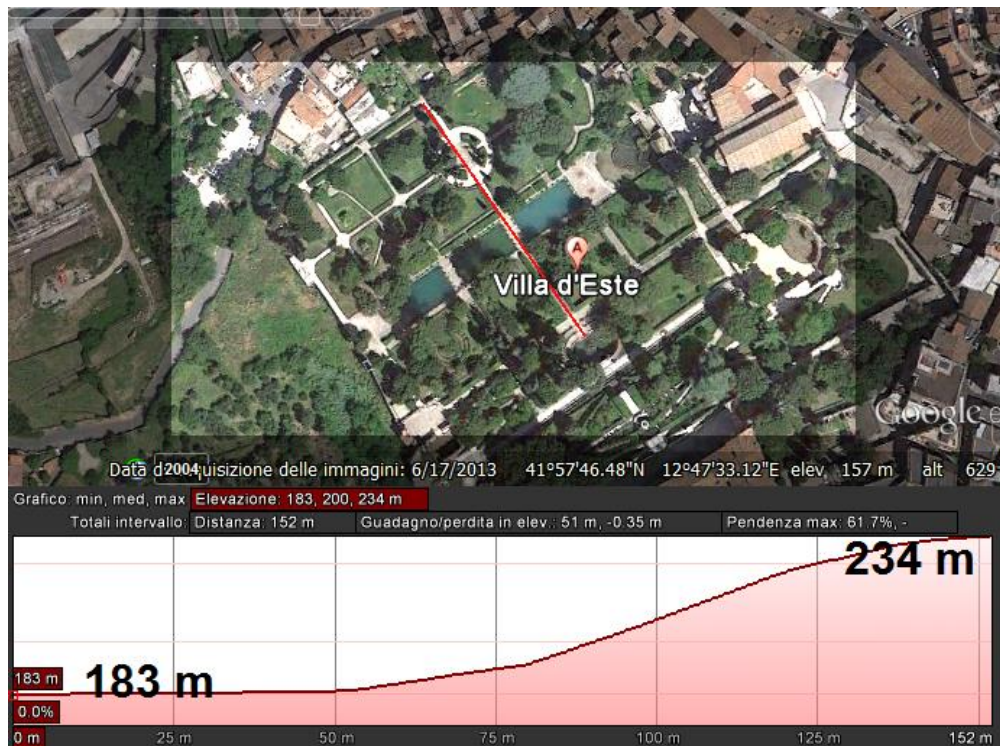


Figure 1: The gardens of Villa d'Este and the elevation profile, along the red line, from Google Earth. The gardens are made of several terraces built on the slope of the hill.

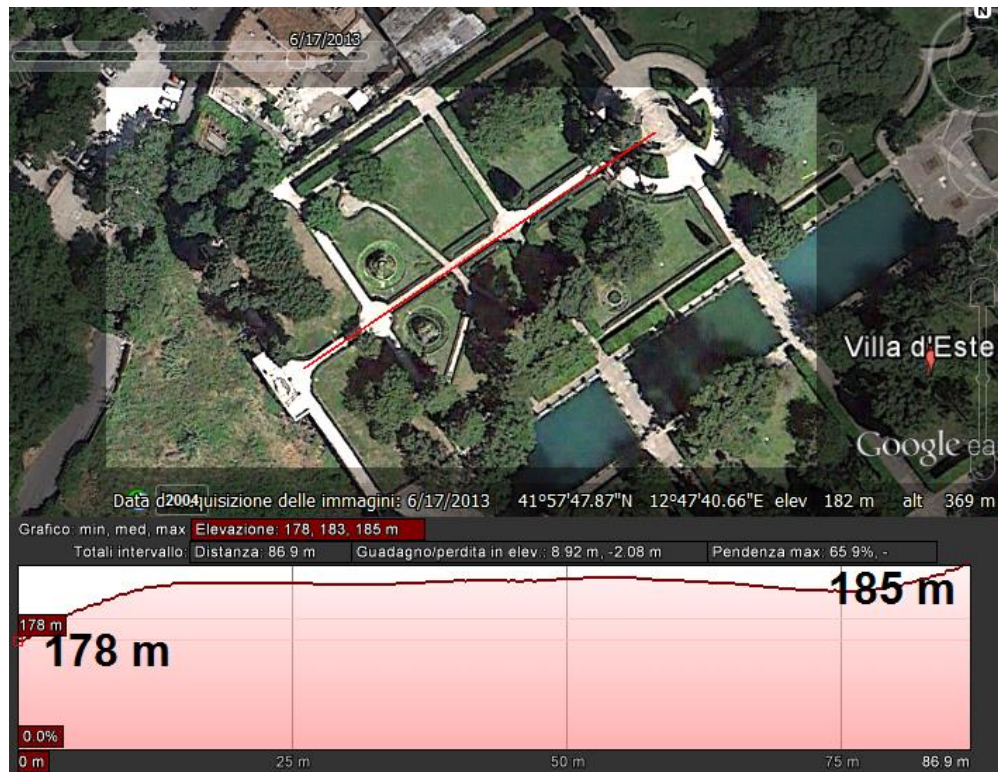


Figure 2: The elevation profile, along the red line, of the terrace of the lower garden (Courtesy: Google Earth).



Figure 3: Antonio Del Re told in his book of 1611: “Il Sole piglia la facciata, ovvero prospettiva principale verso Tramontana & Circio suddetti nel tempo del Solstizio estivo da Levante a Ponente; ma nel Solstizio hiemale (invernale) non lo prende da Levante, ma si bene alquanto da Ponente.” [7] Circius designs to the Romans a WNW wind, whereas Tramontane is the northern wind. Then, these two winds combined together give a NNW direction.



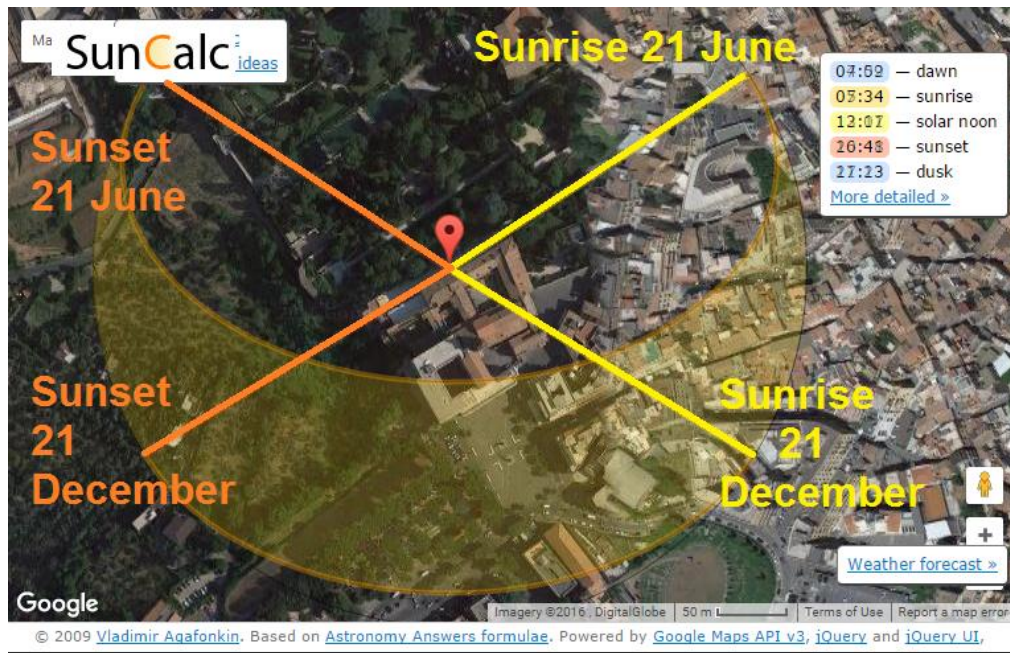


Figure 4: Courtesy SunCalc.net, we have the possibility to see what Antonio Del Re told in his book of 1611 [7], that is, that the sun hits the façade of the villa, which is oriented to Tramontana and Circio, NNW, on sunrise and sunset during the summer. On the winter solstice, the sun hits the façade only on sunset. The directions of sunrise are given by the yellow lines and those of sunset by the orange lines.

