Physics 10293 - Exam 3 Notes, Part 1

By this point in the course, we have now studied the daily and annual motion of stars, the Sun and the Moon. We will discuss the motions of the planets later, but for now, it is enough to know the following about planetary motion in the sky:

Daily Motion of Planets:

Circle in the sky parallel to the Celestial Equator

Long Term Motion of Planets:

Extremely complicated, but it is enough to know for now that planets do slowly change their positions in the sky over time relative to the fixed background stars and constellations. As planets rise and set over the course of many years, they have "excursions" like the Sun and the Moon.

That means that while a planet completes a cycle of long-term motion relative to the background stars, it will have "extreme northern excursion" rising and setting points (like a summer solstice or lunar standstill) and "extreme southern excursion" rising and setting points.

We have reason to believe some cultures may have tracked these planetary excursion points for a variety of purposes.

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Now that we understand the basics of how astronomical bodies move through the sky, we can finally learn some principles of Archaeoastronomy and examine some case studies to see how these principles are applied.

Our goal in this study is to gain insight into how ancient cultures interacted with the sky. As you have seen in your outside reading, we try to learn about ancient cultures by studying what they have left behind. In some cases, cultures may have left behind important clues about how they interacted with the sky.

Before we jump to any conclusions about a given structure or alignment, we must first determine whether or not its supposed astronomical orientation is intentional or just a coincidence. If the alignment we discover is accidental, then we really can't draw any valid conclusions from it.

How do we determine whether an astronomical alignment is intentional or accidental?

We try to address this systematically, by asking some basic questions. I will try to cover these in rough order of importance.

Question #1: How significant is the alignment?

The more significant that the target of the alignment is, the more likely we are to believe that the alignment is intentional and not accidental. So, in order of significance:

Rank 1 - The Sun

The most common thread in all of the intentional alignments discovered to date is the Sun, but not all cultures have aligned things with the Sun in the same way. For northern and southern latitudes, the most common alignments are with summer and winter solstice rise/set directions (Stonehenge is perhaps the most famous example of this, as we will see). Obviously, since this is correlated with the weather, it would be important to note the Sun's position for agricultural purposes.

For equatorial/tropical cultures, solstice directions are not as significant since there are no big seasonal changes there ("rainy" and "dry" seasons do not usually correlate with solstices). Instead, the most common alignments are with sunrise and sunset directions for days in which the Sun passes through the zenith.

You might imagine a sun-watcher who is in charge of ceremonial activities in a zenith chamber. This is a dark room completely underground with a 2-3 inch diameter vertical tube in the ceiling that is open to the sky. When the Sun is directly overhead, it can illuminate the chamber, but otherwise, the chamber will be dark.

So it would be in your interest to know ahead of time if today is a day that the Sun will pass briefly through the zenith point. That's an example of why a culture might want to mark the sunrise location on a day when the Sun is expected to pass through the zenith at noon.

A final point about solar alignments: Solstice and zenith alignments are usually considered to be more significant than

"halfway" alignments, such as equinox alignments. The solstices, for example, are the furthest north and furthest south rising and setting points. Those are unique and easy to track over time. Equinox alignments, however, are not as obvious. They aren't a "stopping point" in the Sun's annual motion, so they aren't as easy to track and less likely to be targets for alignment.

Rank 2 - The Stars

I'm hoping that you remember the definition of "heliacal rising" from question #17 in study guide #1. If not, please review it now before continuing.

We have evidence that some cultures purposefully incorporated alignments into buildings to point at rising or setting points of specific stars (for example, the Egyptians with the bright star Sirius). Why would they do this? Because like the Sun, the stars can be used to establish a calendar, and a calendar based on motions of stars is actually a little bit more accurate than a calendar based on motion of the Sun (that's why we have leap years, more about that in part 3 of the course).

The heliacal rising of a particular star is an event that happens exactly once every year on about the same day each year. So like the Sun hitting a solstice point, the heliacal rising of a star can tell you what time of year it is. So there is a practical reason for some cultures to create alignments with rising or setting points of particular stars.

The problem with stellar alignments is that there are a LOT of bright stars in the sky, and many of them rise and set in similar directions. For example, if you look in the precise direction of Sirius rising, a few hours later, another bright star (Gienah, the third brightest star in the constellation Corvus the Crow) will rise. Then a few hours later, Zubenelgenubi (the brightest star in Libra the Scales) will rise. Then a few hours after that, Deneb Kaitos (the second brightest star in Cetus the Whale).

And several other bright stars rise within a few degrees of this direction. So when we see something that we think may be aligned in the direction of the rising point of Sirius, we have to be careful to be sure some other star wasn't the intended target! And there's no way of knowing without further evidence.

Rank 3 - The Moon

Although the Moon is much brighter and easier to see than any bright star, I rank it third in order of significance because it has such a crazy pattern of rising and setting directions. You have already learned earlier about the concept of lunar standstills, so you know that unlike the Sun's solstice points, the Moon's northernmost and southernmost rising points differ every year in a long (18.6 year) cycle.

Not only that, you learned in study guide #1 (question #23) that there are many potential errors that can be made by skywatchers trying to pinpoint the exact direction of moonrise, some of which are not applicable to stars.

So, moving the Moon up on the significance list: the Moon is bright, easy to see, and definitely fits in with the sky lore of every culture. We know that Babylonian and Mayan cultures tracked the Moon closely, because they were extremely skilled at predicting eclipses, so that's one in the Moon's favor.

