

How to Catch a Moon (or Two) of Pluto

Mark R. Showalter (*SETI Institute*)

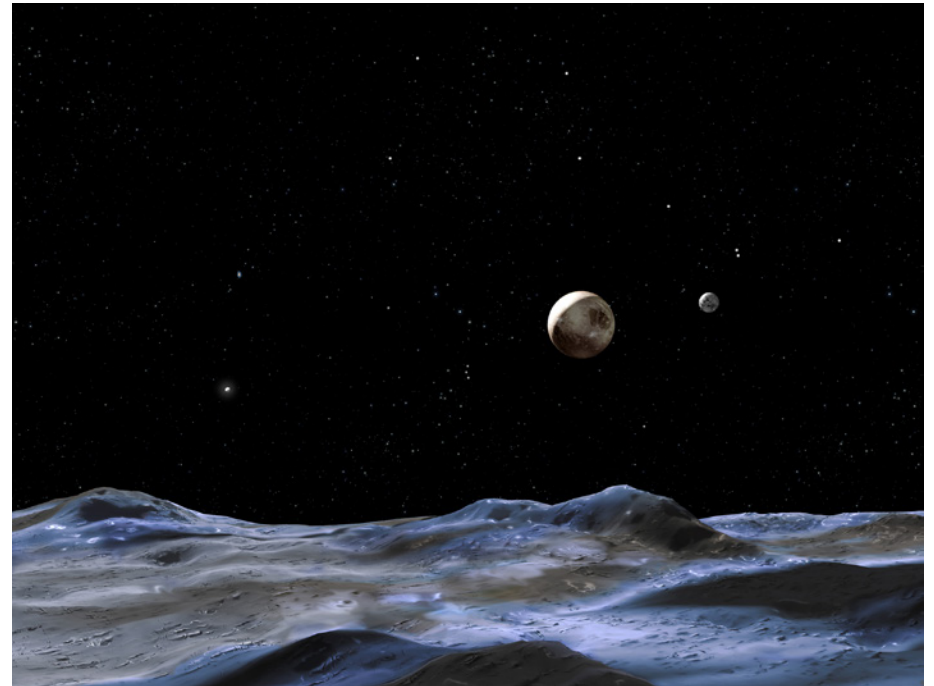


Some research projects lead more or less where you expect them to go. A few lead nowhere. However, every scientist will tell you that the best projects are the ones that spin off in completely unexpected directions. So it was with our plan last year to use the Hubble Space Telescope (HST) to search for faint rings around Pluto.

This idea is not (quite) as crazy as it sounds. The other outer planets, starting with Jupiter, all have rings of some sort. Many of these rings are just faint clouds of dust, visible only with powerful telescopes or visiting spacecraft. Pluto may have been officially “downgraded,” but a dwarf planet is still a planet. Pluto has two 50-kilometer-diameter moons, Nix and Hydra, and we know that tiny moons often raise clouds of dust, which can spread out to form rings.

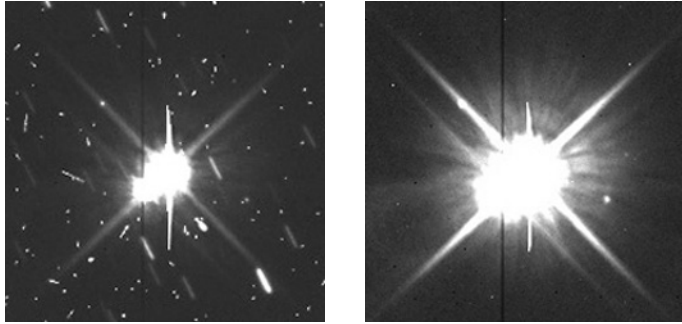
A detection of rings around Pluto would be very timely. The New Horizons spacecraft will fly past Pluto in July 2015. The more we know in advance about where to point its cameras, the better. In fact, the New Horizons science team has already been planning the Pluto observing sequence for years, and with less than three years to go, it is now very late to be making additions or changes.

In our request for time on HST, we added a brief throw-away line, “...our observations will also reduce the current detection threshold for unseen moons by a factor of two.” We were about to take the longest exposures ever made of the Pluto system, so we realized that there might be a few surprises. However, I have done previous



This illustration shows the Pluto system from the surface of one of the candidate moons. The various members of the Pluto system are just above the putative moon’s surface. Pluto is the large disk at center, Charon is the smaller disk to Pluto’s right, and the other candidate moon is the bright dot on Pluto’s far left. Courtesy NASA, ESA and G. Bacon (STScI).

searches for the moons and rings of the outer planets, and I have learned that they do not give up their secrets easily. If something hasn’t been seen before, that is probably because it’s not there!