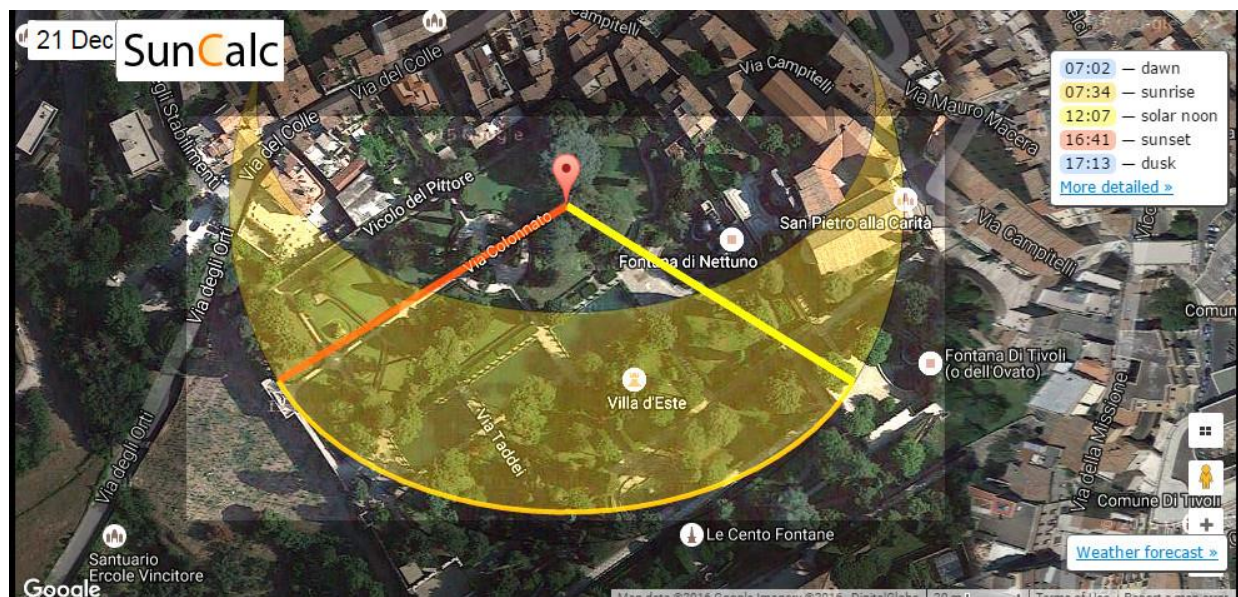


Figure 5: Using SunCalc.net we can see the direction of sunrise (yellow line) and sunset (orange line) on the satellite image. Here it is shown the sun on the winter solstice.



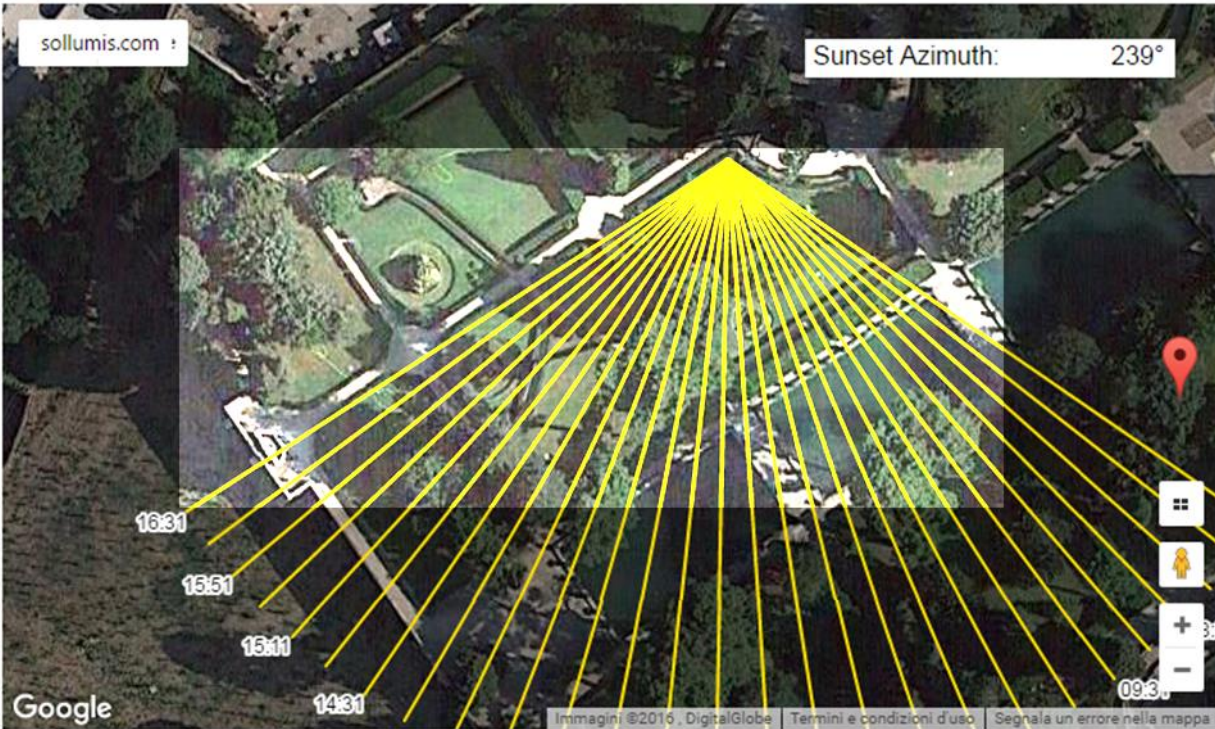


Figure 6: Using Sollumis.com we can see the direction of the sun during the day of the winter solstice, at some given hours. Note the direction of the sunset and the axis of the garden.



Figure 7: Using Street View in Google Earth we can imagine how it would appear the sunset on the winter solstice. Note the belvedere at the end of the perspective. In the image we can also see two “sweating” fountains, the giant “guardians” of the garden.