Moving the Moon down on the significance list: The Moon's position is difficult to precisely measure, it has an irregular and very long cycle, and it's unique rising and setting points (the standstills) really have nothing to do with establishing a good long-term calendar (for agricultural purposes).

The Moon's rising position doesn't really govern the weather or much of anything else in the natural world (except eclipses), so we have to wonder: why would any culture bother to go to the trouble to track it? I'm not saying every astronomical alignment must have some physical relevance to be intentional, but it would certainly help the argument if that's what you want to prove.

Rank 4 - The Planets

Venus is the third brightest object in the sky, behind only the Sun and the Moon, so it is easy to track. It is also usually found in the evening sky near sunset or the morning sky near sunrise. From an astronomical standpoint, the planet Venus is always found within about 45° of the Sun's position. You can even see it in the daytime if you know exactly where to look.

Venus also has a complicated cycle of rising and setting points, even more irregular than the Moon, but that cycle is shorter and

happens to last precisely eight years. So if you have reason to keep track of cycles of time longer than one year (and we know the Mayans did this), Venus can help you do that.

Jupiter, like Venus, has a regular cycle that happens to last exactly 12 years. That's Jupiter's sidereal year, the time it takes to return to the same position in our sky, relative to the background stars. We know that the Chinese culture tracks the position of Jupiter as it moves through the background constellations in a 12-year cycle.

So it is plausible that a culture would create an alignment to track the rising/setting point of a particular planet, but the short-term motions are so difficult and complex to track, that moves planets far down on the significance list. And like the Moon, where planets happen to rise or set doesn't seem to have any physical significance to our environment, although you could argue planetary positions are important for astrology (which some ancient cultures value highly).

Question #2: Is the alignment repeated elsewhere?

This one is MUCH simpler than question 1. If you find an alignment like Stonehenge, where there seems to be a clear intention to align the monument with the direction of sunrise on the day of the summer solstice (or sunset on the day of winter solstice), you would like to know if this alignment is repeated elsewhere. Does the alignment only happen at one specific place? If so, it more likely to be accidental. If it happens repeatedly at many different sites, then it is more likely to be intentional. I stretched that out to a whole paragraph. I hoped you liked it!

Question #3: Is there any written evidence supporting the alignment?

Many ancient cultures had some form of writing (not the architects of Stonehenge, though), and if we can translate that, we may find out what they believed about the sky. It doesn't have to be blatantly obvious, like someone scratching into a rock "HEY! This is lines up with Jupiter because we think that's a cool planet!" The clues are often more subtle.

For example, there are some Mayan buildings that seem to have alignments associated with the northern or southern extremes of the rising point of Venus. By itself, there are so many Mayan

buildings with different orientations, we might not be surprised to find alignments like with Venus here and there.

However, we also know from glyphs and a few surviving Mayan manuscripts that the Mayans carefully tracked the motion of Venus and incorporated its movements into their calendar and mythology. So the written evidence gives more credibility to the claim that the Mayan alignments with Venus were intentional, especially if the writing is found on the building itself that has the alignment!

Question #4: How accurate is the alignment?

Most architectural alignments take a lot of planning and effort to accomplish, and if they are for some sort of important ritual purpose, you might imagine the builders would take great care that the alignment is accurate. So if we find a particular building or line of sight within a building or city that seems to line up with summer solstice sunrise, that's one thing. But what if the alignment is off by two degrees (that's the angular size of four fingers held at arm's length)? Or four degrees?

At some point, the alignment error gets to be so big, it's hard to imagine the builders really were trying to achieve it. And this is especially true for stellar alignments since there are so many bright stars in the sky. If your alignment is off by a few degrees, then it would be pointing at a completely different stellar rising point than what you originally thought. So it's hard to be sure that the alignment is intentional.

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These four questions are the framework we will use to address several case studies. Some of these case studies we have already seen in films we have watched, but I think it is useful to look at them again in the context of these questions.

Case Study #1 - The Temple of Kukulcan (El Castillo)

We saw this hierophany (see study guide question #63 if you've forgotten what that is) in the Discovery channel film "Tools of the Maya" which the over-the-top host who was way too enthusiastic about everything. They even built a replica of the temple in the film and used a light bulb to show how the shadow and light pattern works on the North face.

Check out the left (North) side of the temple. See the series of triangles of light on the staircase? And notice at the bottom is the head of a snake. That's the serpent god Kukulcan, and on the day of the Vernal and Autumnal Equinox, the temple is oriented just right so that the "snake body" seems to rise toward the heavens as the Sun sets.

I will show you a closer look at this on the next page.

So, let's analyze this alignment using our four questions.

Question #1: Is the alignment significant?

The Sun is the most significant target on our list, although equinox is not as attractive an alignment compared to a solstice or zenith day rising direction. I will also point out that this temple is aligned a little differently than the other buildings at the site, which are more truly north-south-east-west. So that also indicates there may be an intent here.

Question #2: Is it repeated?

While there are other structures we will see later that seem to be aligned with special solar days like solstice and equinox, there is nothing else in Mayan culture like this, and the Mayans left behind a LOT of cities and buildings. So the answer here is mostly "no."

Question #3: Written evidence?

There is no written evidence at the site itself or any surviving writings linking the temple to an alignment with the Sun. However, on each of the four sides of the temple, there are

exactly 91 steps, and if you add the top temple floor as a last "step" that adds up to 365 steps, which suggests a solar calendar of some kind. So the answer is mixed.

Question #4: Accuracy?

