Transits of Venus: New Views of the Solar System and Galaxy
Proceedings IAU Colloquium No. 196, 2004
D.W. Kurtz, ed.

doi:10.1017/S1743921305001328

Maya observations of 13$^{\text{th}}$ century transits of Venus?

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Abstract. With the advent of the 2004 transit of Venus, interest in historical observations of past transits has been rekindled. We present evidence suggesting that the Maya of the post-classic period actually observed at least one transit of Venus. The frescoes of Mayapan, which are proposed as a record of 12$^{\text{th}}$- or 13$^{\text{th}}$-century transits, are described and discussed in their astronomical context

1. Introduction

The city of Mayapan was the most important urban and military center of the Yucatan Peninsula during the postclassic period (1000-1519 AD). It is located at about 40 kilometers southeast of Merida, the present capital of the state of Yucatan. The first settlements date from the preclassic period (300 BC to 300 AD), but it was during the early postclassic that the city became prominent, and the Chichen-Itza heritage is readily apparent in its architecture. The main Mayapan temples resemble those of Chichen-Itza, although without the refinement of the latter. Mayapan shows a mixture of architectural elements characteristic of both the Maya and the peoples of Central Mexico. The city occupies an area of 4 square kilometers, and is surrounded by a wall that encompasses over 4000 structures. The central plaza includes buildings of civic, administrative and religious nature, as well as the living quarters of the governing classes (Peraza-Lope 1999; Milbrath and Peraza-Lope 2003).

According to Diego de Landa (1941), oral tradition indicates that Mayapan was founded during the second half of the 13$^{\text{th}}$ century by Kukulkan itself. This legendary personage, closely associated with Venus, governed the city during several years, returning later to Central Mexico. During his time at Mayapan the great pyramid bearing his name was erected, as well as a circular building with four entrances (Landa 1941). These buildings resemble respectively El Castillo and the Observatory at Chichen-Itza, but are smaller in size. Even the famous descending serpent formed by the Sun's rays at the time of the equinox on the stairway of El Castillo at Chichen-Itza has an analog in Mayapan, but it occurs during the winter solstice, when the shadow of the nine pyramid bodies is projected by the Sun on the balustrade (Arochi 1991). This is illustrated in Fig. 1. †

In the middle of the 15th century Mayapan was destroyed as a result of a civil war and its chieftains fled. In 1950, several structures and buildings at Mayapan were excavated and restored by the Carnegie Institution (see Jones 1952 for the designation of the Mayapan structures). But it was only in 1996 that a comprehensive project of excavation and stabilization was begun (Peraza-Lope 1999). This project resulted in the discovery of new frescoes and in the salvaging of previously reported ones. In this work, we analyze, from an archaeoastronomical point of view, the mural paintings in the so called Fresco Hall (structure Q.161 in the Carnegie scheme).

† All photos can be viewed in color in the electronic version of this paper

Figure 1. The City of Mayapan can be considered as a direct inheritor of Chichen-Itza, the great metropolis of the classic period. The pyramid of El Castillo in Mayapan also shows a hierophany at its north balustrade, but at sunset of the winter solstice. (Courtesy O. Casares Contreras).

Figure 2. The Fresco Hall in Mayapan is adjacent to the pyramid of El Castillo.

2. The murals in the Fresco Hall

The Fresco Hall is situated at the southern end of the Central Plaza of Mayapan, adjacent to the eastern wall of the Castillo (Fig. 2). It is a rectangular structure, with a small protrusion at one end. The painted wall, about 14-m long, lies at the center of the structure and is oriented in east-west direction. A shorter perpendicular extension (4-m long) is found at the easternmost end. A number of columns are still extant, which probably once supported a roof. The frescoes are still visible on the north and south surfaces of the central wall, as well as along the northern part of the slope of the adjoining Castillo.

The paintings are organized in horizontal rows. On both sides of the wall the themes are similar: we find a rectangular frame surrounded by a stripe and depicting two personages in profile, facing each other. At the center, between the two figures, a circular disk is located, inside of which another anthropomorphic figure is depicted in a descending position. In spite of the fact that the paintings are relatively well preserved, it is not easy to interpret them, since many details are blurred. In this paper, we propose an interpretation based on the available iconographic elements and aided by astronomical calculations that consider the orientation of the building that contains the murals.