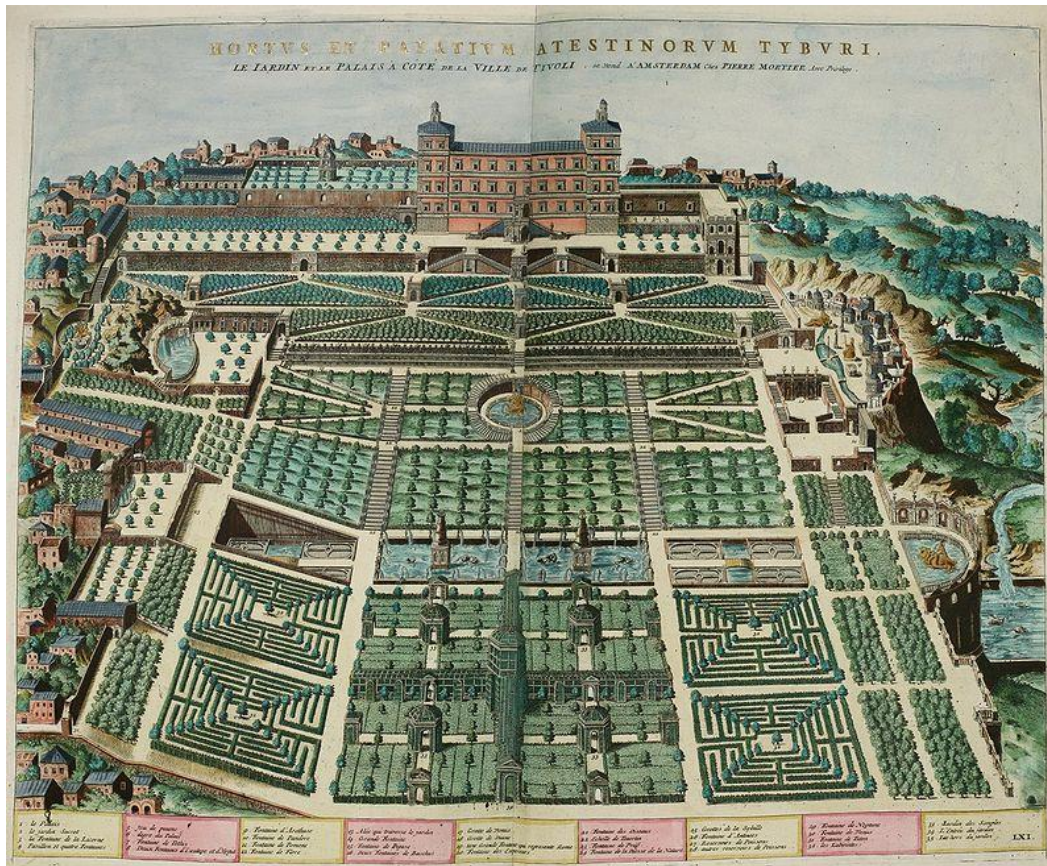


Figure 8: The gardens of Villa d'Este in the XVI century, in a bird's-eye view made by Étienne Dupérac, 1560-1575 (Courtesy Wikipedia). Note the belvedere of Figure 7 at the right end of the lower garden.



Figure 9: The “Metae Sudantes” in an engraving of 1685 by Giovanni Francesco Venturini (1650–1710). Note the rotunda of the Cypresses [9].



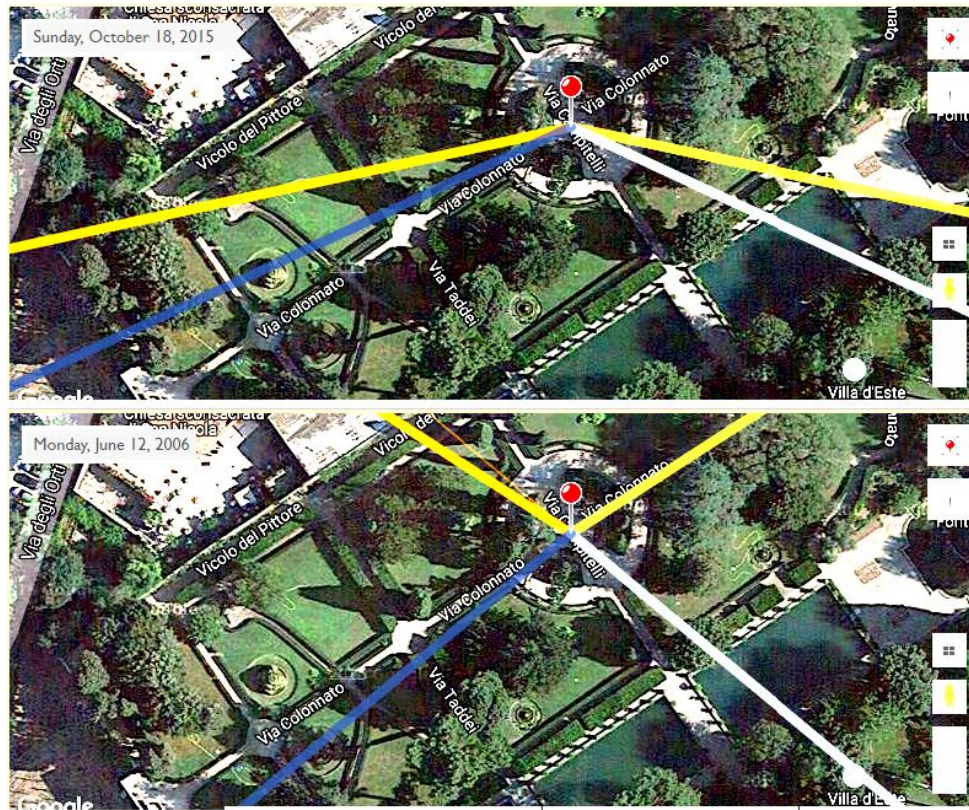


Figure 10: The Photographer's Ephemeris (TPE) is a software giving, besides the direction of sunrise and sunset, also the directions of moonrise and moonset. We use the reference point shown in the images, coincident to the center of the Rotonda of the Cypresses; the blue directions are the southern azimuths of moonset on a minor lunar standstill (upper panel, October 2015) and on a major lunar standstill (lower panel, June 2006). The blue lines are passing where there are the two "sweating" fountains, the "guardians" of the garden.



Courtesy: Yair-haklai for Wikipedia



## The Garden of Vignanello and the Summer Solstice

Amelia Carolina Sparavigna

Politecnico di Torino

**Abstract:** In this article we will discuss the Garden of the Ruspoli Castle in Vignanello, which is one of the best extant examples of Renaissance garden. It was designed by Ottavia Orsini probably at the beginning of the seventeenth century. The garden has a beautiful geometric parterre composed of twelve plant beds. From the parterre an avenue originates having an astronomical orientation. In fact, the avenue is aligned along the direction of the sunrise on the summer solstice. It is possible that the twelve plant beds of the parterre had been created to represent the months of the year.

**Keywords:** Architecture of Gardens, Satellite Images, SunCalc Software.

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The Ruspoli Castle, originally Rocca Marescotti, is a sixteenth-century fortress which is located in Vignanello, in the province of Viterbo. The castle, which is owing its name to the Ruspoli family since 1704 [1-3], is famous for its garden, one of the best preserved examples of the gardens of Renaissance. The garden was created in the early seventeenth century by Ottavia Orsini, daughter of Julia Farnese and Vicino Orsini, the person that created the Bomarzo gardens [4]. Octavia, who married Marcantonio Marescotti in 1574 and took care of the management of castle since 1579, wanted to leave in the parterre of the garden a sign of the Orsini family. "The hedges are composed in a manner to draw, with symbols and emblems, the rose of Orsini's family and the initials of the names of her two sons" [3]. Actually, the garden was commissioned by Alfonso Marescotti and his wife Giulia Baglioni in the second half of the sixteenth century [4], but its final completion was made in the period during which the castle was ruled by Ottavia Orsini.



Figure 1: The castle and the garden. In this image from Google Earth we can see also the bridge connecting the castle to the garden (Courtesy: Google Earth).



As mentioned in the article written by Antonio Rocca [3], the garden of Ottavia Orsini is creating a powerful and suggestive contrast between the "intimate dimension of the garden" and the "angular ramparts of the fortress" (Figure 1). In fact, as suggested elsewhere [4], the castle is an excellent example of how the changes introduced during sixteenth century in the construction techniques of the fortresses actually served for the building of "a sumptuous palace, designed with substantially residential purposes "[4]. In the Rocca Marescotti, the new military architecture that was developed in Italy right in the sixteenth century to resist the invading armies armed with guns [5], is operated and accomplished with a remarkable result of "sobriety and formal elegance" [3].

The castle is connected by a bridge to the garden, which is surrounded by a wall (Figure 1). The garden was already in its present form in 1656, as we can see from an inventory of the goods of the castle. In the inventory, it appears as split in the parterre, called the "giardino di verdura", in the secret garden, and in Barchetto and Barco. The parterre is the portion of the garden which is best preserved. It is divided by into twelve sections, with a central monumental stone pool (Figure 2) [4,6]. In the Barco, which is surrounded by a wall too, there is the "peschierone" that we can see in the Figure 3 [6].