This is one of the images from the P4 discovery sequence, taken by the Hubble Space Telescope on June 28, 2011 (*left*). Pluto is at the center, intentionally overexposed in this six-minute observation. Charon, also overexposed, is below and to the left of Pluto (looking attached to the bigger blob). The vertical and diagonal lines are all artifacts. Hydra falls along the upper left diagonal and Nix is at the 4 o'clock position. The long streaks through the image are background stars. The scattered "snow" of additional white pixels is common in Hubble images; they are caused by cosmic rays hitting the detector. When we combine all 10 images from the P4 discovery sequence, and subtract out the stars and cosmic ray hits, the image looks much cleaner (*right*), and an unmistakable extra dot is visible to the right of Pluto and above Nix. This is our first sighting of P4. Courtesy M. Showalter, SETI Institute.

Nevertheless, with the discovery a few years ago of two small moons and two faint rings of Uranus, I received ample compensation for all those years of frustration and disappointment.

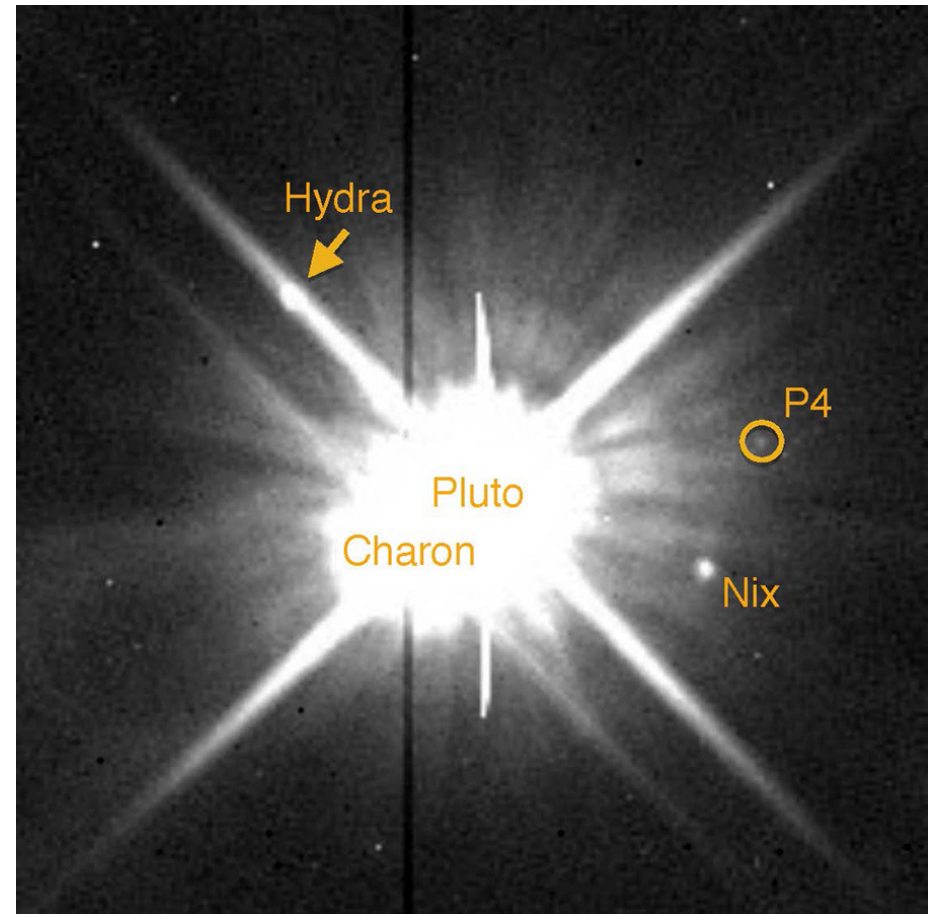
First Results

My heart sank just a little when I saw our first Pluto images (*above left*) in June 2011. Everything had executed exactly as planned, but I was not prepared for the number of bright stars streaming through the field of view. Pluto sits in front of the galactic center, where background stars are abundant. In similar images of Uranus, we almost never see background stars.

Nevertheless, a few image-processing tricks came to the rescue. We took many identical exposures, where the only thing changing from one image to the next was the location of the star streaks. By comparing multiple images that are otherwise identical, it becomes easy to recognize the stars and subtract them out (*above right*).

Within a few minutes, I had obtained a clean, starless image of Pluto. It and its large companion-moon Charon were at the center, saturated by the long exposures. Hydra and Nix were just where they ought to be.

However, an extra dot caught my eye. After six long days of waiting, we received our second set of images, and the dot was still there, having moved just about the right distance for an object



The discovery of P4 was announced on July 20, 2011, after it was detected in two more sets of Pluto observations and seen to follow a predictable orbit. Courtesy M. Showalter, SETI Institute.

orbiting Pluto. Shortly thereafter, we announced the discovery of a new moon for Pluto — “P4.”

