

Air and Space this Week

Item of the Week

New Horizons: To Pluto and Beyond, with Style!

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January 19 was the 15th anniversary of the launch of the New Horizons spacecraft toward Pluto. It successfully returned spectacular pictures of Pluto and its moons and other data. It also successfully flew by the Kuiper Belt Object, Arrokoth, and it will visit at least one other KBO as it continues its journey away from the Sun

And here's the kicker. Remember that NASA does amazing things, and it does them with style. New Horizons is a great example.

When I was a post-Doc back in the day, at the Lunar and Planetary Institute, one of the duties I particularly enjoyed was managing the Institute's colloquium program. We'd bring in visiting speakers to talk about a variety of Solar System exploration topics. We even hosted noted scientific science fiction writer Robert Forward, as I have mentioned previously in A+StW.

One of the presentations I remember most was by a young planetary scientist from the University of Colorado who spoke fervently about the need to examine Pluto, both to complete our initial reconnaissance of the Solar System, and because Pluto and its orbit have some rather unusual characteristics. His name was/is Alan Stern.

Dr. Stern's pitch at LPI was pretty compelling, and NASA must have thought so, too, because he played an integral role as Principal Investigator for the *New Horizons* mission to Pluto!

The Proposal

Alan Stern was a graduate student when *Voyager 2* flew by Neptune in 1989, the only spacecraft to date to have done so. Like many planetary scientists, he was amazed at Neptune's large moon, Triton. Its unique cantaloupe-like surface texture was a puzzle, and plumes of nitrogen geysers were a big surprise, because nobody figured there would be a heat source capable of causing eruptive behavior. Many assumed that Pluto would be very similar to Triton, making a trip that much farther out to be less necessary.

Others, such as Stern, noticed that Pluto was an odd body, so maybe the assumption that it would be just like Triton was as bad as the initial assumptions were about Triton. At least a fly-by trip was needed to round out our reconnaissance of the Solar System and to address any surprises we might encounter there. Getting to Pluto would be a challenge, but NASA [agreed](#) to give it a go!

The Primary Mission

A big operational constraint on mission planners was time. Pluto's orbit is more elliptical than the eight planets of our Solar System. Pluto's perihelion was on September 5, 1989, and it was actually closer to the Sun than Neptune from 1979-1999. It's been moving farther from the Sun since then. Although Pluto's surface is cold at any time, the growing distance from the Sun (and Pluto's high obliquity) will likely to cause its tenuous atmosphere to "freeze out" and lie on Pluto's surface, making it more difficult to study from a spacecraft fly-by. *New Horizons'* mission planners wanted to study the plutonian atmosphere as much as anything else, so they had to get *New Horizons* there as quickly as feasible.

The calculation of the Hohmann transfer orbit from Earth to Pluto is difficult to calculate because of Pluto's orbit eccentricity. Let's just say that if you wanted to get a mass to Pluto using the least fuel possible, you'd need a couple of decades to do so and you'd likely need to wait decades for a launch window.

The tyranny of orbital mechanics and the desire to get to Pluto soonest meant that *New Horizons* needed to be as light as possible, and would need to use the largest booster in the fleet. That's what they did, and, using a gravitational slingshot at Jupiter, it still took 9 years, 5 months, 25 days from launch, on January 19, 2006, to the Pluto fly-by, on July 14, 2015.

Two other operational constraints loomed large. Operation at 40 AU means that solar panels are useless, so *New Horizons* used a radio-isotope thermal generator (RTG) for power. Heat from the radioactive decay of on-board plutonium was converted directly to electricity in the RTG, no nuclear reactions were involved. RTGs also powered *Voyager 1* and *Voyager 2*, and a number of other spacecraft. Plutonium is in very short supply (it must be made in a breeder reactor) and requires special handling, but on the plus side, the RTG aboard *New Horizons* can power the spacecraft until the mid-2030s. The other constraint on size and mass is the communications gear necessary to return data to Earth (the main high-gain antenna is 2.1 meters across).

The spacecraft carried a suite of six instruments led by the LOng Range Reconnaissance Imager (LORRI), a high-resolution visible light CCD imager. An imager named Ralph works in the near-IR, and another named Alice works in the UV (What, no Ed or Trixie? I suppose "Doing it with Style" includes paying homage to a classic TV show from the 1950s.). The other instruments are named PAM, PEPSSI, and REx (for details, see [here](#) and especially [here](#)).

Pluto Has a Heart!

Triton was much different than expected, and so was Pluto, so *New Horizons* was a really worthwhile mission.