Figure 2: The parterre and the secret garden (Courtesy: Google Earth).



Figure 3: The "peschierone" is on the right of the image (Courtesy: Google Earth).



As explained by Sofia Varoli Piazza in [6], the date which suggests the presence of the garden in its current location is a plaque on the portal of the Palace, located on-site during the construction of the bridge leading from the fortress to the garden. The plaque tells that the bridge was built by Ottavia Orsini in 1611. In the Reference [6] it is also noted that the construction of the garden on the ridge of Vignanello hill required some earthworks, necessary to create the plant beds. The secret garden is set at a lower level, southward oriented. Barchetto and Barco have a more irregular layout, to follow the features of the place [6]. Finally, the castle possesses, "in a direct continuity with the garden", the Marescotta estate, which occupies the land at the north-east of the castle [6]. The design of the parterre (Figure 4), as we have already mentioned, is subdivided into twelve parts, the frames of which are made of different types of plants. The boxwood hedges are used to make the drawings inside the frames, including the initials of Ottavia Orsini and of her sons, Sforza and Galeazzo [6]. The boxwood hedges were also used to create the compartments in the Orchard in the Marescotta estate. This estate was placed in a direct continuity with the garden, in "a system of vegetable garden - orchard garden, that existed in the gardens of earlier periods "[6].



Figure 4: The parterre seen from the castle (Courtesy, Tao Ruspoli, Wikipedia).

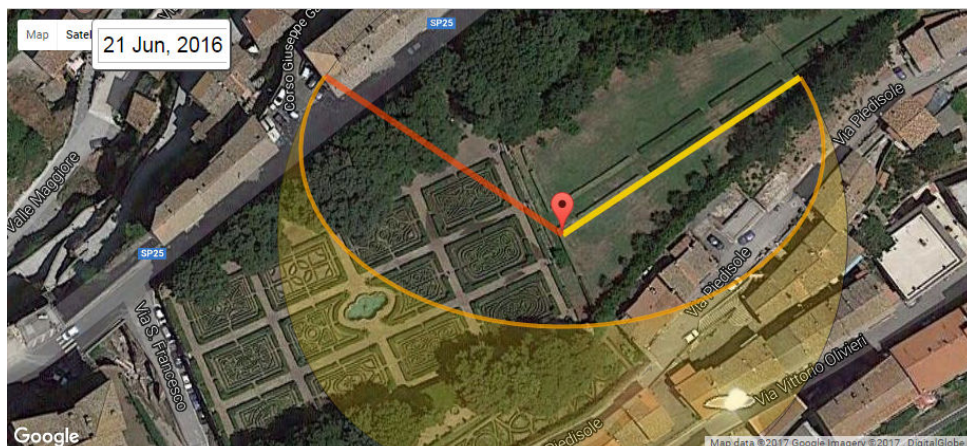


Figure 5: Using the SunCalc.net software, we can see the direction of sunrise and sunset on every day of the year, represented by the yellow and red straight-lines drawn on a satellite image. In the case of the garden avenue, leading from the parterre to the Marescotta estate, we have a perfect coincidence with the direction of the sunrise on summer solstice (Courtesy: SunCalc.net).

As we can see from the Figure 4, an avenue stretches from the parterre, moving towards the East part of the garden and running down to the Marescotta estate. As shown by the satellite images, it follows the ridge of the hill of Vignanello. This avenue has an interesting feature: it has an astronomical orientation. Using SunCalc.net software (as in Figure 5), a software that shows the direction of the sun at sunrise and sunset on every day of the year, we can see that the avenue leading from the parterre to the Marescotta estate is aligned along the direction of the sunrise on summer solstice. The following figure, (Figure 6), shows that the alignment exists for the whole length of the avenue. Along with the twelve flower beds of the parterre that could represent the twelve months of the year, this alignment means that the layout of the garden also contained some references to the motion of the sun and to the seasons of the year. Alignments along sunrise and/or sunset on summer or winter solstices are observed in other gardens, as discussed in the articles at the following references [7-14].

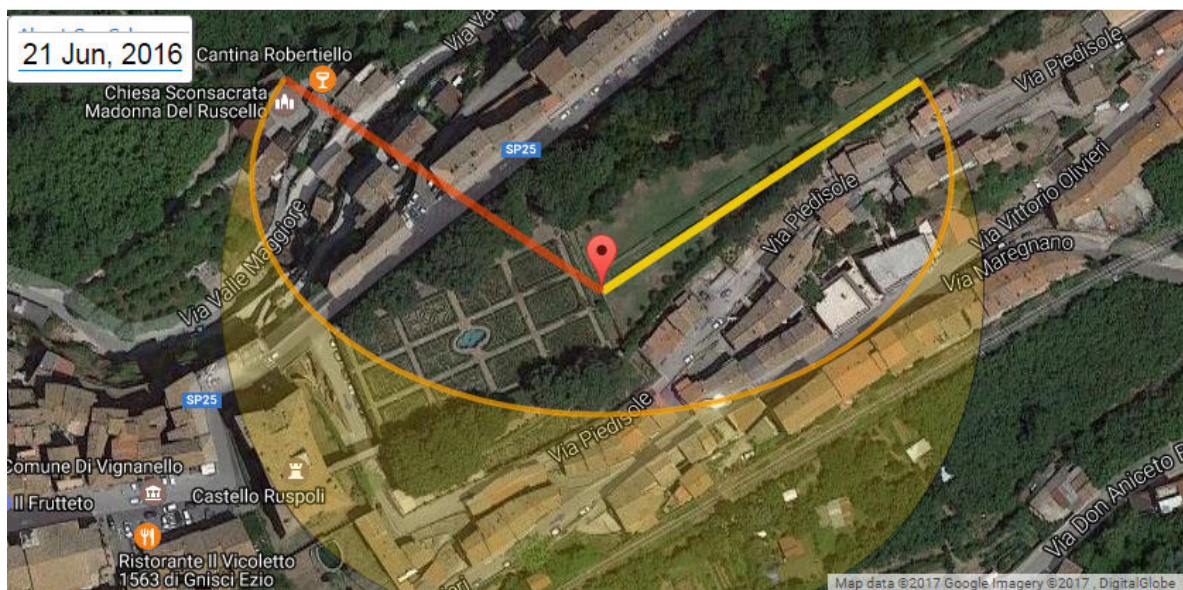


Figure 6: The alignment with respect to the summer solstice exists for the whole length of the avenue, such as shown by SunCalc.net.

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# Il Giardino di Vignanello e il Solstizio d'Estate

Amelia Carolina Sparavigna

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# Il Giardino di Vignanello e il Solstizio d'Estate

Amelia Carolina Sparavigna

Politecnico di Torino

**Abstract:** In questo articolo discutiamo il Giardino del Castello Ruspoli a Vignanello, uno dei migliori esempi ancora esistenti di giardino Rinascimentale. Esso venne realizzato da Ottavia Orsini all'inizio del diciassettesimo secolo. Il giardino ha un bellissimo parterre geometrico di dodici aiuole da cui si origina un viale che presenta un'orientazione astronomica. Il viale è infatti allineato col sorgere del sole al solstizio d'estate. Le dodici aiuole del parterre potrebbero essere state create per rappresentare i dodici mesi dell'anno.

**Keywords:** Architettura dei Giardini, Immagini Satellitari, SunCalc Software.

Il Castello Ruspoli, in origine Rocca Marescotti, è una fortezza del sedicesimo secolo che si trova a Vignanello, in provincia di Viterbo. Il castello, che porta il nome della famiglia Ruspoli dal 1704 ([1-3] ed Appendice), è famoso per il suo giardino, uno degli esempi meglio preservati di giardino rinascimentale.