The existence of P4 raised interesting questions for the New Horizons mission planners: What else might be out there? A single speck of dust in the path of the spacecraft could be catastrophic, never mind the presence of unknown rings and/or moons.

This brings us to 2012. We have just completed the most extensive survey of the Pluto system ever performed. Last year, the P4 discovery involved eight hours of HST time in total. This year, we were allocated more than 50 hours. It was our expectation that by taking more exposures and repeating them more often, we would be able to detect smaller moons and fainter rings.

One More Sidekick

Nothing at all turned up in the first 12 of our 14 “visits” (observing periods), so my expectations were not particularly high on Saturday, July 7, while I was downloading the newly available data for visit number 13. Surely anything new would have turned up by now, right? Nevertheless, I ran the star subtraction procedure and, within a few minutes, I was staring at the latest data. Five moons stared back at me (*above right*).

This particular visit comprised three HST orbits, which is enough time for the moons of Pluto to move just a little bit. The fifth moon was moving at the proper rate to be a real body orbiting Pluto, and not some random glitch in the background noise. Nevertheless, it took me an hour or so to convince myself that I was not hallucinating, after which I began to contact my colleagues on the New Horizons mission. I interrupted Alan Stern, the Principal Investigator for New Horizons, as he was sitting down to dinner in a Mexican restaurant. He did not seem to mind the interruption.

“P5” orbits a bit closer to Pluto than Nix, but still well outside the very large moon Charon. It is about half as bright as P4, which ex-

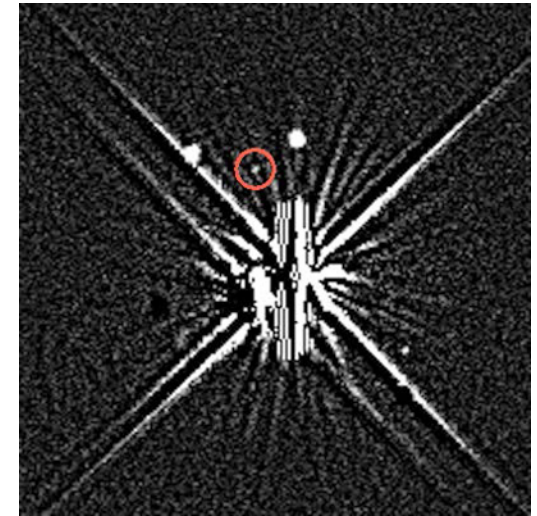
plains why we did not see it in 2011. With further analysis, it turned up in many of our visits from 2012; we had overlooked it previously because it had just completed a very slow, close passage of Nix, a much brighter moon. (Unlike astrologers, astronomers prefer it when the planets *don't* align.) We announced the discovery on July 11, 2012.

A Family History

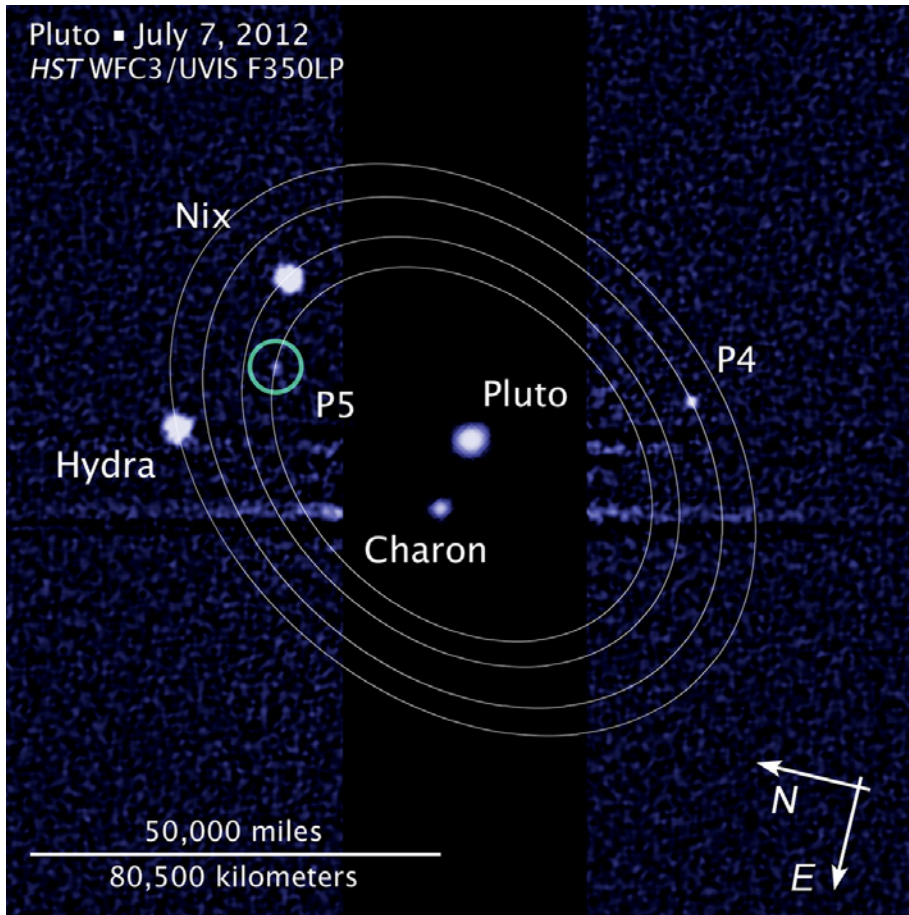
This family of moons tells an interesting story about the Pluto’s history. Prior to the discovery of P4, there was still some scientific