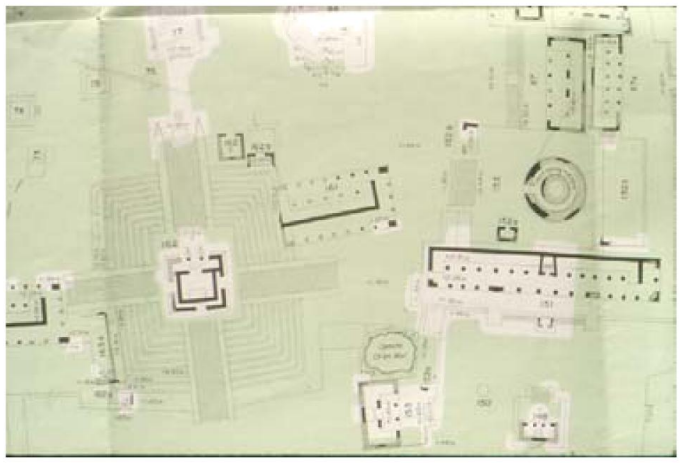

Figure 3. Map of Mayapan's Central Plaza. Buildings 152, 161 and 162 correspond to the Observatory, the Fresco Hall and the pyramid El Castillo, respectively (Pollock 1962). North is at the top.

A total of eight discs can still be recognized, but the surviving rectangular frames allow us to surmise that there were originally as many as 13. If indeed this was the original number of discs in the Fresco Hall, it would be very interesting, since the number 13 is extremely important in the Mesoamerican calendar. In fact, the ritual calendar, or Tzolkin, was organized in 20 periods of 13 days.

Basically, all 8 of the surviving representations are similar. In each, the pair of personages depicted in profile look towards the central circle. They seem to be walking towards it. They carry in their hands a long lance-like object, inclined upwards, that reaches the central image. This lance is painted in red and yellow, and touches what appears to be the head of a serpent in profile. The attire of the personages is quite rich: they wear sandals, earrings and elaborate headdresses. Their bodies and faces are painted in a very dark red, almost brown. Remarkably, their mouths are yellow, and so is a stripe running along their noses and foreheads. They also wear a kind of ornament under their chins, painted green and yellow.

In all cases the central element is painted yellow. The two personages in profile that we just described look towards it. This element is composed of concentric circles with four superimposed Sun rays, in the style of the postclassic representations found in Central Mexico. Inside the circles we find descending personages, with their legs flexed. They carry a kind of shield in one arm. Their faces are now quite blurred and do not allow a detailed description to be made. However, they all look different from one another, especially as regards the form and color of their faces (see Figs 4 and 5).

Despite the differences in time and place, the figures remind one of the well known mural at Teopancaxco, in Teotihuacan, where again two personages – probably priests, judging from their rich clothing – stand in front of each other. Between them a disk is painted, which occupies the central position in the whole mural. The disk has solar connotations, because in its interior is painted a glyph with a jaguar, a sign usually associated to the Sun – specifically to the setting Sun – in the Teotihuacan iconography (Ruiz-Gallut et al. 1996). Such solar discs are fairly common in Central Mexico, but we emphasize that apart from the ones in the Fresco Hall at Mayapan, none are known with personages painted inside them.

Radiocarbon dating has been carried out (Peraza-Lope, personal communication) and it indicates that the murals were painted between 1200 AD and 1350 AD. The style of the paintings of the Fresco Hall does not resemble the Maya style characteristic of that

Figure 4. Painted panel at the Fresco Hall in Mayapan. Two representations of the Lord of Night Yohualtecuhtli escort the solar disk within which a descending personage is depicted.

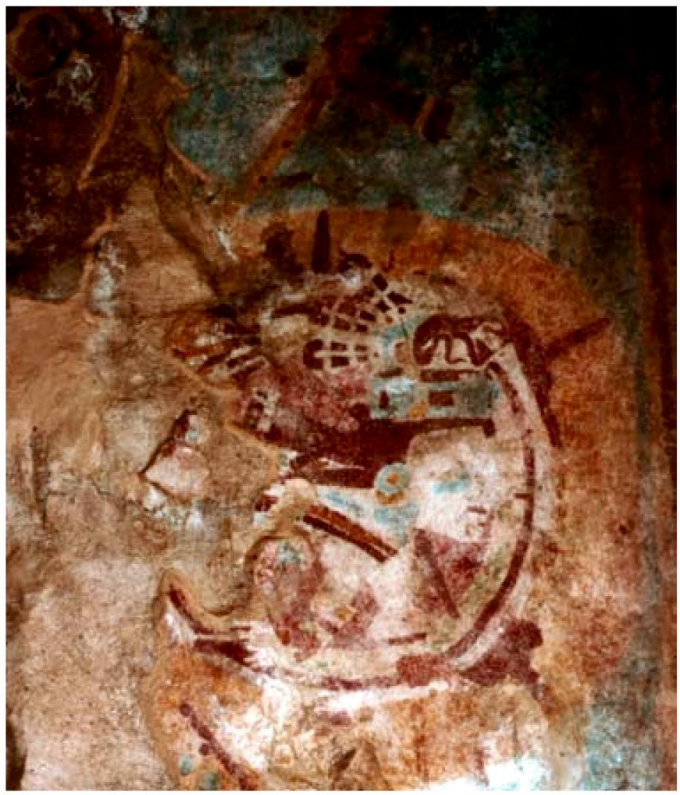

Figure 5. Detail of a painted panel at the Fresco Hall showing a descending personage, sumptuously dressed, in the interior of a solar disk. The pictorial design and the color palette used associate this mural to the cultural tradition of Central Mexico.