Il giardino venne creato all'inizio del diciassettesimo secolo per volere di Ottavia Orsini, figlia di Giulia Farnese e Vicino Orsini, il committente dei giardini di Bomarzo [4]. Ottavia, che aveva sposato Marcantonio Marescotti nel 1574 e si curava della gestione del castello di Vignanello già dal 1579, volle lasciare nel parterre del giardino un segno del casato paterno: "le siepi sono infatti composte in modo tale da disegnare, in sigle ed emblemi, la rosa simbolo degli Orsini e le iniziali dei suoi due figli" [3]. In realtà, il giardino era stato commissionato da Alfonso Marescotti e dalla moglie Giulia Baglioni nella seconda metà del sedicesimo secolo [4], ma la realizzazione del giardino si protrasse nel periodo in cui il castello era retto da Ottavia Orsini.



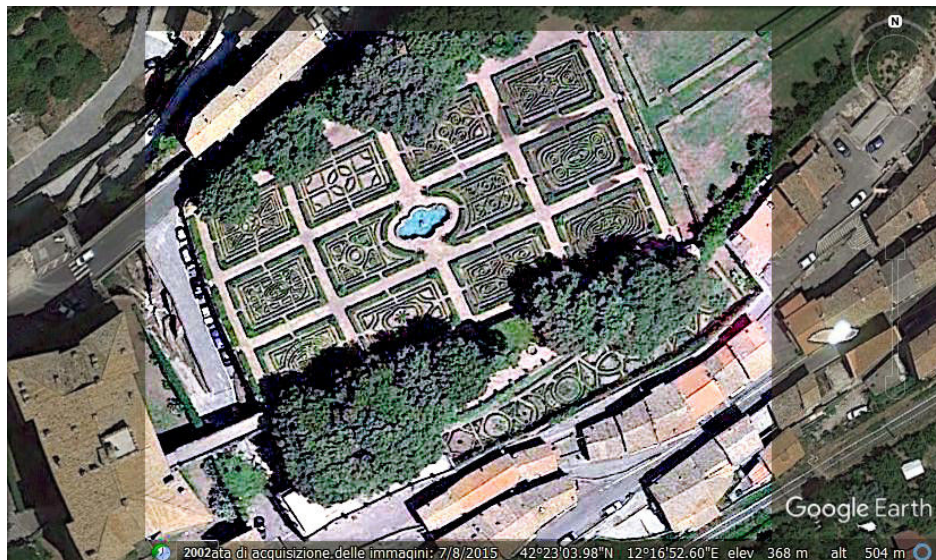
**Figura 1:** Il castello ed il giardino. Nell'immagine di Google Earth è anche possibile vedere il ponte che collega il castello al giardino (Courtesy: Google Earth).

Come detto nell'articolo di Antonio Rocca [3], il giardino di Ottavia Orsini crea un contrasto potente e suggestivo, tra la "dimensione intima del giardino" e i bastioni angolari della fortezza (Figura 1). Come altrove suggerito [4], il castello è un ottimo esempio di come le novità introdotte durante il Cinquecento nelle tecniche di costruzione delle fortificazioni siano state invece poste "al servizio di



un sontuoso palazzo concepito con scopi sostanzialmente residenziali” [4]. Nella Rocca Marescotti, la nuova architettura militare che era stata introdotta in Italia proprio nel sedicesimo secolo per resistere agli eserciti invasori armati di cannoni [5], viene piegata “a intenti di sobrietà ed eleganza formale” [3].

Il castello è collegato da un ponte al giardino, che è cinto da un muro (Figura 1). Il giardino risulta già nelle forme attuali in un inventario dei beni del 1656, come suddiviso nel parterre, detto il giardino di verdura, in quello segreto, nel Barchetto e nel Barco. Il giardino di verdura è la porzione meglio conservata. E’ suddiviso da quattro viali che lo dividono in dodici sezioni, con al centro una monumentale vasca in pietra (Figure 2) [4]. Nell’inventario del 1656 il giardino risultava avere Peschiera, Fontana, Uccelliera, Gioco della Palla a corda, il Giardinetto segreto con i suoi giochi d'acqua, il Barchetto con Peschiera, Fontane e Rimessa [6]. Poi c’è il Barco grande con il ‘peschierone’ (Figura 3), circondato anch'esso da muro [6]. Come spiegato da Sofia Varoli Piazza in [6], la data che fa supporre la sicura presenza del giardino nel luogo attuale è la targa sul portale del Palazzo, posta in loco in occasione della costruzione del ponte che porta dalla Rocca al giardino, realizzato da Ottavia Orsini nel 1611.



**Figura 2:** Il parterre ed il giardino segreto (Courtesy: Google Earth).



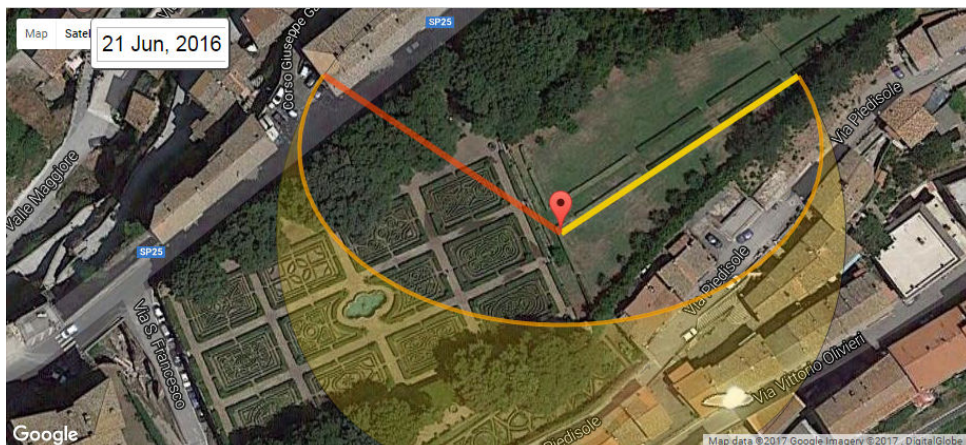
**Figura 3:** Il “peschierone” si vede a destra dell’immagine (Courtesy: Google Earth).



Come spiegato in [6], la costruzione del giardino sulla dorsale del promontorio di Vignarello ha richiesto lavori di spianamento necessari per creare le aiuole. Il Giardino segreto è posto ad un livello più basso, orientato verso mezzogiorno. Il Barchetto ed il Barco hanno un andamento più irregolare, per seguire la morfologia del territorio [6]. Infine, si ha, “in diretta continuità col giardino” la tenuta della Marescotta che occupa le terre a nord-est [6]. Il disegno del parterre (Figure 4), che come già detto in precedenza è diviso in dodici scomparti, è fatto da siepi miste formate da diversi tipi di piante. Le siepi di bosso sono usate per fare i disegni all'interno dei riquadri, comprese le iniziali di Ottavia Orsini e dei figli Sforza e Galeazzo [6]. Le siepi di bosso servivano anche a creare gli scomparti del Frutteto nella tenuta della Marescotta, che era posta in diretta continuità con il giardino, in “un sistema quello dell'orto-frutteto-giardino corrispondente ai giardini di più antica data” [6].



