Astronomy Cast 216 for Monday, January 17, 2011: Archaeoastronomy

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Fraser: Welcome to Astronomy Cast, our weekly facts-based journey into the Cosmos, where we help you understand not only what we know, but how we know what we know. My name is Fraser Cain, I'm the publisher of *Universe Today*, and with me is Dr. Pamela Gay, a professor at Southern Illinois University at Edwardsville. Hi, Pamela how are you doing?

Pamela: I'm doing well, Fraser, how are you doing?

Fraser: I'm doing great. It is still really cold and snowy, so we can't go outside yet, but that's going to be changing soon. OK, so this week -- we don't have a lot of time so we gotta roll! The sun moon stars and planets are visible with the unaided eye, so there were astronomers before recorded history, but some of the earliest records we do have tell us what the ancient astronomers thought about the heavens and how they used the changing night sky in their daily lives. Let's look at archaeoastronomy. Archaeoastronomy? It's like archeology and astronomy. Is it archeologists who like astronomy? Or is it astronomers who like archeology?

Pamela: It's like one of those bad interdisciplinary fields where everyone lays claims to it, and so you really have to be good at all of it to be good at the field. So you have…even anthropologists get thrown into the mix, but that then becomes a word no one can say.

Fraser: Sort of an Indiana Jones with a telescope?

Pamela: Exactly!

Or a [missing audio] with a bullwhip?

Pamela: Not so much…

Fraser: OK, so can you give us some examples, then, of what would…are we talking about buildings, documents…what is Archaeoastronomy?

Pamela: Generally, it's a matter of talking about something that is physically built that allows you to use the structure itself to make

predictions to make measurements about sky phenomena, so the classic examples are the "spiral and dagger" that is seen near Chaco Canyon in the American southwest. This is a place where sunlight passing between two rocks makes a dagger of light that, on different special days of the year, either appears just beside a spiral on one side or the other, or pierces it directly through the center. And these alignments only occur on the solstices and equinoxes.

Fraser: Oh, but this isn't a natural structure. Some hard-working rock chisellers went out and actually figured out the math, lined things up and then cut the holes.

Pamela: This is actually probably something that required even more patience than that -- where someone noticed, "Hey, these two rocks make this dagger of light. Let's mark in (whatever the Stone Age equivalent of pencil is) the location of that dagger on this equinox, on that equinox (well, the equinoxes will be in the exact same place), on the winter solstice and on the summer solstice…" and then very carefully, once they had figured out where the dagger was on these three extremes of most northern, most southern and central position, let's carve a spiral into the rock to denote *when* those locations occur.

Fraser: I've never seen this, so maybe you could kind of give people a picture of what this…maybe people in the U. S. are more familiar with it, but I've never even seen a picture of this. What does it look like?

Pamela: So, you're looking at a rock, well it's the inside of a cave, and the way the sunlight comes through, there's a spiral pattern carved into the rock, and just like any spiral, there's a central point and then it curves outwards and forms basically – it's round -- and on the winter and summer solstices, the dagger of light appears just touching one edge or the other of the spiral, and then on the equinox (in both equinoxes the sun is in the exact same place), that dagger of light pierces exactly through the center.

Fraser: Wow! So, can you give us some other examples? I mean, there are some pretty famous ones, right? Stonehenge, the Pyramids…

Pamela: Those are the two big ones that everyone points to, and what's interesting about Stonehenge, in particular, is it's an example of where we do archeo-astronomy without having any social context for trying to

understand what we're looking at. Archaeoastronomy…there's two general ways to do it: you either start from, "I have a giant something I don't understand," and you try to find astronomy references within it using statistics, or you start from the, "I know Venus was culturally very important to this society," and you look for references to that particular thing that you know was important. So you're either looking for astronomy within the context of the society, or you're trying to find astronomy to *give* you context to the society. So these are two different ways of doing it, and Stonehenge is the, "Wow! This is kind of awesome! I wonder if it lines up with anything?" and it was very quickly realized that, yes, there are summer solstice alignments with the heel stone in Stonehenge. And people since then have been looking for all the possible alignments you can find between "Stand here, look there -- ah look, there's the sun, a planet, a star…"

Fraser: And so what is the event? If you wanted to go to Stonehenge on the right day and really appreciate its use as an astronomical tool, what day and what would you be seeing?

Pamela: Well, the big day to go to it that everyone goes to it -- and I've been there the day after, but not the day of is the summer solstice -- and this is because of the sun's rising position directly over the heel stone…the place, Stonehenge, is a lot smaller than you think of it. The rocks are huge, the circle is huge, but the place that it's located is wedged between the north-south or east-west, I forget the directions of the highway…it's kind of odd…so you'd be crammed into this area between the two directions of the highway, along with a lot of people who smoke interesting things.