period. Rather, it is reminiscent of the images of the Borgia Codex, a pictorial document with calendric significance dating from approximately the same time as the murals, but showing clear influence of the cultures of Central Mexico (Seler 1906).

Another structure, called the Temple of the Painted Niches is located in the northern part of the Mayapan central plaza. Although its paintings have no obvious astronomical meaning, the building has been shown to have astronomical connotations (Ruiz-Gallut et al. 2001).

3. Archaeoastronomical analysis

3.1. *Measurements of the orientations*

The archaeoastronomical study of both murals required the measurement of the orientations of the Fresco Hall with respect to the celestial north. The geographic longitude of the site is 89°27′39″, the latitude 20°37′44″. We measured the azimuthal angle of both sides of the central wall containing the paintings, and the result was 88°56′ for the north side and 88°16′ for the south side. In both cases, the apparent horizon is defined by the upper part of the circular temple (henceforth the Observatory), located about 40 m to the east of the eastern flank of El Castillo. The measured height of this horizon is 7°10′ and 9°30′ for the north and south sides, respectively. At the time of the measurement (1998) the reconstruction work on this temple was not yet finished. At present, the upper part of the temple is almost twice as high. We considered two kinds of possible astronomical alignment for the Fresco Hall: with the Sun, along the central wall, and with stars, along the direction perpendicular to both sides of the wall. For our search, we have adopted the midpoint (1275 AD) of the interval during which the murals have been dated. Since the surrounding terrain is quite flat, we assumed an horizon height of only 1°30′. We have also studied, for the same epoch, the direction perpendicular to the south side of the wall, with an azimuth of 178°16′, assuming the same horizon height.

3.2. *Alignments with stars*

The pictorial designs on the mural can be recognized as having solar significance. However, since the alignments of both perpendicular directions do not point toward the Sun, we think their significance is rather of a ritual character, related to some solar concept derived from the Mesoamerican ideology.

The direction perpendicular to the northern side of the wall (with an azimuth of 358°56′) points towards a region with few bright stars. However, it is a singular sky region: far from the Milky Way, it corresponds to the circumpolar region. In this region, the north celestial pole is surrounded by the Little Dipper and Draco. This suggests that the Maya wanted to point to the region of the sky where the Sun is never seen, the place of the dead which remains forever dark and serves as the great axis to the celestial sphere. It seems that we find here the concept of the nocturnal Sun, the Sun of the Underworld which is devoured by the Earth Monster at dusk, and which continues its labors until dawn. In this way, the cultural influence on the Maya of the peoples of Central Mexico would be apparent in the pictorial design representing the Lord of the Night, Yahualtecutli or Ahuau Ak'ab. In Central Mexico the nocturnal Sun (depicted as a sun-circle) is often escorted by personages having attributes of Yahualtecutli (similar to the pairs of figures in profile at Mayapan).

In contrast, the southern side of the wall points towards a part of the sky where the Milky Way is seen almost horizontally, with the constellations of Centaurus and the Southern Cross. The latter is particularly striking, because near upper culmination its vertical axis almost coincides with the direction of the southern side of the wall. This constellation, which describes a small arc over the southern horizon, would signal the Underworld regions, where the counterpart of the dark northern region is to be found. In the region far from the Milky Way the direction of the southern wall points toward the Large Magellanic Cloud, visible to the naked eye.

In view of the importance of the Observatory building (Fig. 6) regarding the Fresco Hall, we have also analyzed the direction in the sky towards which the central wall points. We have centered our search on the year 1275. In early May of that year, an observer placed at the central wall would have noted that the Jaws of the Sky Monster (which

Figure 6. The rounded building known as the Observatory at Mayapan. This structure is similar to El Caracol from Chichen-Itza, whose architectural elements show diverse astronomical alignments.

correspond to the Great Rift of the Milky Way) were emerging from over the Observatory (Freidel et al. 1993). In early August of the same year, a narrow portion of the Milky Way appeared over the Observatory, but there were also many bright stars nearby. In particular, the Orion constellation emerged precisely from behind the building. If we use for our search an apparent horizon of 17° to take into account the probable height of the original building, we find that three exceptionally bright stars appear to emerge from the top of the Observatory: Alpha Aql (Altair); Alpha Ori (Betelgeuse), and Alpha CMi (Procyon). The coincidence of the rising of these stars over the top of the Observatory, and in the direction determined by the central wall increases the astronomical significance of the alignment described earlier.