The hierophany of the snake ascending into the heavens is actually visible on the north face of the temple for a few weeks on either side of the equinox, so there isn't one particular day that stands out for a unique spectacle. So the answer here is also uncertain.

So what do we conclude about El Castillo? Is the alignment intentional or accidental?

If you remember much about your reading concerning science and philosophy, you will not find this answer surprising:

WE DON'T KNOW!

Further research into questions 2 and 3 may eventually push us one way or the other to certainty about a "yes" or "no" answer, but right now, it would not be scientific to offer a conclusive answer.

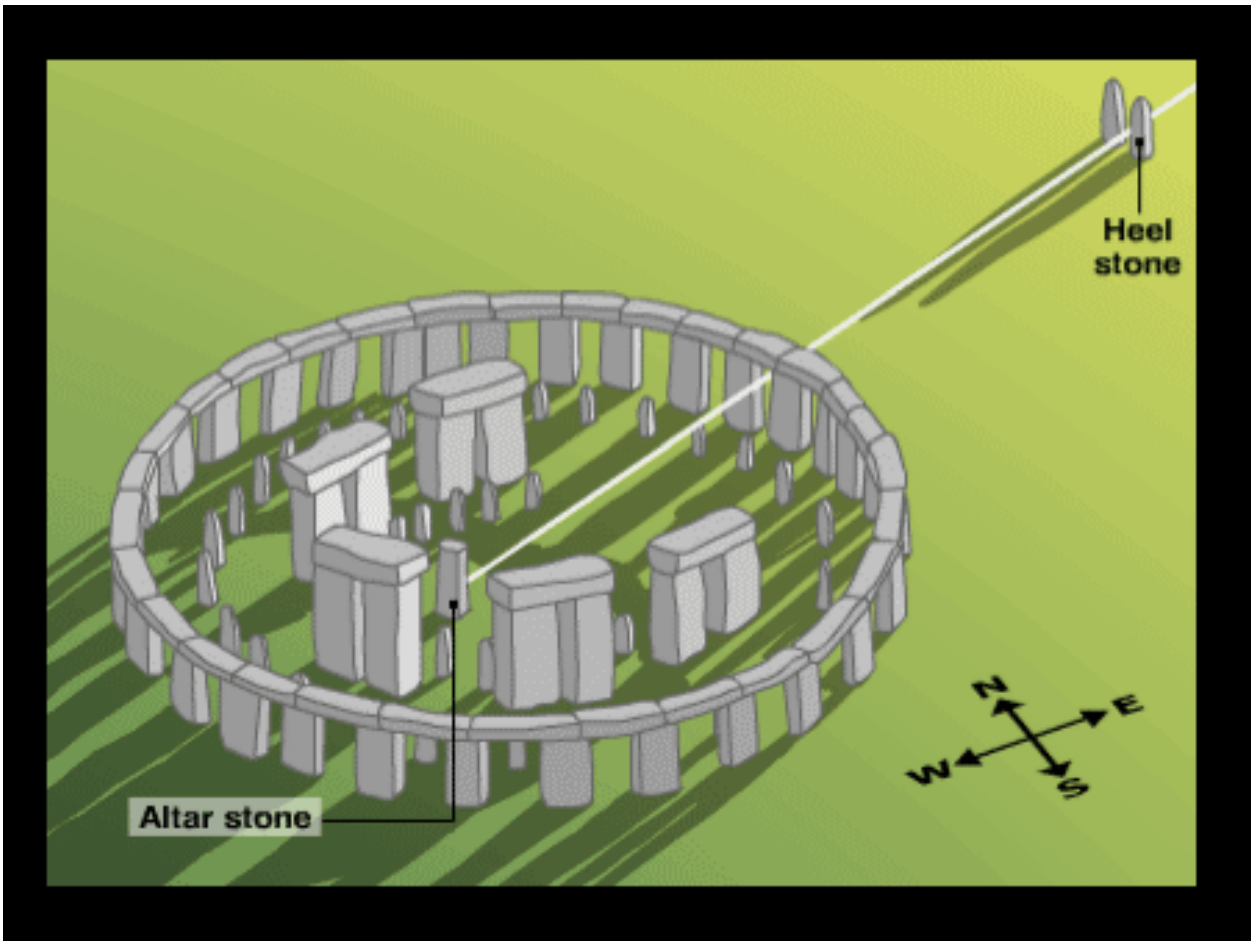
Case Study #2 - Stonehenge

Ah, Stonehenge. Isn't it magnificent? When first constructed, it looked even more impressive, as seen in the reproduction on the next page.

If you stand near the center of the stone ring at the altar stone, and you look out toward a prominent pair of carefully placed stones in the distance (only one of which is still there, called the heel stone, but evidence in the ground next to it tells us it had a companion stone), it points quite accurately toward the rising of the Sun on the day of summer solstice.

TCU has its own version, known as "Frog Henge" just outside of the Bailey Building, across University to the West of our SWR building, it is the School of Education's main building. It has a "recumbent" altar stone (a rectangular shaped stone on its side), flanked by two standing stones, and then a loose stone ring. There are a few outlying stones that align with the altar stone in directions that are intended to be significant to TCU's culture and history.

You can read more about Frog Henge at https://bit.ly/3dfORGc if you are interested, but it won't be on the exam!



So let's put Stonehenge to the test and ask our questions:

Question #1 - Is the alignment significant?

YES! Alignment toward the summer solstice is one of the most common alignments found across all cultures. When found, we usually default to a position that the alignment is intentional.

Question #2 - Is it repeated?