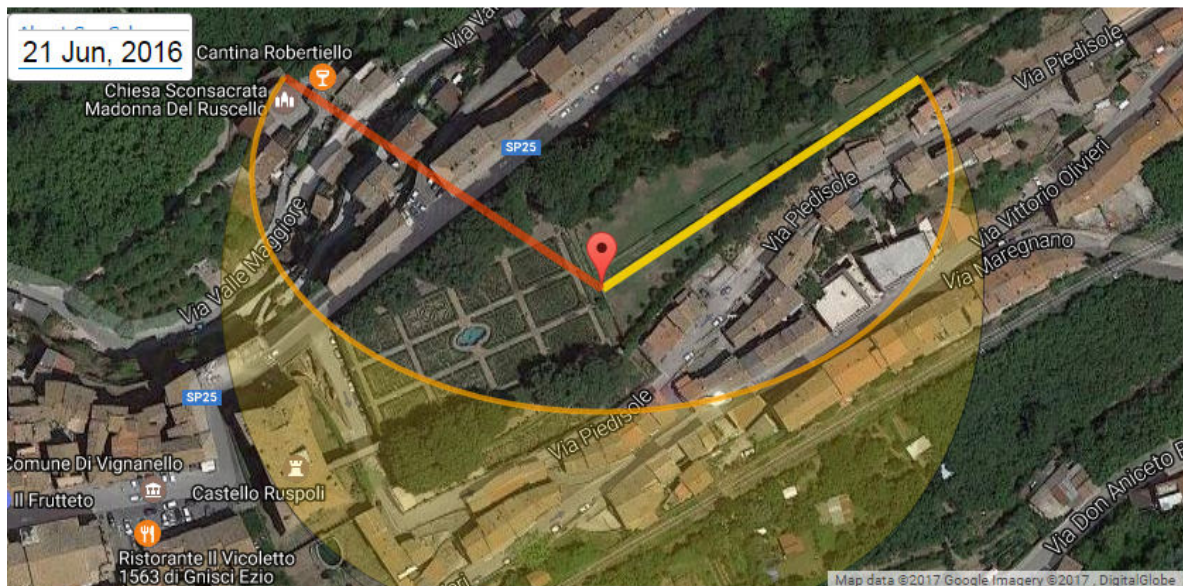
**Figura 4:** Il parterre del giardino visto dal castello (Courtesy, Tao Ruspoli, Wikipedia)



**Figura 5:** Usando il software SunCalc.net, possiamo vedere le direzioni del sole all'alba ed al tramonto di ogni giorno dell'anno, rappresentate dalle rette gialla e rossa su una immagine satellitare. Nel caso del viale del giardino che porta dal parterre alla Marescotta si ha una perfetta coincidenza con la direzione del sorgere del sole al solstizio d'estate (Courtesy: SunCalc.net).

Come possiamo vedere dalla Figura 4, dal parterre si allunga un viale che porta alla parte Est del giardino che finisce nella Marescotta. Come mostrato dalle immagini satellitari, esso segue il promontorio di Vignarello. Questo viale presenta una caratteristica interessante: esso ha

un'orientazione astronomica. Usando il software SunCalc.net (come nella Figura 5), software che mostra la direzione del sole all'alba ed al tramonto di ogni giorno dell'anno, si può vedere che il viale del giardino che porta dal parterre alla Marescotta è allineato con la direzione del sorgere del sole al solstizio d'estate. La seguente figura, (Fig.6), mostra che l'allineamento esiste per tutta la lunghezza del viale. Questo allineamento, insieme alle dodici aiuole del parterre, che potrebbero rappresentare i dodici mesi dell'anno, significa che il disegno del giardino conteneva anche dei riferimenti astronomici al moto del sole ed al succedersi delle stagioni. L'allineamento verso il sorgere o il tramontare del sole ai solstizi d'estate e d'inverso si osserva in altri giardini, come già discusso negli articoli ai seguenti riferimenti [7-14].



**Figura 6:** L'allineamento rispetto al solstizio d'estate esiste per tutta lunghezza del viale, come mostrato da SunCalc.net.

## Appendice

Di Vignanello ci parla il Dizionario di Erudizione del 1860, compilato dal Cavaliere Gaetano Moroni [2]. Una cospicua terra, Vignanello, "già feudo e capoluogo di governo, giace sopra un colle ameno alle falde del Cimino, spalleggiata da suoi boschi, sufficientemente fornita d'acque potabili ... Per la sua felice e centrale posizione, circondata da vari comuni, gode puro e temperato clima in tutte le stagioni, nell'inverno prevalendo la tramontana. Le strade interne sono tutte selciate regolarmente; e le abitazioni sono bene disposte, precipuamente lungo la bella e spaziosa via di mezzo, da est ad ovest, adorna al presente anche dal maestoso palazzio municipale, ... La rocca o palazzo de' conti e marchesi Marescotti, divenuti nel 1700 principi Ruspoli, che tuttora il possiedono, ... è circondato da cupo vallo, ed ha i suoi ponti levatoi."

Secondo il Dizionario, l'edificazione di Vignanello risalirebbe all'anno 412. Per tradizione locale, ebbe origine da un certo Giulio, da cui ebbe il nome di Giulianello, poi cambiato in Vignanello. Come castello, ne fa menzione Papa Gregorio I nel 604. In seguito fu occupato da Carlo Magno, dopo avere espulso i longobardi dal dominio locale. Suo figlio Lodovico I il Pio restituì il luogo al Papa nel concilio d'Aquisgrana. Nell'853, regnando Leone IV, Vignanello era governato dai monaci benedettini, "al cui ordine avea appartenuto. Nell'invasione dello stato pontificio di Federico I imperatore, questi quando i viterbesi nel 1169 a lui si assoggettarono, loro lo donò con altri castelli riferiti dal Bussi. Questo storico dice pure, che dopo 85 anni nel 1254, i consoli di Viterbo ne infeudarono la famiglia Ildibrandina signora di Bisenzo".



Nel 1316, privata tale famiglia del feudo, Vignanello ritornò soggetto al papato. "Nel 1451 Vignanello fu afflitto e desolato dalla Pestilenza, che serpeggiava nella provincia." La popolazione di Vignanello fu colpita da pestilenza anche durante il pontificato di Clemente VII, "nell'infausto 1527", l'anno del sacco di Roma ad opera dei Lanzichenecchi. "Quel Papa concesse Vignanello in feudo perpetuo a Beatrice Farnese figlia di Pier Bertoldo, nipote del cardinal Alessandro Farnese, che gli successe col nome di Paolo III, e suocera del conte Sforza Marescotti. Ed a quest'ultimo, come marito d'Ortensia figlia di Beatrice, dedita glie ne affidò il governo. Tale fu il principio della dominazione feudale del Marescotti in Vignanello".

Secondo il Cavaliere Moroni la famiglia era originaria della Scozia. In effetti, si dice che le origini dei Marescotti risalgono a Marius Scotus, nato in Galloway nel sud ovest della Scozia nell'VIII secolo, che arrivò in Italia nell'anno 773 a seguito della campagna militare di Carlo Magno.