3.3. *Alignments with the Sun. The Venus connection*

We have also studied the possibility of an alignment with the Sun. The painted panels located at the side of El Castillo certainly suggest such an alignment, because the direction perpendicular to them points eastwards. A solar alignment would correspond to a grazing illumination of the paintings by the Sun. Even after its recent restoration, the Observatory does not appear to have the large dimensions mentioned by 19th century explorers (Marquina 1990). The northern part of the wall has a protrusion that would obstruct a grazing illumination by the Sun.

However, the southern side is clear, and allows the solar rays to penetrate when the Sun appears over the top of the circular building. With conditions as measured in 1998, we calculated the dates of grazing illumination of the southern part of the central wall to be April 2 and September 10. However, after the reconstruction of the observatory the dates were recalculated, and they turned out to be April 9 and September 2. The importance of these dates lies in the fact that sunrise on such days defines the division of the solar year of 365 days in a relationship of 2/3 with respect to the summer solstice. That is, counting from the first alignment, these dates divide the solar year in one period of 73 days before the solstice, one of 73 days after the solstice, and three periods of 73 days to complete the year.

Note that, according to the structure of the Mesoamerican calendar, in the course of 52 years of 365 days each, when the Tzolkin starts again simultaneously with the Haab, 73 periods of 260 days must pass. Thus, we are dealing with a calendric-astronomical alignment, like the ones that have been identified in several other Mesoamerican sites.

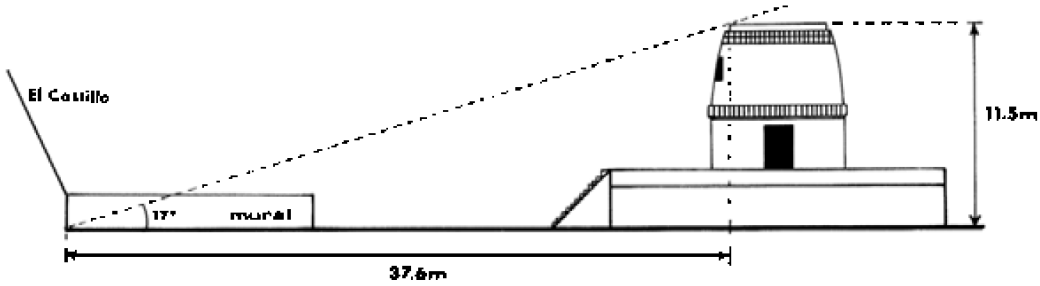

Figure 7. Reconstruction of the height of the Observatory from Mayapan in order to allow the grazing illumination of the mural painting at the Fresco Hall by solar rays. This event occurs on two dates which are important for the Mesoamerican calendrical system.

Most important for our purpose, however, this alignment is directly connected with the synodic period of Venus, 584 days, since the latter can be expressed as 8 periods of 73 days. This association with Venus appears probable when we remember that several circular buildings in Central Mexico, also dating from the postclassic epoch, have been associated with the planet Venus as a manifestation of the deities Quetzalcoatl and Xolotl, being the morning and evening star, respectively. Plausibly, the Maya at that time were assimilating the ideas related to a foreign deity, which they called Kukulkan. The angle necessary for the effect of grazing illumination to occur on the painted panels is about 17°, measured from the line joining the floor of the hall and the wall abutting the side of El Castillo (see Fig. 7). Taking into account the distance between that line and the circular building, that angle determines a height for that building of 11.5 m. The reconstruction of the building, considering data provided by 19th century explorers (Marquina 1990) gives a height of 10.65 m, a difference of less than 10 percent from the calculated value.

Attention should be called to several circular column bases in the Hall of Frescoes, which suggest the possibility that a roof might have existed. Such a roof would have obstructed the passage of the solar rays from the south side of the central wall. We estimate that the maximum column height to just allow the passage of the solar rays is 4.28 m. It is suggestive that the height of the wall at its westernmost extreme, where it meets El Castillo, is about 3 m. This renders plausible the idea that the columns too had this height, and allowed the free passage of the Sun's rays on the suggested days. This, in turn strengthens the importance of the suggested ritual and calendric interpretation, since the close relationship of the Sun and Venus is pointed out by the calendar and the orientation of the mural itself. Furthermore, it was possible to calibrate the synodic period of Venus by observing, every 365 days and three periods of 73 days, the rising of the solar disk over the top of the Observatory building. We recall that the Maya and other people of Central Mexico had a precise knowledge of the Venus cycle. The Dresden Codex, for instance records a synodic period of 584 days, as well as the dates of the four principal Venus stations : inferior and superior conjunction, and the dates of heliacal rising and setting (see Fig. 8).