YES! Throughout Great Britain (and especially Scotland), there are hundreds of stone circles (sometimes called megaliths or megalithic circles), none quite so impressive, but the circles are everywhere, and they all share a similar alignment toward summer solstice.

Some examples are shown on the next page.

Question #3 - Written evidence?

The builders of Stonehenge had no comprehensible written language to guide us, so the answer here is “no.”

Question #4 - Accuracy

I cannot speak about the accuracy of the other sites, but Stonehenge’s alignment is good to within a degree.

So, is the alignment of Stonehenge intentional or accidental?

VERY LIKELY INTENTIONAL.

Like most scientific questions, you have to get used to the fact that absolute certainty is rare in any scientific endeavor. When you mix in our imperfect understanding of ancient cultures, Stonehenge is about the best case you will get. If I had to put a number on it, which is really kind of preposterous because its just my opinion, but I would guess around 95% that yes, it is intentional.

On to the next case study!

Case Study #3 - Pueblo Bonito in Chaco Canyon

One of the nice things about these online lecture notes is that I can indulge myself in little side narratives even more than during lecture because there really is no time limit! So please allow me to tell you a little bit about how to travel to this place (it is one of the most extensive and easiest archaeoastronomy sites for those of us in Texas to visit), even though I already told some of this story in lecture. That way you'll have it written down somewhere in case you ever decide to go.

This short travel guide won't be in the study guide or on the exam, so if you want to skip ahead to "BACK TO LECTURE NOTES", feel free. It won't hurt my feelings if I don't know you did it.

Ok, so if you ever want to go, you can start from Albuquerque, NM and drove north along I-25 for about 30 minutes until you get to the turnoff for West highway 550, which is a beautiful drive. About 90 minutes on highway 550 gets you to the Chaco Canyon turnoff, marked by this sign:

Just 21 miles to go, but it will take you maybe more than an hour to get there, depending upon how much damage you want to do to your car and whether you want to risk sliding off the road into a ditch. I recommend a rental car for this trip, maybe spring for the damage waiver, too.

They really mean it when they say no gas, no food, no lodging. You really only want to stay until after sunset if you are planning to camp out. And the campsite does have a central bathroom/shower complex, but everything is else is primitive and requires reservations in advance.

There is an excellent visitor center at the entrance to the park, and they do have a couple of different ranger-guided tours you can sign up for. However, if you really want to learn in depth about what you will be looking at, a native guided tour is definitely the way to go. Contact the Salmon Run Museum in Bloomfield to arrange a day-long tour. It will make your time

spent in Chaco much more informative and fulfilling. There is SO MUCH there that you would miss otherwise without knowing where to look and what it means.

I went to research this place in Summer 2019, and I got some great insights and photos I will share with you.

BACK TO LECTURE NOTES

So as you get close to the entrance to Chaco Canyon, the most impressive sight to see along the way is the famous Fajada Butte, home of the Sun Dagger spiral petroglyphs.

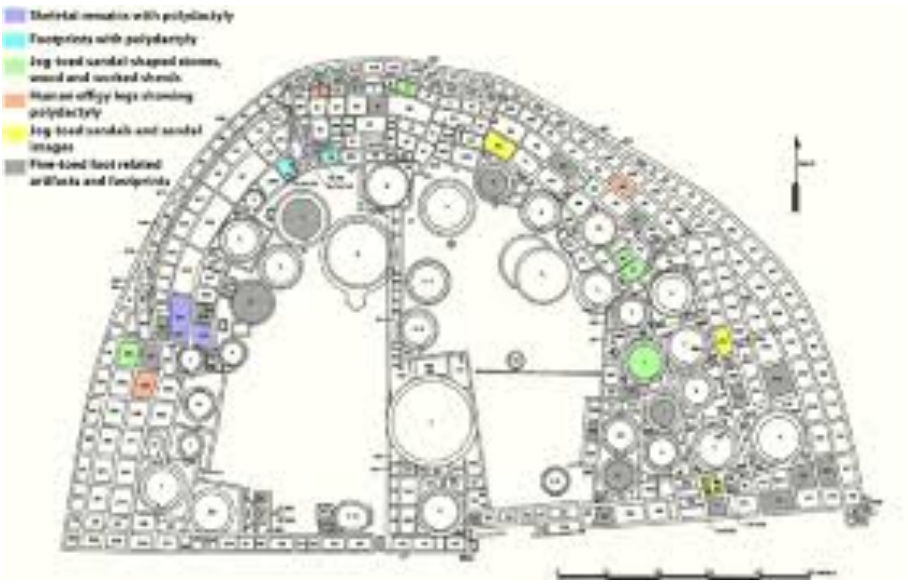
In this photo, the petroglyphs are located at the top of the formation, not in sight from this side of the Butte. The Butte is closed to hikers, in any event.

Already, the site has been visited so many times since the 70's that the foot traffic has caused the rock formation to shift slightly, meaning the original sun daggers first seen there on summer solstice are no longer visible.

One of the most impressive structures in the Canyon is Pueblo Bonito, shown here with a photo taken from the north rim of the canyon. Note the long, straight east-west well and also the shorter north-south wall that sort of cuts the main flat area (the plaza) in half.

The little round areas within the pueblo are called kivas, and you have learned about those in your homework reading. Also visible are some of

the hollow square chambers we learned about in the film. Below is a north-south-east-west diagram of the complex:



At the bottom is the east-west wall that is aligned with the equinox rise/set of the Sun. So let's ask the question: is this alignment intentional or accidental?

Question #1 - Is the alignment significant?