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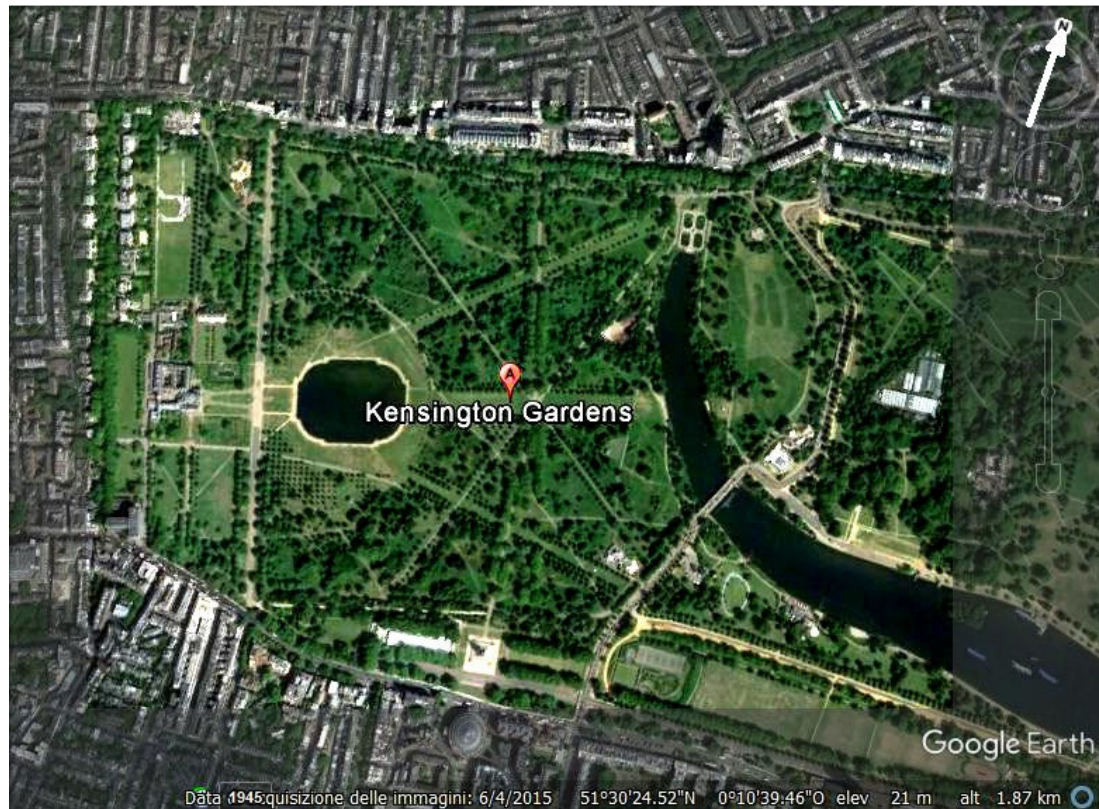


Figure 2: The Kensington Gardens in a Google Earth image (Courtesy: Google Earth). The layout is the same of that shown by Rocque's map.

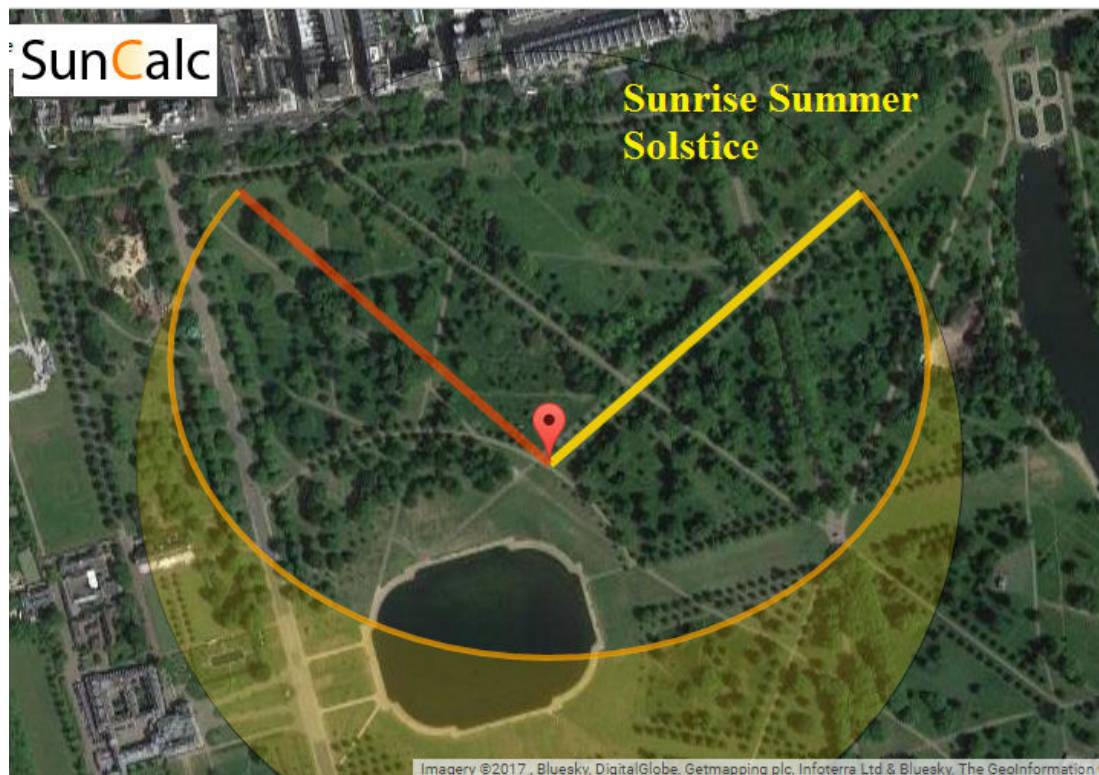


Figure 3: One of the main avenues of the Gardens is aligned along the sunrise on summer solstice, as given by SunCalc.net software. The yellow line represents the direction of sunrise, the red line is giving the direction of the sunset. The orange curve is representing the path of the sun.



If we use Google Earth (Figure 2), we can observe that the layout of the Gardens that we see today is the same of that depicted in the Rocque's map. To compare the satellite image with the map dated 1754 we rotated it, as given by the white arrow in the Figure 2. It means that the main avenue of the park is not cardinally oriented East-West. However, let us investigate if the Kensington Gardens have other specific orientations and alignments, for instance along the sunrise on summer or winter solstices, alignments that we can find in other gardens [5-11]. As made in the given references, to evidence such astronomical alignments we can use the SunCalc.net software, which is giving sunrise and sunset directions on Google satellite maps for any day of the year. In the case of the Kensington Gardens, we have that one of the main avenues, radiating out from the circle around the pond, is oriented along the sunrise on the summer solstice (Figure 3). Another avenue is oriented along the sunrise on the winter solstice (Figure 4).

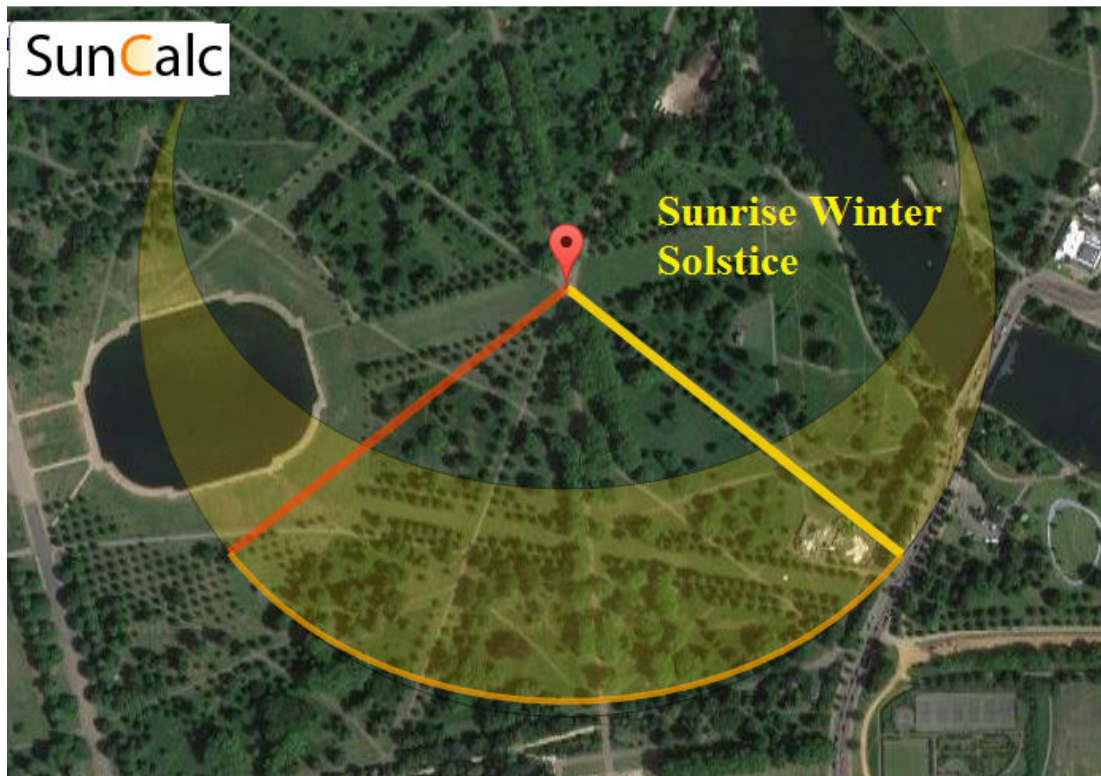


Figure 4: One of the avenues of the Gardens is aligned along the sunrise on winter solstice, as given by SunCalc.net software.