The importance of Venus in Maya thought leads us to ask if the planet is depicted in the mural. As we know, during the classic period the Maya developed numerical tables to predict solar and lunar eclipses (Brickner & Brickner 1983, Martin 1993). At the time of both conjunctions, the planet is obliterated by the Sun's light, and these inferior conjunctions are not observable, unless they occur under special circumstances, as a

Figure 8. This stele was found in the Venus Platform at Chichen Itza and shows a remarkable characteristic of the motion of the planet. The hieroglyph over the bunch of reeds signifies "year". Eight small circles represent the number 8 and the vertical bar on the left, close to the Venus hieroglyph means the number 5. Further, the stele establishes that 5 synodic periods of Venus (5×584) equals 8 solar ones (8×365). Such an "equation" represents a remarkable example of the interest accorded to Venus by Maya priest-astronomers.

transit of Venus through the solar disc. Of course, a transit of Venus can normally be observed with the naked eye only when the Sun is close to the horizon, either at dusk or dawn (or through thin clouds). Then, due to the obscuring effect of the atmosphere, it is possible to recognize structures on the solar disc. It is, for instance, easy to distinguish sunspots, especially at times of maximum solar activity. For this reason we suggest that the descending personages depicted inside the sun-circles in the various panels of the mural might represent a Venus transit.

To explore such a possibility we have analyzed the transits of Venus that occurred between 1150 and 1400 AD (all dates are Gregorian) and were observable in Mayapan. During this period, four transits occurred: on November 30, 1153; June 1, 1275; May 30, 1283; and December 1, 1396. The last two events took place during the daytime, but the first two were observable at dusk. So, at 5:15 in the afternoon of November 30, 1153, when the solar limb was in contact with the horizon at an azimuth of 246°41′, Venus was observable on the solar disk, at about 1/4 of a solar radius from the limb. The times given correspond to the meridian 90° west of Greenwich. Similarly, at 6:31 in the afternoon of June 1, 1275, when the solar limb touched the horizon at an azimuth of 293°55′, Venus was located inside the solar disc, at about 1/3 solar radius from the limb.

Surely, the observation of the Sun with Venus inside its disc, both descending towards the horizon, corresponds quite closely to the depictions in the mural. The observations must have been carried out from a high site, likely from the top of the adjoining El Castillo, the highest structure in Mayapan. We think our proposed identification of the personage painted inside the Sun circles with Venus is plausible inasmuch as we are

dealing with exceptional events that are nevertheless observable. The time of the observation could have been calculated, since the priest-astronomers carefully followed the trajectory of Venus for calendar purposes, and they would have noticed when an inferior conjunction was about to occur.

3.4. *Venus transits or sunspots?*

Although the proposed observations of Venus appear feasible, it is interesting to note that large sunspots could give a similar visual impression. However, the motion of such objects on the solar disk is very different. Whereas sunspots remain practically motionless during several hours, the changing position of Venus is easily recognizable even for naked eye observers.

For the proposed transits in 1153 and 1275 we have revised data on the solar activity obtained by different methods. The results are somewhat controversial. Schove (1955) uses historical records of aurorae and sunspots to estimate the solar maxima and minima, and obtains a strong maximum in 1151 and the next minimum in 1155. For the year 1276 he obtains a moderate maximum. However, results based on auroral activity often lead to ambiguities due to the confusion of aurorae with other phenomena like comets, noctilucent clouds, etc. To avoid such ambiguities, Wittman (1978) traced the solar cycles using sunspot observations alone. He determines two consecutive maxima for the years 1148.5 and 1161.2, so that the minimum would occur in 1154.9. No data are given near the 1275 event. On the other hand, Usoskin et al. (2004) have reconstructed sunspot numbers averaged over 11 years since 850 AD. They use physical models for the production of ^{10}Be in the Earth's atmosphere and data on the ^{10}Be concentration measured in ice cores from Antarctica and Greenland. They find that the level of solar activity for 1153 and 1275 is significantly lower than that found in earlier analyses. Therefore, we can assume that the transits of those years could have been observed without significant contamination by giant sunspots.

3.5. *Naked-eye visibility of a Venus transit*

The apparent angular diameter of Venus at inferior conjunction has a mean value of 61 arc seconds (Allen 1973). This angular size allows a comfortable visual perception of Venus as a little disk on the bright photospheric background. In fact, the minimum size of perceptible naked-eye dark structures on the solar disk is found to be 19.3 arc seconds (Keller & Friedli 1992).