Although this isn't a solstice alignment, Pueblo Bonito still seems to be aligned with the Sun in two ways. First, the east-west wall aligns with equinox sunrise and sunset. And the north-south wall, shown to the right from my own trip journal, lines up with the sun when it crosses the meridian (my photo was taken close to noon, so the shadows are very short).

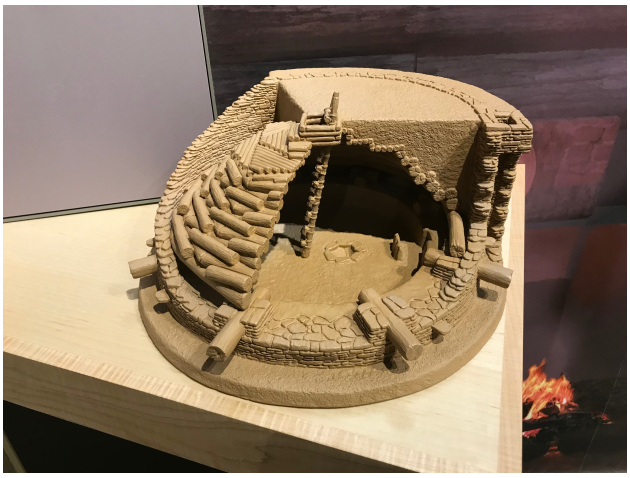
So the answer here is a qualified "yes" that there is a solar alignment at Pueblo Bonito.

Question #2 - Is it repeated?

Yes and no. There are no other major structures with precisely the same alignment as Pueblo Bonito. However, there are many kivas nearby (like Casa Rinconada on the south side of the canyon, shown below) that are also oriented with a north-south or east-west axis. Below is a photo of Casa Rinconada, looking toward the North and Pueblo Bonito across the canyon.

Casa Rinconada is an example of a "grand kiva" about 20 meters in diameter, capable of holding hundreds of people at a time. There are perhaps other astronomical alignments built into this structure, such as certain alcoves in the wall illuminated by the rising sun on certain days of the year (like solstices), but those are less clear and beyond the scope of our current discussion.

A quick side-note about kivas: what we see today is just a circular hole in the ground, big or small. A small kiva within Pueblo Bonito is seen on the next page. But when these kivas were originally built, they looked very different!



This is one of the kivas within Pueblo Bonito, and next to it, a cutaway of what the unseen upper portion of the kiva looked like. You can see that the rocky rim of the kiva we see today is only the foundation of a much more elaborate structure with a dome-like roof made from wood and mud, a hole in the center of the roof like a chimney, and a ladder for entry/exit.

Anyway, there are many other structures within Chaco that also appear to have alignments towards the equinox directions or the solstice directions, but there is no definitive pattern that is easy to discern, so the answer to this question is probably yes. The theme of Sun-oriented buildings in and around Chaco Canyon is repeated.

Question #3 - Written evidence

As we saw in the film (and I asked about in study guide #78), there is no written language supporting the alignment, but there are petroglyphs nearby. The most famous one is shown to the left. See how the semicircle at the bottom is asymmetric just like Pueblo Bonito? And it has an arrow pointing through it pointing to the South toward the spiral glyph that represents the Sun. This indicates someone knew the layout of Pueblo Bonito and commemorated it in a rock carving. That suggests the alignment is intentional, not to mention the many other petroglyphs nearby that also seem to mark solstice or equinox in some way.

Question #4 - Accuracy

The alignments are accurate to within a degree for Pueblo Bonito, so the answer is yes.

So, what's the verdict? Intentional or accidental?

VERY LIKELY INTENTIONAL!

Like Stonehenge, there is quite a bit of corroborating evidence supporting the case that the alignment is intentional. The Ancestral Pueblo clearly had an intimate relationship with the sky, and this is perhaps the clearest example of that.

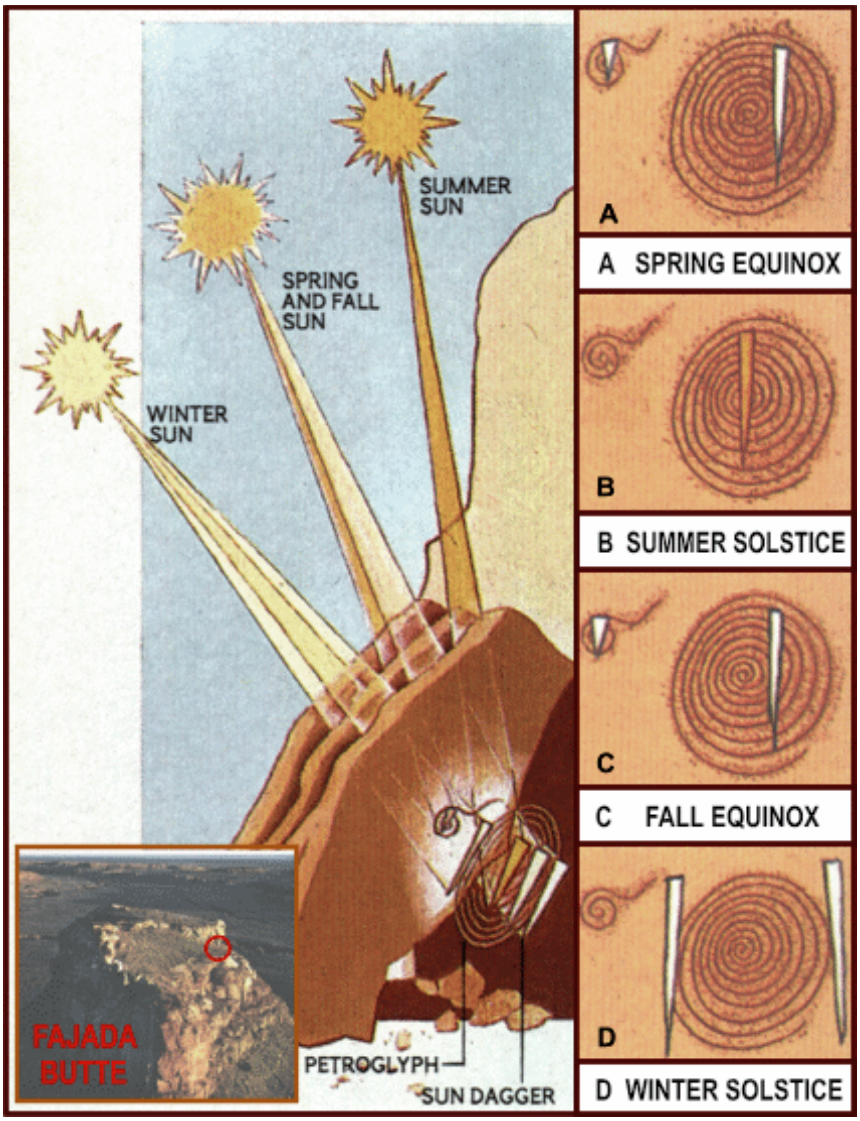
Onward!