It means that the architects planned the gardens, including two references to the apparent path of the sun, through the sunrise on solstices. As observed in [12], the focus of the garden was the Kensington Palace and “the Round Pond that Bridgeman dug in front of it. Avenues of trees radiated out from the pond like spokes on a wheel” [12]. One of the spokes is the direction of the sunrise on the summer solstice. In the layout shown by the map of the Figure 1, the astronomical alignments are not evident, because the map is not cardinally oriented but rotated by a few degrees. In fact, the aim of the drawing was probably that of enhancing the symmetry of the planning. However, the use of a software, such as SunCalc or other, can help us in finding any possible alignment along the rising and setting of the sun, in the satellite maps of the observed gardens.

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# Alignments to sunrise and sunset on solstices in the layout of Lafayette Square, Washington

Amelia Carolina Sparavigna  
Politecnico di Torino, Italy

**Abstract:** The paper is discussing the astronomical alignments we can find in the layout of Lafayette Square, a park located directly north of the White House, in Washington. Alignments are marking the sunrise and sunset azimuths on solstices. SunCalc.net software has used for investigating such alignments.

**Keywords:** Landscape Architecture, Solar Orientation, Solstices, Urban Planning, Satellite Images, Google Earth.

Recently we have discussed some remarkable cases of architectures planned with a layout showing solar alignments. In particular we have discussed the Mughal gardens using, for determining the alignments, the SunCalc.net software which is giving sunrise and sunset azimuths on satellite maps for any day of the year [1-3]. The Mughal gardens are displaying alignments to such azimuths on solstices. Of course, these alignments were not used for astronomical or calendrical observations, but to give a symbolic representation of the macrocosm in the local microcosm of the garden.

The Mughal gardens shown in [1-3] have their roots in the old tradition of Hellenistic and Oriental gardens. An interesting research is that of finding examples of such astronomical alignments in more recent and Western structures. Here we discuss an example of solar alignments in the layout of a park, remarkable for its position: it is the Lafayette Square, a public park of the President's Park in Washington DC. The Lafayette park is located directly north of the White House.

The Square is named for the Marquis de Lafayette, hero of the American Revolution. It was planned as part of the pleasure grounds surrounding the Executive Mansion, originally called as "President's Park". At the center of the Square we find the statue of early 19th century President and general Andrew Jackson on horseback. Four statues of heroes of the Revolutionary War are marking the corners: of General Gilbert de Lafayette at SE, Major General Jean de Rochambeau of France at SW, Brigadier General Thaddeus Kosciuszko of Poland at NE and of the Major General Friedrich Wilhelm von Steuben of Prussia at NW.

The history of the planning of the Square is given in [4]. After various designs, Lafayette Park was redesigned by Andrew Jackson Downing in 1851. His plan was reinterpreted by the Corps of Engineers in the 1870s and 1880s and then by the National Park Service in the 1930s. The park was redesigned from 1962 to 1970 by the architectural firm John Carl Warnecke Associates, in association with Mrs. Paul Mellon and the National Park Service. "Warnecke used Andrew Jackson Downing's earlier design as a framework by which to design an urban park space that would link new construction on the east and west ends of the park while providing for the preservation of significant 19th century streetscapes on Madison and



Jackson Places" [4]. "Downing's 1851 plan for President's Park is the first detailed development plan ... with a central elliptical walkway bisected on the north and south by two additional walkways curving in towards the center of the park. In the center of the park a pedestal was installed as a base for an equestrian statue of Andrew Jackson dedicated in 1853" [4].

The preservation of the Lafayette Park with its Victorian-like outlook given to it by Downing was strongly supported by Jacqueline Kennedy, the wife of President John F. Kennedy, and First Lady of the United States. As discussed in [5], "were it not for Jackie Kennedy's spearheading the historic preservation movement in the nation's capital, Lafayette Square would likely have been bulldozed". In a letter the First Lady wrote "All architects are innovators, and would rather do something new than in the spirit of old building. I think they are totally wrong in this case, as the important thing is to preserve the 19th Century feeling of Lafayette Square". And, in [5], we find also that the final plan for Lafayette Square, developed by the architect John Carl Warnecke, "showed Jackie's strong influence".

Thanks to the First Lady we can observe the Lafayette Square planned by Downing in the satellite images. If we use SunCalc.net, the Square appears having alignments of the four statues along the sunrise and sunset azimuths on solstices. Let us observe them in the Figure 1.

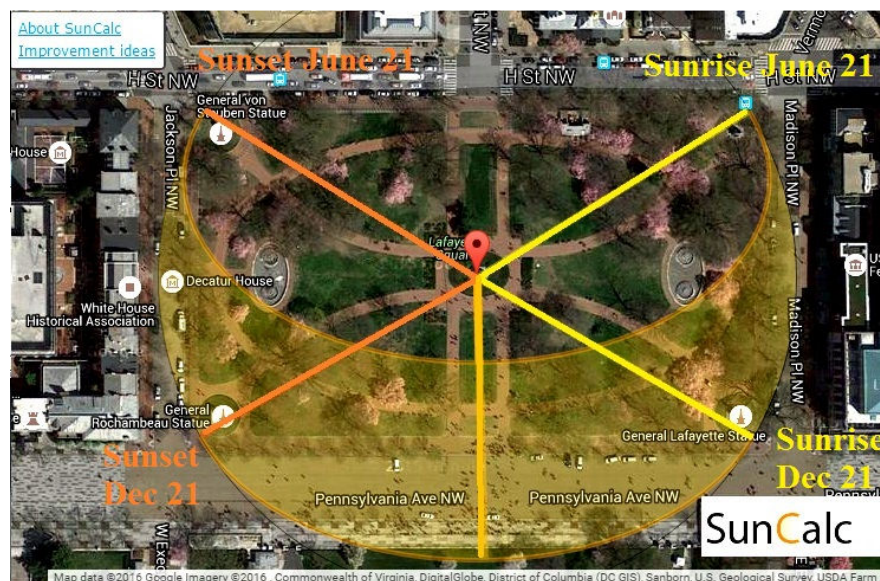


Figure 1: The Lafayette park is located directly north of the White House. At the center of the Square we find the statue of President Andrew Jackson. Four statues of heroes of the Revolutionary War are marking the corners. SunCalc.net shows the sunrise (yellow) and sunset (orange) azimuths on solstices. Note the alignments of statues which are at the ends of the curved pathways.

If we compare the Figure 1 to the figures in [1-3] of some Mughal gardens, we easily see the analogy. The gardens have a rectangular layout, with the axis coincident to the cardinal

direction NS. Moreover, they have the solar alignments. No references to a specific planning of alignments along the solar azimuths for the Lafayette Square are available. However, since, the central elliptical path bisected by the two curved additional walkways is proper of Downing's 1851 plan [4], we can tell that these alignments were also in the original Downing's planning. They had not been added by Warnecke, because the layout is the same of that we can see in the Figure 2, which is showing the Square in 1949. It seems that



Figure 2: The Lafayette Square in 1949 (Courtesy Google Earth).

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