Of course, the Maya could also have observed the transits of Venus by making use of a *camera obscura*, which could have been easily constructed from bark paper or vellum. The vertical shaft of the observatory at Xochicalco, which can be easily stopped to the required small aperture, suggests that the *camera obscura* effect could have been used there too.

3.6. *Further connections with Venus*

In spite of the blurring of the images inside the sun-circles which prevents us from appreciating details in them, we suggest that they represent a deity associated with Venus. This suggestion is supported by the motion of the planet relative to the Observatory. The planet rises from behind the Observatory to an altitude of 10° to 24° according to whether it is viewed from the slope of the Castillo, or from the eastern end of the Fresco Hall.

In Ruiz-Gallut et al. (2001) the apparent motion of Venus for one eight-year cycle was calculated. As is well known, the planet alternately ascends and descends, a motion that surely was observed by the Maya. Now, let us draw the silhouette of the Observatory

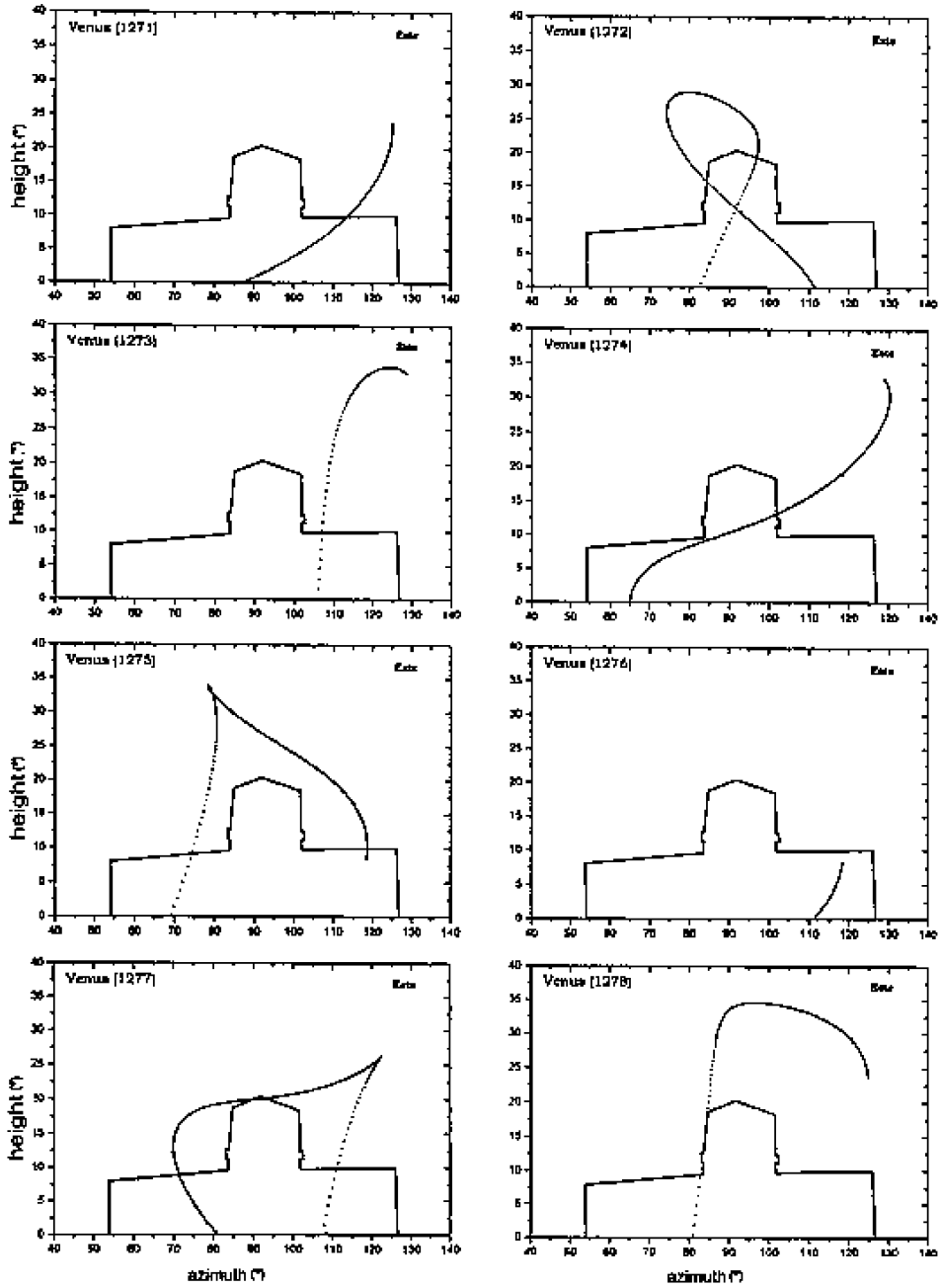

Figure 9. Apparent trajectories of Venus as Morning Star for the years 1271 to 1278 (Gregorian calendar) as registered by an observer situated at the east end of the central wall of the Fresco Hall at Mayapan. The apparent horizon formed by the outline of the Observatory is also depicted. The positions of Venus were calculated for the time of sunrise. Diagram adapted from Ruiz Gallut et al. (2001).