Case Study #4 - The Sun Dagger Petroglyph in Chaco Canyon

Although we got to see this briefly in a film before Spring Break, it would be a good idea for you to watch a short (4-minute) video to refresh yourself on what exactly is happening at this site when we are talking about alignments. Visit:

https://tinyurl.com/s3m7n29

Watch the short video there, and note the patterns of sunlight and moonlight on the spiral petroglyph during solstices, equinoxes and standstills. I will be asking about those in the study guide questions. See also the image below.



This is a rather complex alignment, marking out solstices, equinoxes and even perhaps lunar standstills all at the same time! Let's see how we answer our four questions and where the Sun Dagger is found on the spectrum that ranges from intentional to accidental.

Question #1 - Is the alignment significant?

The solar alignments, yes. The lunar alignments are more questionable. At this time, there are arguably ZERO archaeological alignments with lunar standstills found anywhere in the world, at least where such alignments have made a very convincing case.

As an aside, there was an archaeologist who claimed to find lunar alignments among the rocks at Stonehenge, but his work has been largely discredited. And this pattern has been repeated at many sites around the world when lunar alignments are supposedly discovered. So we treat claims of lunar alignments with extreme skepticism in part because of that history and in part for reasons I discussed earlier when I ranked lunar alignments low on the significance list WAYYYY back on page 4 of these notes.

Question #2 - Is it repeated?

As with the Pueblo Bonito case, you could argue that solar alignments are certainly repeated in petroglyphs (that are bisected by light and shadow on equinox days, for example) on Fajada Butte and buildings throughout the Chaco Canyon region. So the answer here is a qualified yes, though there is nothing that seems to mark EVERYTHING (both solstices and equinoxes) quite like the Sun Dagger appears to.

Question #3 - Is there written evidence?

Not explicitly, no. Nowhere else is there any indication of what the Sun Dagger petroglyph is supposed to be. There are many spiral petroglyphs throughout the Chaco Canyon region, but not all of them appear to have any special connection to solstice or equinox.

Question #4 - Accuracy

The light and shadow patterns do seem to have some relation to the spiral patterns in the cliff face. A related question to this issue, though, has to do with the three vertically standing

stones that create the light/shadow pattern. Did they just fall into place and create the light/shadow pattern that was then commemorated after the fact? Or were the stones deliberately placed there and their edges carved with tools to create the patterns we see? This one will be difficult to answer since the site has been altered rather dramatically by a large amount of foot traffic in the 2-3 decades after its discovery (the site is now closed in a belated attempt to preserve what remains).

So the verdict here is not quite as resounding as with Pueblo Bonito. It does seem likely that this was some kind of sun watcher station. Such places were often remote from settlements and had petroglyphs to help the observer determine important dates in the calendar year.

Now for one more case study in this region of the United States…

Case Study #5 - Chimney Rock in southern Colorado

This site is located about 15 miles West of Pagosa Springs, Colorado, a short drive along highway 160. While the twin spires of Chimney Rock can be seen from the highway, if you want to hike up to the top of the adjacent mountain, you'll need to take a marked turnoff that takes you to the Visitor's Center on the south side of the highway, south of the ridge that contains the rock formation.

From above, Chimney Rock (the spire to the left) and its companion spire are not very close together. However, the top of the hill in the lower right of this photo has a small pueblo on top, complete with a few kivas and living quarters. As seen from that hilltop, the two rocks appear very close together with a narrow gap between them.

The view from the ridge top pueblo is shown here to the left. In the gap between the two rocky spires, if you happen to be on top of that ridge for the full moon rise near winter solstice (the northernmost lunar standstill), you will see the moon rise in that gap for a 3-year span very 18.6 year lunar cycle. It rises closest to the center of the gap when it is at a major lunar standstill, the northernmost full moon rising point in the Moon's 18.6-year cycle.

The question: Was the hilltop pueblo on the adjacent ridge intentionally built there in order to observe and commemorate the major lunar standstill?

This image shows the full moon just starting to rise between the two spires during winter close to one of the major lunar standstill dates.