Perhaps the most striking memory most would have from the fly-by would be one of the first images available/released, showing Pluto with a prominent heart-shaped surface feature covering a large portion of the visible surface. It was certainly a shock to the illustrator of the children's book, *Pluto's Secret*, who was a work colleague. She was waiting for me at my office the morning after the fly-by, jumping with excitement. "Pluto has a Heart," was her cry of joy,

then she was off like a shot to make an alteration to the illustration she drew for the book's cover, carefully adding a heart to the smiling Pluto. That picture's in a lot of offices, both at NASM and at NASA; I'm looking at my copy, signed, on my office wall as I type.

The heart-shaped area, now called Sputnik Planitia (it was classed as a Planum initially), is a [gigantic glacier](#) of frozen nitrogen. The glacier is [presently in active motion](#). Because of the nature of Pluto's orbit and obliquity, there may have been liquids on its surface at one (or more) time(s), and *New Horizons*'s images show some evidence of that. Images also show evidence that Pluto once had a frozen-over ocean, much like those on Io, Enceladus, Ganymede, and other moons. Pluto's may even still be liquid deep inside. The basin in which the Sputnik Planitia glacier resides is almost certainly an impact feature. Gravity measurements made by *New Horizons* [suggest](#) that Pluto had a 100 km thick subsurface ocean at the time of the impact.

Pluto's major moon, Charon, has features resembling a wry smile and a shock of red hair. The smile is really a giant tectonic rift, perhaps due to the general expansion of Charon due to the freezing of internal material. The reddish area, Mordor Macula, may be due to the accretion of atmospheric material that escaped from Pluto during times of high atmospheric density there. For more about Charon, including a flyover video created from *New Horizons* data, see [here](#).

All of Pluto's other known moons were imaged at low to medium resolution. The data are sparse, but crater counts for those moons yield similar ages, suggesting that all of them, and Charon, formed at the same time, likely by a single collision between Pluto and another body.

Check out the Pluto fly-by sequence here: <https://time.com/4018747/new-horizons-flyby>

More *New Horizons* results: See the mission websites, [here](#), and [here](#).

But Wait, There's More

Mission planners recognized early on that any fly-by mission to Pluto could also include a fly-by of at least one Kuiper Belt Object after Pluto, and that possible extension was built into the proposal to NASA, even though the planners had to allow for the exact targeting decision to be made long after launch.

KBOs were objects of interest independently of *New Horizons*, and searching for them proceeded apace. On June 26, 2014, a little over a year from the Pluto fly-by, a KBO was found that *New Horizons* could reach for its encore fly-by. Initially called 2014 MU69, this particular KBO acquired the name "Arrokoth," a [Powhatan](#) name for the sky. [BTW: I once had an in-law who was a member of the Pamunkey tribe of Virginia, members of the Powhatan Confederacy.]

New Horizons flew by Arrokoth on January 1, 2019, a great way to start the new year, providing scientists with their first close look at a KBO. That look [showed Arrokoth](#) to be shaped like a snowman, likely two separate bodies that ran into each other, very gently. Arrokoth's age and shape [is providing clues](#) to the processes involved in the formation of our Solar System.

New Horizons is funded through this year. Another extended mission will allow it to visit another KBO or two. Its RTG will last for at least two more decades, and it still has a lot of hydrazine (thruster fuel) on board.... Stay tuned!

New Horizons Follow-up Missions: A team has prepared a concept study for the next mission to Pluto, an orbiter this time, called *Persephone*. Check it out [here](#). Other Pluto/KBO missions under development for NASA's Discovery Program include Centaurus and Chimera; for more info, see: <https://www.space.com/nasa-centaur-missions-centaurus-chimera.html>.

As Only NASA Can, and With Style

The Item of the Week of the November 23, 2020, installment of Air and Space this Week was about the 1964 [Mariner 4 mission to Mars](#). One of the aspects of that important mission was the Radio Science Experiment, which allowed scientists to constrain the value of Mars' atmospheric density, showing it to be too low for vegetation. The radio signal *Mariner 4* used to transmit data to Earth would be attenuated by the martian atmosphere as *Mariner 4* appeared to pass behind Mars, and that attenuation would depend on the density of the atmosphere. The RS experiment had not been "official" until after launch, and represented a wonderful example of the stylish flexibility and innovation NASA planners bring to their task.

