Air and Space this Week

Item of the Week

Hokule'a, the "Star of Gladness"

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This item was inspired by the NASM program we conducted in May, 2016, built around the arrival in the DC area of the Polynesian Voyaging Society's canoe, Hokule'a, at the end of a circumnavigation that used only traditional Polynesian navigation methods. No GPS for these super-mariners! It was a wonderful program, we used the NASM Planetarium to help demonstrate the Polynesian techniques, we had the* Time and Navigation *gallery staffed with extra experts for visitors, and we even had Polynesian music and dancing demonstrations.

Four years ago this week, I managed one of my favorite NASM educational programs. It was an unplanned opportunity, and we were able to take full advantage of it to come up with an engaging, inter-/multi-disciplinary event.

It was all about the Polynesian migration and long-distance ocean navigation.

In 2010, I had the pleasure of visiting Easter Island for a total solar eclipse. We staged through Tahiti, and were able to visit Bora Bora as part of the deal. The US Navy had constructed a supply depot and hospital there soon after Pearl Harbor. It was an important part of the supply line between the USA and Pacific/Australian bases, and was defended by its fringing reef, and a number of 8" coastal defense guns, most of which are still in position. Our guide was an interesting fellow, and he visibly puffed with pride whenever I used his name, "Rapa." I knew that "Rapa Nui" was the Polynesian name for Easter Island, since I had just been there, so I asked him about his name. He explained that, in his youth, he was known for his prowess with large ocean-going canoes, and from that had earned the nickname he now went by. Anthropologists have shown that the Polynesian people migrated eastward from the southwest Pacific centuries ago. Some made it all the way to Easter Island (because of the shape of the coastline of the Americas, Easter Island is much further east than you might expect; it's in the Mountain Time Zone!). Those that did were regarded as the best navigators and mariners, hence, being known as "Rapa" – one from Easter Island – is a great honor.

The Polynesian Voyaging Society, in 1975, built a large double-hulled "canoe," the *Hokule'a*, along traditional lines, the same design and construction techniques that got ancestral Polynesians all the way to Rapa Nui. An old-timer had been found on Sonsorol a few years before, one that had, as a young boy, been trained in the traditional Polynesian navigational techniques. He was able to train a new generation of navigators before he passed. The PVS

idea was to take this new old canoe on a circumnavigation of the Earth, and not have any modern navigation tools aboard, relying solely on the newly-learned old ways.

The voyage was a big success, and it drew a lot of attention to Polynesian history and culture. Similar voyages were held after the first, and it was one of those that gave us the opportunity for a really cool Museum program. *Hokule'a* was finishing its round-the-world trip and would sail up the Chesapeake/Potomac to the DC area and conduct public programs. NASM was contacted to see if we'd be interested in a program, especially since NASM has a Planetarium that would facilitate an explanation of the navigational techniques they were using.

We jumped at the chance! It was a wonderful program, complete with a talk by the canoe's captain built around the Planetarium demonstration and a number of other program elements relating to navigation, special tours of the "Time and Navigation" NASM gallery, and even Polynesian music, dance, and other cultural items.

The canoe's name, "Hokule'a," means "Star of Gladness."

Before I can relate how they navigated, and the significance of its name, I need to make a digression to basic astronomy.

Imagine that the Earth were transparent, and had at its core a bright light. It is a sphere, lying within, and concentric to, a spherical screen. They only markings on the Earth's clear surface are lines of longitude and latitude. The light would cast shadows of the lines on the outer screen, duplicating their pattern. Just as we use latitude and longitude to specify any point on the Earth's surface uniquely, we can also use the celestial equivalent of latitude and longitude to specify any point on the "Celestial Sphere" uniquely. To make things seem more complicated, the terms "declination" (dec) and "right ascension" ("RA") are used for the celestial equivalent of "latitude" and "longitude," respectively.

Stars and galaxies are "fixed," in other words, they have a declination and RA that do not change. Planets are so-named because they "wander" in position relative to the fixed stars. The planets orbit the Sun in more-or-less the same plane (the "Plane of the Ecliptic") which is tilted with respect to the projection of the Earth's Equator in the sky by 23.5°. This is the "reason for the seasons," but I'm not going there here.