An overhead view of the Chimney Rock Pueblo on top of the adjacent ridge. You can clearly see two kivas here and a few rectangular chambers similar to those found in Pueblo Bonito. Pit houses and other living quarters are found in the more spacious area below the ridge in the surrounding forest.

Question #1 - Is the alignment significant?

Not really, no. Even in cases where we know cultures tracked eclipses of the Sun and Moon (and so might have reason to closely track the Moon's motion), we haven't found any lunar standstill alignments that have held up to scrutiny. Here, we have no evidence the Ancestral Pueblo were in the business of tracking or predicting eclipses, and it is hard to imagine any other reason they would want to track small variations in the direction of full moon rise over many years.

I also think it is important to keep in mind that the lunar standstill can only be observed in the middle of winter, when conditions on this high ridge in southern Colorado are far from ideal. When I visited there during the Summer of 2018, the full moon rose nowhere near the spires.

That doesn't mean the alignment is not valid or intentional, just less likely to be intentional.

Question #2 - Is the alignment repeated elsewhere?

The architecture of the Chimney Rock Pueblo clearly borrows heavily from similar architectural designs found in Chaco Canyon, which is about 100 miles due South from here. So you could argue that if you believe the lunar alignments found in the Sun Dagger in (more speculatively) between pairs of buildings in Chaco and outlying regions (as the film "The Mystery of Chaco Canyon" claimed), then the answer would be yes, there are other places within the same culture that may have also marked the lunar standstill.

Question #3 - Written evidence?

No. Unlike the Chaco Canyon region with a great many petroglyphs and potential alignments, there is nothing like that around Chimney Rock Pueblo.

HOWEVER!

There does seem to be some intriguing evidence "written" into the buildings themselves by nature. We can analyze the tree rings of the fragments of wood used in the construction of this Pueblo to deduce precise years when those trees were harvested and then used. In the case of Chimney Rock Pueblo, there appear to have been a few years in which a lot of construction took place, then long periods of no activity.

Those years when the most construction took place were 1011, 1018, 1076 and 1093. The latter three of those dates coincide with the Northern major lunar standstill. A little weird that they would complete construction in two phases almost exactly 18.5 years apart (remember, the alignment is visible for a year on either side of the standstill as well, so there is some wiggle room in these dates). You might imagine they waited to build until the Moon showed them it was the right time.

Question #4 - Accuracy

It's hard to blame nature for the moonrise being visible for a year on either side of the actual lunar standstill in the Chimney Rock gap. Nevertheless, it does make it a little bit less likely that the Pueblo nearby was constructed with the intent being to commemorate the major lunar standstill. It is not a "precise" alignment, in other words.

So the verdict for Chimney Rock is mixed. Of course, if you go to the Visitor's Center, that's not necessarily the story you will hear or read about, but in the academic literature, the opinions are quite a bit more reserved and skeptical on this matter. At best, it's a 50/50 case in my opinion.

I will say, though, that like Pueblo Bonito and Chaco Canyon, it is a really neat place to visit. If you happen to time your visit near full moon, then I HIGHLY recommend you try to visit the site near sunset so that you can attend their special sunset/moonrise program. You can watch a beautiful astronomical spectacle in the sky while listening to stories and songs about the Ancestral Pueblo in the region.

The visitor's center website with the calendar of events (so you can see which days the full moon rise ceremonies will be held) is found at http://www.chimneyrockco.org/ . There is a little bit of a climb along a steep path to get to the top of the ridge, but when I was there, people of all ages were able to make the climb fairly easily. The climb down is actually a little tougher, but also manageable.

One last case study to go…

Case Study #6 - The Governor's Palace at Uxmal

I was originally going to show you this as well as a more detailed study of the Cahokia Mound (you read about the nearby Cahokia Sun Circle back in Chapter 2 of Echoes and I asked about it in study guide #22) in a recent PBS documentary, but I have not found a way to stream it for free for all of you. Nor can I be sure you could all access the stream even if it were free, but I will at least cover the Governor's Palace.

This building is called the Governor's Palace at Uxmal (pronounced Oosh-mahl). This shares a potential astronomical alignment with the Caracol of Chichen Itza, which we explored earlier in Echoes Chapter 2 (study guide question #24) and saw in the film "Tools of the Maya".

What you are seeing in the photo above is the front side of the building, which faces a bit South of East. Across from the building is an altar and a platform, both of which once held elaborate sculptures, as seen on the next page.

Above is a view from inside the main entrance of the Governor's Palace, looking out toward the southeast, over the platform and altar just across the plaza.

To the left is a wider view just outside of the Palace doorway, and the arrow at the top of the image points to a distant pyramid on the horizon known as Cehtzuc. Amazingly, if you follow this line of sight, it points to the maximum southerly excursion of the planet Venus, which rises exactly over that distant pyramid exactly every 8 years.

Authors have argued over whether the alignment may be reversed, and it is really the pyramid that is supposed to be the viewpoint toward the Governor's Palace, which reveals the northernmost excursion of Venus. When Venus sets at this location in April every 8 years, it is the beginning of the rainy season in this part of Central America.

So that's the purported alignment. Is it real?

Question #1 - Is the alignment significant?

Planetary alignments are at the bottom of my list (covered back on pages 4-5 of these notes) of significance for reasons I gave there. However, for the Maya, we have reason to believe that Venus was significant (recall study guide questions #66 and #69 from the film "Tools of the Maya"). Reason enough to move Venus up the list, perhaps, to a place of more importance.