Fraser: Great…

Pamela: …and potentially are dressed as druids or wiccans, and then, of course, you have all the photographers who are there and all the scientists that are there, so it's highly chaotic; but nonetheless it's the kind of thing that, looking at all the photos and being there the day after or the day before, can give you a real appreciation for: "That is a giant well-aligned rock." And make you wonder just how is it that the ancient people were able to do the things that they did.

Fraser: Making sure that rock was lined up with the sun on the summer solstice was clearly very important to them.

Pamela: Right. It's one of these things where we can't even figure out exactly how they moved these rocks. And then the idea of using a system of pulleys, and logs, and rope…basically, you dig a hole dig a hole dig a hole, stand the stone upright in the hole, and once it's standing up, you're looking at leaving the entire village to adjust how it's standing in that hole -- and it's a perfect alignment.

Fraser: So Stonehenge is one great example, and I talked about the Pyramids as well, which is, again, on an even grander scale…

Pamela: And with the Pyramids, it's potentially even a double-alignment. You have, on one hand, the directions of the Pyramids are exactly lined up with the Cardinal points, and this is to within all observable limits of the human eye...

Fraser: Sorry, Cardinal points, what does that mean?

Pamela: North, South, East and West...

Fraser: OK so, what is it – the corners are North, South, East and West?

Pamela: The sides.

Fraser: So if you draw a line from two corners, you'll go North-South, and if you draw a line from the other corners, you'll go East-West?

Pamela: Exactly. So one of the really neat things you can do with the Pyramids is just go to Google maps and type in "Pyramids of Giza," and when you look at them you can see, "Wow! The edges are exactly North-South – exactly East-West!" And then when you look at the 3 pyramids (the 3 big ones), they form this slope. And when you look at them, yeah, you can go "OK, they're exactly lined up neatly on diagonals," but the other thing that people say is that they were designed to look like the belt stars of the constellation Orion, so what the ancient Egyptians were actually building was the belt of Orion when they put these three pyramids where they put them. Now, it's not known for certain if this is exactly what was intended, but it's just one of those neat things to look at on Google maps and go, "Huh, yeah, I can see that!"

Fraser: If they had more time to build more Pyramids, then they could have had the shoulders and the feet and the sword, and the shield…so yeah, I guess they just didn't really commit.

Pamela: Well, considering how big those suckers are, I'm not sure that you really need to worry about commitment issues.

Fraser: Have you ever seen them?

Pamela: Yeah, I was actually there. We actually left Alexandria two hours before the New Year's Eve bombing; so I was there, and if can find the picture, we can post the picture of me, a camel, and a pyramid on the website. They're really quite impressive to see, but if you do visit the Pyramids, take a tour guide who speaks Arabic and will stick to your side because the Pyramids are surrounded by people who are going to try and sell you things, and it's very overwhelming.

Fraser: Yeah, you gotta learn "Leh, shokrun," -- "No, thank you." OK great! So the Pyramids are another one, but there are ancient buildings around the whole world designed for astronomy. These are just a few examples. Let's have some more.

Pamela: The other really neat example that I particularly like to use is… I'm going to mispronounce it…it's the "Chichen Itza." I can't say it -- I'm just going to let you say the word for me. It's this ancient observatory, and when you look at it, you're like "Wow! That's an observatory built out of stone, except the dome doesn't rotate!" And the building was set out with slits in the dome that allow you see when different things line up. So the way the dome is designed, it's not good for letting in light, but it is good for saying "Aha! *That* is lined up *there* now; therefore, I know *when* I am!"

Fraser: So, it's in Mexico, right?

Pamela: It's in Mexico, and it has a lot of sites on it that are related to the planet Venus. This is an old Mayan relic. Venus is one of the particularly important stars, whether it was (not stars, planets)…whether it was up as an evening object or a morning object. And one of the neat things about Venus is you can trace its pattern on the sky by taking observations at the same time everyday, and depending on exactly where Venus and Earth are

in their orbits, you get different snake-like patterns, and so the path of Venus on the sky from night to night to night during each of its appearances is traced out in a whole variety of different Mayan relics.

Fraser: OK, I see, and so they would take that path that you would trace, and then they would make it look like a snake and have it be embedded in some other object.

Pamela: So, it was often feathered serpents, and this was how they viewed it. And it's one of those things where you've got to imagine how they tried to piece together what Venus was because it's this object that only appears – it was two different objects to them – it only appears either right after sunset or right before sunrise, and it's so amazingly bright, but it never hangs around the entire night, and both objects are never up at the exact same time, and so it was seen as two different sides of, basically, a god depending on which culture you were in.