From our perspective on Earth, the dec/RA grid on the sky rotates above us. Each star follows its dec circle in the sky just as each point on Earth's surface follows the same path in 3-space during the Earth's rotation. It rises in the same place, sets in the same place, and follows the exact same path across the sky. The only change with the seasons is the time of day that a star is on a particular point of its declination circle. These properties were well-known to a number of ancient civilizations, which built observation points and studied the rising and setting of stars and planets for religious and other purposes.

We in the northern hemisphere are navigationally spoiled, because a relatively-bright star lies very near the point in the sky to which the Earth's north polar axis projects. Polaris appears to be stationary in the sky, while the other stars pinwheel about it as the Earth rotates. If one measures the elevation of Polaris in degrees, that number is an excellent approximation of one's latitude on the Earth. (Longitude is another matter, but finding latitude is pretty easy.)

The right-hand star in Orion's Belt, Mintaka, lies almost exactly on the Celestial Equator. If you are on Earth's Equator, Mintaka will always rise in the due east part of the sky, rise vertically, pass directly overhead, descend vertically, and set in the due west. Again, the time at which Mintaka rises, passes overhead, and sets changes throughout the year, but its path across the sky does not.

Similarly, a star with a dec of, say, +20°, will rise 20° north of due east, set 20 north of due west, and pass 20° north of the Zenith in between. BUT, if you were observing from +20° latitude, that star would rise in the due east, set in the due west, and pass directly overhead.

This is the key to Polynesian navigation!

"Hokule'a" translates into English as the "Star of Gladness" and the name refers to the star we know as "Arcturus," a first-magnitude star found by following the arc of the Big Dipper's handle. Its declination is the same as Hawaii's latitude. In other words, when you are at the same latitude as Hawaii, Arcturus will pass directly overhead at some point during the day/night. If you were a Polynesian navigator making for Hawaii, you would look to the sky for Arcturus. If it culminated north of the Zenith, you'd steer north, and vice-versa. Once you were at the right latitude, you'd then steer due east or west to Hawaii. The navigators had a number of stars they would use similarly for different island destinations.

It was highly engaging to hear of these tactics while the projector operator would "move the sky" to demonstrate!

One reason I am covering the *Hokule'a* in this Item is that the program was four years ago this week, as mentioned previously. Another is that Polynesian navigation and the details of its timing is in the news.

First, let's consider what would motivate folks to board a canoe, however large, and attempt to cross thousands of miles of ocean. Was it the need for living space, a famine, escaping some sort of threat, or what? We know from archaeological, linguistic, and other evidence that colonization of Polynesia spread from west to east, hundreds of years ago.

Recently, an international team studied lake-bottom deposits on several of the islands of Tonga, Vanuatu, and the Southern Cooks for clues. They found evidence (including fecal remains) that showed human occupation began several centuries earlier than previously thought, and the timing of the arrival of humans to those locations could be linked to a period of unusually dry climate in the Tonga/Samoa region, a situation that could/world lead to food shortages for people living at those places, and hence, trigger migration attempts. Yes, people poop evidence has, once again, allowed anthropology to move forward.

Too bad we didn't know this at the time of the NASM program!

For a general description of this research, see: https://eos.org/articles/humans-colonized-polynesia-much-earlier-than-previously-thought; for the actual paper, see: https://www.pnas.org/content/117/16/8813.

For the latest on the *Hokule'a*, see: http://www.hokulea.com/vessels/hokulea

For info and educational materials relating to their 2016 voyage, see: https://www.marinersmuseum.org/hokulea-events

See the latest posting (May 8) about the *Hokule'a*: https://www.hokulea.com/34232-2

Given the importance of The Star of Gladness in navigating to Hawaii, it should come as no surprise that a song extolling the joy of having it to navigate by has been written, including ukulele accompaniment. For its lyrics and chord tablature, see: https://tabs.ultimate-guitar.com/tab/israel-kamakawiwoole/hokulea-star-of-gladness-chords-2698257.

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