New Horizons offers two examples of how NASA could take advantage of opportunities to conduct scientific studies not planned for in the initial mission plan at launch. I'm not talking about the first fly-by of a KBO object, which turned out to be Arrokoth, because that had been on the mission planners minds for an extended mission option should the Pluto fly-by had been successful. I'm not even talking about any additional fly-bys of other KBOs, which wasn't in the original concept, but is more of a continuation of the main plan. There are two other big contributions *New Horizons* has made/is making that were not even thought of at launch!

COB: How dark IS Space? It's not a trivial question, and scientists have wondered about it from the days of Olber's [paradoxical observation](#) that Space could not be infinite without the night sky being infinitely bright. And as [Brian May](#) would attest, interplanetary dust scatters sunlight, particularly in the inner Solar System, causing the Zodiacal Light (the "[False Dawn](#)" of Omar Khayyam). But what about farther out? There's some light there, coming from many sources. Figuring out how much ambient light there is (the cosmic optical background, or COB), and what sources contribute how much, has considerable importance in figuring out many cosmological questions.

There is so much sunlight reflecting off interplanetary dust in Earth's vicinity that deconvolving all the different other sources of COB is difficult. But, *New Horizons* is over 45 AU from the Sun and getting farther away every minute, ideally placed for COBservations, a fact that occurred to the NH team while the spacecraft was *en route* to Pluto. They used the LORRI instrument aboard *New Horizons* to make important COB measurements. For a summary, see [here](#); you can see the full scientific report at:

https://imgsrc.hubblesite.org/hvi/uploads/science_paper/file_attachment/622/2011.03052.pdf

Stellar Parallax: Recall when I went all trigonometric on you with the January 4, 2021, Item of the Week on “[Surveying With the Stars](#),” about the use of parallax measurements to determine the distances to the stars. We can now accurately measure the distance to stars within a couple of hundred light-years or so using the Earth’s orbit as a baseline. But what if we had a much longer baseline available for parallax measurements, say 45 AU? That would increase the precision of our distance measurements, and allow for distance to be determined accurately much farther away.

[That idea occurred to the *New Horizons* folks, too.](#) On April 22/23, 2020, *New Horizons* imaged the nearby stars Proxima Centauri and Wolf 359 at the same time that those stars were imaged from Earth. The shift of apparent position of the target star relative to background stars and galaxies nearby was much larger than measurements taken six months apart on Earth.

Parallax shifts give us our depth perception and is the basis for 3D pictures and movies. Now *New Horizons* has helped astronomers use parallax to make distance determinations of unprecedented precision. As only NASA can, and With Style!

REFERENCES

Pluto

NASA in-depth page: <https://solarsystem.nasa.gov/planets/dwarf-planets/pluto/in-depth>

NASA image gallery: [here](#)

NASA page on Pluto’s moons: [here](#)

NASA Space Place Pluto page: <https://spaceplace.nasa.gov/ice-dwarf/en>

Cruikshank, D.P. and W. Sheehan, 2018, *Discovering Pluto: Exploration at the Edge of the Solar System*, Tucson: University of Arizona Press, ISBN-13: 978-0-8165-3431-9, 475 pp.

New Horizons

NSSDCA page: <https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=2006-001A>

NASA mission page: https://www.nasa.gov/mission_pages/newhorizons/main/index.html

New Horizons page at APL: <http://pluto.jhuapl.edu>

The Wikipedia page is quite good: https://en.wikipedia.org/wiki/New_Horizons

And don’t miss Brian May’s musical tribute to *New Horizons*:

https://www.youtube.com/watch?v=j3Jm5POCAj8&ab_channel=QueenOfficial (don’t miss the comment about May morphing into Isaac Newton!)

And for those of you with (grand)kids, most definitely check out the delightful pre-*NH* book for young people, “**Pluto’s Secret!**” See here: <https://airandspace.si.edu/stories/editorial/plutos-secret-writing-museums-first-childrens-book>.

Alan Stern

Alan Stern has enjoyed quite a career, both with Solar System exploration and as a consultant on a variety of private sector space efforts. You can find the details of his career [here](#).

NASA bio from his term as Associate Administrator for NASA's Science Mission Directorate: https://www.nasa.gov/about/highlights/stern_bio.html

Feature in the journal, *Science*: <https://www.sciencemag.org/news/2015/06/feature-how-alan-stern-s-tenacity-drive-and-command-got-nasa-spacecraft-pluto>

Much has been written by Alan Stern. Of particular interest might be a book he edited in 2003 entitled, "Worlds Beyond: The Thrill of Planetary Exploration as Told by Leading Experts." ***After all, aren't we all in the sharing the thrill business when it comes to Space exploration?!?*** ISBN: 978-0521812993, Cambridge University Press

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