Fraser: But some of them did figure it out, I mean, they realized that it spends some time in the night, then it spends some time in the morning and then it sort of lines up, so if you were going to use Chichen Itza, then you would be able to -- what? -- see through a hole at a certain time and see Venus, and then be able to know "OK, it is this day in the Mayan calendar?"

Pamela: Well, we're still trying to figure out how you use it. That's one of the problems that we run into. This is an example of where we're understanding astronomy within the culture of the people. So we look at the building; we see the orientations of the building relative to north, south, east and west. We look at the carvings on the building; we see references to Venus. We look at the slots; you can tell the slots are designed for lining things up, and we're not entirely sure *what*. It's a challenge! We're still trying to figure out all these different details. We do know that there are places where, if you're standing on the right platform, and you're looking past the right pillar, it lines up with Venus when it's a morning or an evening star, but it's not particular to a time on the Mayan calendar. It's not necessarily particular to a certain orbit, but the alignments are there.

Fraser: Hmm…so then, astronomers would look at this from one point of view, I guess, and they would say, "What did they know then? What parts of modern astronomy did they ancient people have figured out?"…[missing

audio] and so on, but I can't imagine astronomers going the other way and saying, "What do these things tell us about the people?"

Pamela: And this is where it ends up being two different areas of archaeoastronomy. With things like the Nazca Lines, which are these giant lines in the Atacama Desert that trace out spiders and geometric figures…

Fraser: Yeah, Google map them. I mean, you can see them; they're pretty neat! They are like these enormous, almost like roadways, ground into the desert -- in the Atacama Desert --visible from huge altitudes, and these really elaborate shapes. They're quite amazing!

Pamela: And the thing about the Nazca Lines is you have to be in an airplane to see them. There's a monkey, there's a spider, there's a chicken, there's all kinds of crazy geometric shapes, there's birds and no one's quite sure why, and the way they're made. Different scientists have tried to replicate them, and it's actually not that hard once you figure out how you want to shape the lines. It's just a matter of going through and moving the stones to make the shape you want, so if you can imagine making crop circles, or something…all you need is rope and something to bash down the corn, and you can make any shape you want, but you can't see what shape you're making while you're in the cornfield. Nazca Lines are the same thing. All you need is a rope and a plan and you can make any shape you want, just by moving rocks around. And so, in trying to figure out why, one of the theories that was come up with is, "Well, maybe the head of the spider lines up with something? Maybe the tail of the monkey lines up with something…" And so people have looked for astronomical alignments, and what's been realized is that if you take any one place to stand, and any one thing to line up with on the horizon, and you run simulations, you can always find at least one day of the year that a really bright star or planet aligns with that particular position and place on the horizon, and that makes understanding a lot of this stuff hard because you have to ask yourself, "What's chance and what's on purpose?"

Fraser: Yeah, I mean is that likely? I mean, could you take any object? Could I take a kids' jungle gym and stand at the various corners of it outside and line up with stars and planets? I mean, is it unlikely that you're going to get that kind of a situation?

Pamela: If you start to narrow it down and say "an alignment only on the

solstices and equinoxes," if you start to say "only with planets," if you start to say "only with certain stars of known ethnic importance" – so, like the star Sirius has importance in several societies, then it starts to become a matter of, "No, chance alignment isn't likely," but if you open it up to any day of the year, and any star that is third magnitude or brighter, you can pretty much find alignment with anything if you open up the calendar wide enough.

Fraser: But I think you touched upon something that is really important there, which is that if you find some kind of structure and it lines up with Sirius, for example, perfectly on the winter solstice, maybe, then that really tells you that Sirius is important to that culture. Then you can start digging to find some references to it. So you can see how the archeology will help you, and then knowing the astronomy will then help you find something out about the culture.

Pamela: And this is where it's been so neat looking at Mayan ruins and seeing the "snakes" that mark out the path of Venus in the sky, and this is where it's been so frustrating with Stonehenge trying to figure out, "Well, there's been 165 different alignments found, and there's a 50/50 probability that that's chance," and so trying to figure out what's chance and what's real, and things like: there's a set of holes at Stonehenge -- the Aubrey holes -- and you can come up with all sorts of crazy ways to move rocks from one Aubrey hole to the other Aubrey hole that could predict solar eclipses, lunar eclipses, star cycles, and it's just a matter of: "Well, what do we know? Very little. What is possible? A whole lot."…and trying to infer, "Well, what was it actually used for? Here are our best guesses…" We can only go as far as our best guesses.