as seen from the easternmost end of the central wall and ask the question: When could Venus be observed emerging from behind this building? The apparent motion of the planet during the cycle 1271 to 1278 is drawn in Fig. 9 (adapted from Ruiz-Gallut et al. 2001). We can see, for example, in early 1271 the planet's day-to-day descent towards the southern side of the Observatory, behind which it disappeared on February 23. Later, in 1272, it rose from behind the building toward the end of April, and remained visible

until early September. Venus reappeared as a morning star in early November 1273 and was visible until early April 1274. From mid-June 1275 until December 1275 the trajectory of Venus appeared to encircle the Observatory. A similar trajectory could be observed during January-August 1277. Note that during 1276 Venus was not observable as a morning star, since it did not reach sufficient height to appear above the building. Finally, in 1278 the planet emerged again from behind the top of the building and was observable as a morning star for the remainder of the year. The appearance of Venus as we have described is, of course, repeated every cycle of nearly eight years. Clearly there is a close relation of the planet with the Fresco Hall and the Observatory.

A very remarkable design calls for special attention. It is painted at the top of one of the rectangles that surround the sun-circle and the personages facing it. This design appears only on the southern side of the central wall, near its middle. It is a wavy line design, similar to a Yacametzli (a nasal ornament shaped like the Moon hieroglyph) but with two small circles underneath each end. On page 15 of the Madrid Codex we find a similar design, which bears the name of a personage and depicts an eye. Could the Mayapan design also represent an eye, perhaps indicating that observations were performed from that part of the wall?

It is worth noting that other parts of the southern wall, above the painted strips, also exhibit vestiges of designs, almost obliterated now. Nonetheless, one of these designs, shown to us by Peraza-Lope during a brief visit to the site in 2000, depicts a kind of eye with an oval ornament underneath, which resembles the representation used in Central Mexico for a star.

The Temple of the Painted Niches was also measured in order to determine its orientation with respect to the celestial North. We obtained an azimuth of $183°42'$ for its symmetry axis, and an apparent horizon height in that direction of $2°30'$. Once more, we find a southern orientation. If we search around 1275 AD we find an observational pattern similar to that found for the southern side of the central wall of the Fresco Hall. In this extremely southern region, the motion of the stars is in the form of short arcs. So, for several months the most striking constellation, the Southern Cross, points its vertical axis towards the horizon and beneath, thus signaling to the Underworld. It is not easy to find a correspondence between a particular design in the murals of this temple and an astronomical object. But we could, conversely, suggest an interpretation of the pictorial designs with some particularly striking celestial object in the direction considered. The open jaws of the serpent painted in Structure Q80 could be associated with the circular trajectories around the unseen (but clearly inferred) South Celestial Pole. The Nocturnal Sun could be associated with the personages brandishing the lances and accompanying the Sun-circles.

Recent archaeological explorations in Mayapan have revealed other mural paintings (Peraza-Lope, personal communication). Inside the Observatory, for instance, four painted niches were found, with very complicated designs. Their colors are bright and resemble those of the murals of the Fresco Hall. Several frames decorated with green feathers can be identified. There are even fragments of what could be sun-circles. It would not be surprising to find paintings with astronomical connotations, since the astronomical importance of the building is clearly established (Ruiz-Gallut et al. 2001).

4. The 2004 transit of Venus from Mayapan

In an attempt to recreate the Maya observations during the June 8, 2004 transit of Venus, one of us (J. G. T.) traveled to Mayapan. The completely flat terrain would have allowed a comfortable naked-eye observation from the main pyramid, with the light of

the solar disk being naturally filtered by the atmosphere at dawn. The observational circumstances for the transit were not very favorable in Yucatan, because only the very final phase of the transit was to be visible for a few minutes. Unfortunately, a dense fog at sunrise made impossible the observation of the solar disk. This observation will be attempted again at the time of the next transit of Venus, in 2012.