debate about whether Nix and Hydra could have been captured objects, rather than having formed in place. With two more moons in the system, the idea that they were all captured has become far too unlikely to be taken seriously.

Furthermore, the moons form a very tidy system of nested, nearly circular, co-planar orbits — think Russian dolls. Charon takes roughly 6.5 days to orbit Pluto. Nix takes almost exactly four times as long, P4 takes five times as long, and Hydra takes six times as long. Although we do not yet have a precise orbit for tiny P5, it is closer to Pluto and its orbit lasts approximately — you guessed it — three times as long as Charon’s. This system of so-called “orbital resonances” cannot have arisen by chance. The picture that emerges is one in which



The discovery image of P5 from July 7, 2012 (red circle), after processing very similar to what went into the P4 discovery image. The big, messy splotch in the middle is what this processing does to the overexposed images of Pluto and Charon. Nix is at 12 o’clock, P4 is at 4 o’clock, and Hydra is at 11 o’clock. The extra dot, circled in red, is the Pluto system’s newest member. Courtesy M. Showalter, SETI Institute.



This false-color diagram, created by the artists at the Space Telescope Science Institute, shows a “family portrait” of the Pluto system as we know it today. The circular paths of all four outer moons are shown; they appear as ellipses when projected onto the sky. Note the nearly uniform separations between the orbits — a result of orbital resonances at work. Courtesy NASA, ESA, M. Showalter (SETI Institute), and L. Frattare (STScI).

something large collided with Pluto long ago, breaking off the large pieces that eventually formed Charon. The remaining debris from the impact formed a disk and, eventually, the four (or possibly more) remaining moons. In this process, the influence of Charon’s gravity locked these moons into their current configuration.

This story may sound a bit familiar, because one other planet in our solar system received a similar impact — Earth! Our own Moon formed when a Mars-sized body collided with Earth early in its history. The Moon was originally much closer than it is today; it has been spiraling slowly outward for the last four billion years due to the orbital energy it loses because of the pull of Earth’s ocean tides.

For all we know, Earth may have also once had a family of tiny moons farther out, much like Pluto does today. If it did, those moons would have been lost over the eons as our much larger Moon spiraled outward and swept them all up. The Pluto system seems to show us an early moment of the Earth’s history, now frozen in time. Somehow, astronomical observations always seem to bring us back to Earth.

The Name Game

What about those boring names? We took our time proposing an official name for P4 to the international community, because of suspicions all along that a “P5” might be lurking in the system. We were never able to confirm that in the data from last year, but this year’s data did not disappoint. I still would not rule out the possibility that a “P6” will turn up in the latest data, but if it’s in there, it is going to take a whole lot more digging.

With two moons now ready to be named, we will be submitting our proposal soon. By tradition, Pluto’s moons are named for characters from Greek mythology associated with the underworld. These “minions of Hades” are a colorful cast of characters from which we get to make our selections. Stay tuned.

One last thing. We never did find any rings.

About the Author

Mark Showalter is a Senior Research Scientist at the SETI Institute, where he studies a range of topics related to the dynamics of rings and small moons. His earlier claims to fame include the discoveries of a ring of Jupiter, the innermost moon of Saturn (Pan), plus two small moons and two faint rings of Uranus. He is a co-investigator on the Cassini mission to Saturn, where he focuses on trying to understand the thermal emission from Saturn's rings. He also manages the planetary rings archive for NASA's Planetary Data System.



Resources:

- Hubble's solar system picture album: http://hubblesite.org/gallery/album/solar_system.
- General solar system information: <http://nineplanets.org>.
- New Horizons mission to Pluto: <http://pluto.jhuapl.edu>.
- For scientific data on planetary rings and small moons, visit: <http://pds-rings.seti.org>. ✨

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Wishing You a Happy Holiday
Season and Wonderful New Year!