Fraser: I can imagine it's almost like a typewriter where all the keys are on it, and there's any combination of keys that you could be mashing, but obviously if you're a writer you can make words. But it's hard to know -- if you don't know what the outcome was -- it's hard to know how they were using it because it's so flexible with all of the holes that you could, indeed, predict almost anything you wanted if you were using it right, but at the same time, it could be that they just banged holes in them and thought that it looked good.

Pamela: And this is one of those things where an understanding of statistics becomes very important. It's very easy to say, "Well, because this city is

laid out like a grid with roads going north-south and east-west, clearly, the equinoxes are very important to this city." No, we're just boring, it's the Midwest; we lay things out as grids. It's easy to infer a lot of stuff and then if you take it one step further, and say, "and this Queen Anne Victorian house that has four chimneys…because these chimneys happen to line up with the rising of Gemini with…" and you can come up with all of this different stuff and suddenly you've created a culture that is a cult of Gemini.

Fraser: Right -- incorrectly.

Pamela: And so you have to step back and say, "OK, what is the probability, in general, of this happening by chance? What are all the other possible things that could have happened?" And it's just like the work that Simon Singh has done, pointing out that with the Bible code, you can also take Moby Dick and find all sorts of things predicted in it just be looking for chance alignments of words.

Fraser: Right, and I think this is where this whole endeavor just leads into pseudo-science and madness because, as you said, you can use almost anything to predict anything, and so you can then retro-fit it back in and say, "See? Stonehenge predicted the Great Fire of London…" you know? If you're using it right -- but it's hard to know whether a person is using it right -- you can predict almost anything. I know that a lot of the 2012 predictions, Mayan calendar, Nostradamus -- all that kind of stuff -- totally relies on that. There's so many ways that you could examine: it could be nothing, it could be an astronomical tool…who knows? You've skirted the issue, but with the Nazca Lines, if you could make a picture big enough for only an airplane to see, then they must have had airplanes, you know? [laughing], hot air balloons, or aliens…but no, they might have just said, "Let's make some great, big pictures because it's cool, and fun, and it shows that I'm rich."

Pamela: Right, and this is where we can come up with some good conclusions. We know that there are things that definitely align with the solstices. There is the marking of the summer solstice at Stonehenge. At New Grange in Ireland there's a clear marking of winter solstice. With the sun dagger, we have the solstices and the equinoxes all clearly marked in the American Southwest. We can tell that human beings like to line things up with north, south, east and west. It's just something we do.

Fraser: As someone who lives in Canada, I can tell you that when the days start to get longer, it is a good thing! You want to know that, finally, we're done having shorter nights, now it's time to have longer ones. I can see how a winter solstice is an important thing, and not that complicated, right? You can figure it out pretty easily by looking at the shadows every day, and eventually you'll hone in on the shortest and the longest days of the year.

Pamela: And to get much beyond these solar alignments, and these Cardinal direction alignments, it starts to require us to know something about these cultures. So when we look for alignments…with the Pyramids there's actually windows that only the light of certain stars on certain days do pass through and they were culturally important. With the Mayans, we see Venus replicated. So this is where when we start looking for the alignments that are statistically harder to prove; you have to understand the culture you're working within. So archaeoastronomy is a very rich and complicated field, where sometimes you're just left going, "Huh! That's interesting, but I can't prove it," and other times you're left going, "Wow! I see the same thing over and over and over and, wow! They could observe Venus!'

Fraser: And I bet with modern computers, that's really helped crunch a lot of these numbers. As you said, with statistics you can take this thing, model it in a computer, and then compare it against the night sky and start running simulations. You start to tease out statistical anomalies and say, "Hey, look at that! It *does* work for the solstice, or the Cartesian coordinates…"

Pamela: And where this has become particularly useful, is the sky isn't where it was when the pyramids were built. The sky isn't where it was when Stonehenge was built.

Fraser: That's right, and so the position of the stars, the procession of the Earth's tilt has changed all that, and so they line up with where they *were*, right?

Pamela: Exactly, and so this is one of the things that makes the Pyramids particularly amazing at how well pointed they are. There wasn't a North Star when they built the Pyramids. They had to actually stand there, watch, figure out -- based on the rotations of the stars -- where the North Pole was,

and that's a hard set of observations to make; but nonetheless, they made them and precisely aligned these giant structures.

Fraser: Wow! Alright, well that was great, Pamela. Thanks a lot!

Pamela: It was my pleasure.

Fraser: Take care. Bye.

Pamela: You too. Bye.