However, the 2004 transit was observed from different parts of the world. It is interesting to examine images of the transit obtained from longitudes similar to that of Mayapan at the same phase of the event (see, for instance, Schaaf, 2004; http://www.vt-2004.org/photos and http://sunearth.gsfc.nasa.gov/sunearthday/2004/vt_gallery.htm). Images taken at sunrise without filters, reports of naked-eye observations of Venus on the solar disk and photos containing Venus in transit together with flying birds, as well as reports of comfortable naked-eye observations (Schaaf 2004) strengthen our suggestion that naked-eye observations by ancient observers of a Venus transit at dusk or dawn would indeed have been feasible.

5. Conclusions and summary

Despite the fact that the newly discovered paintings in the Fresco Hall cannot yet be fully interpreted, the study of the principal directions of the buildings has allowed us to highlight the importance of certain religious and calendric concepts that are related to astronomical events.

With regard to the images themselves, it is obvious that they include a mixture of stylistic elements and features related both to those found in Central Mexico and in Yucatan itself for the period we are studying. This makes it more difficult to present a unique interpretation, because cultural traits of both regions have to be taken into account.

It is worth mentioning that the circular temple, which we have called the Observatory, has been reconstructed in recent years, and mural paintings within it have been discovered. Ruiz-Gallut et al. (2001) showed that there is a close relationship between the Fresco Hall murals and those of the Observatory, and suggested that the building served as an actual astronomical observatory.

We finish up by summarizing the evidence which favors the interpretation of the Sun-circles in the Fresco Hall being a record of observations by the Maya of Venus transits. We also point out some problems and directions for future work.

1. The association of the Fresco Hall and the Observatory with Venus is supported by the following facts. (a) The orientation of the building is such that the Sun-circles are illuminated grazingly by the Sun on dates centered on the summer solstice and separated by 73 days, one eighth of the synodic period of Venus. (b) The relative orientation of the Observatory and the Hall of Frescoes is such that as viewed from the latter, the apparent trajectory of Venus appears to encircle the Observatory at the times near the transit, as it does every eight years.

2. The association of the Sun-circles (i.e, concentric circles usually painted red, with four protruding spikes) with the Sun is well documented in many instances. There is even a glyph representing the Sun which is a simplified, stylized version of the Sun-circles (see Fig. 10). However, the Sun-circles found elsewhere do not contain human figures inside them. The fact that all of the Sun-circles depicted in the Hall of Frescoes contain human figures in their interior is suggestive of some kind of eclipse or occultation of the disk of the Sun by a celestial body. Solar eclipses can be ruled out, since the Moon had a very clear and unique pictorial representation. Mercury is too small to be observed with the

Figure 10. Representation of two solar eclipses from page 71 of the Madrid Codex. Both central concentric hieroglyphs correspond to the Sun or Kin (in Maya language) which appear darkened and hang from the so called sky bands.

naked eye when it transits the Sun. A transit of Venus seems by far the most plausible of such events.

3. The figures inside the Sun circles cannot be clearly identified. They do, however, correspond to important priests or gods, and such important personages were often linked to celestial bodies. A mixture of styles is present in their attire, ranging from Central Mexico to Oaxaca and Yucatan. This is consistent with the idea that the Maya were in the process of adopting deities (like Kukulkan) imported from other cultures.

4. Certainly, a transit of Venus occurring at dawn or dusk is visible with the naked eye. The planet's apparent diameter makes it easily distinguishable on the solar disk.

5. The possibility that the Maya might have confused Venus with a sunspot can be ruled out for several reasons. First, the Maya continuously and carefully followed the trajectory of Venus, so that they would have been able to predict a transit, and be ready to observe the event as quite distinct from a sunspot. A sunspot, moreover, is visible over several days, whereas a transit lasts only a few hours, and this difference would not have escaped the keen Maya observers. Also, the fact that the time of the Venus transit corresponded to a period when the solar activity was not very intense should be considered.

Finally, we point out some problems that need future work to be clarified. The number of sun-circles with human figures inside is puzzling. Also puzzling is the fact that all human figures inside the Sun-circles seem to be different. There survive eight such figures, but there are vestiges of five more. The number 13 has intriguing calendric implications. But, why were so many figures painted if, at the most, four Venus transits could have been observed during the relevant period of time, and only two at dusk? Why are all the figures different? Could the Maya have known of previous Venus transits, perhaps observed at Chichen-Itza? Another important problem remaining is the establishment of a clear-cut identification of at least one of the personages with either an image connected with Venus, or with a deity or important person having Venusian connotations. The Mesoamerican gods usually show precise attributes in their garments and ornaments. Such an identification has not yet been found. We are in the process of examining several Maya codices to look for it. However, knowing the importance that Venus had for the Maya, it is conceivable that they would represent an extraordinary event like finding Venus inside the Sun's disk by depicting the Venus-God in different and unusual circumstances.

Acknowledgements

Our sincere thanks to R. Costero for a careful reading of the text and many suggestions, and to A. Poveda for interesting discussions.

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