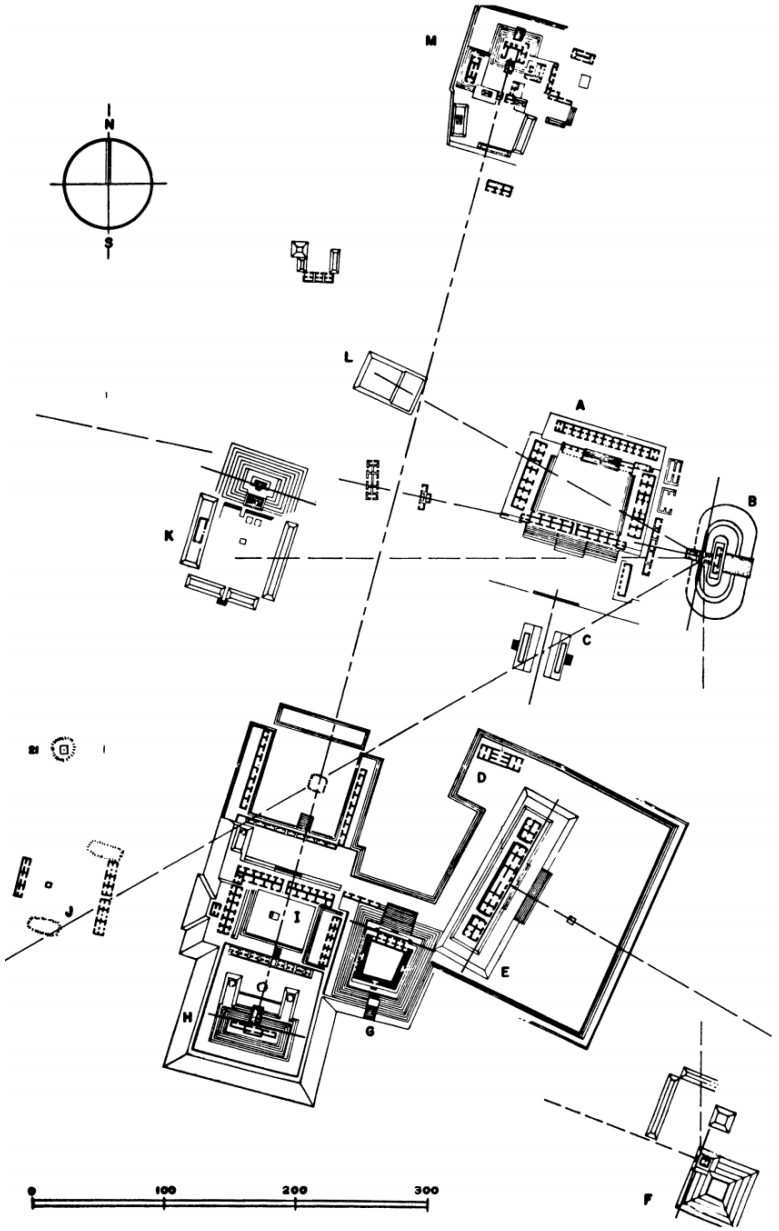
Question #2 - Is the alignment repeated?

As we saw when I asked you to read about the Caracol (and we saw it in the film), we have reason to believe that building also has an alignment with the excursions of Venus, so the alignment is arguably repeated elsewhere, although only in one place for sure (there are a few other places under study). It's not the kind of consistent repetition we saw with Stonehenge, for example, but it's not a definite "no" either.

Question #3 - Written evidence

The Governor's Palace has **OVER 350** different glyphs signifying the planet Venus (and several depicted their rain god, which is why some argue for the reverse alignment heralding the rainy season) as well as the number eight (the number of solar years in the Venus cycle).

Moreover, look at an overhead view of the entire site on the next page…



The skinny rectangular building on the lower right is the Governor's Palace. Note how its direction of orientation of clearly skewed quite a bit compared to the other nearby buildings, which all share pretty much the same alignment. This is reminiscent of the way the Temple of Kukulcan is skewed in orientation a little bit compared to its surrounding buildings, suggesting some sort of intentional orientation.

Question #4 - Accuracy

The alignment is accurate to less than one degree, which is really good considering the two buildings are about three miles apart.

So is this an intentional alignment?

Sorry, you know better than to expect definitive answers by now, I hope, but my unsatisfactory answer is probably yes.

If so, it would be a rare find to see an ancient structure intentionally aligned to a complex planetary motion! But on balance, the evidence seems to point to an intentional alignment. If so, what an amazing accomplishment of engineering, and it gives us some insight into just how important Venus was to these people.

The effort involved to make this alignment and carve all of those commemorative glyphs was astounding, and it potentially teaches us a bit about the Mayan view of cosmology and the importance of heavenly motions to them. It also speaks to the significance of calendrical events that were well known to the social and political elite.

Such alignments as Uxmal were perhaps constructed to share this knowledge of alignments in a way the masses could easily experience for themselves, bringing together people who were otherwise from different social or cultural backgrounds. That's a primary function of calendars in most societies, as we will see in the next set of lecture notes.

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This concludes part 1 of our lecture notes for study guide #3. I considered adding in a section here about the Irish tomb of Newgrange as another case study, but I have nothing really to add about that site other than what you have already read in Chapter 5 of "Echoes of Ancient Skies". You might want to revisit your notes from study guide question #75 and revisit the chapter in light of what you have learned from our questions and case studies. See if you can form your own conclusion about Newgrange!

We will see other case studies as we explore further into our outside readings as well.