Hubble's Famous Plate of 1923: a Story of Pink Polyethylene

David R. Soderblom
Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218; soderblom@stsci.edu

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Abstract On October 6, 1923, Edwin Hubble used the Mount Wilson 100-inch telescope to take a 45-minute exposure of a field in the Andromeda galaxy. This is the now-famous plate marked with his "VAR!" notation. I will discuss this plate and that notation. I will also tell the story of flying copies of that plate on the deployment mission for HST in 1990 as a Hubble memento and then locating those copies afterwards, and how copies were flown on Servicing Mission 4 on 2009 as well. This has led to an effort in which AAVSO members joined to identify and re-observe that noted star, arguably the most important object in the history of cosmology, but largely ignored since Hubble's time.

1. Introduction—Hubble's discovery

On the night of October 6 (UT), 1923, Edwin Hubble took an astronomical photograph that is now famous (Figure 1). He used the 100-inch Hooker telescope on Mount Wilson to expose a 4 × 5-inch glass plate for 45 minutes under conditions of fair seeing. The object observed was the great nebula in Andromeda, M31. Standard practice with photographic plates was to use a dull pencil to write the plate number near the edge; the pressure activated the emulsion and caused the writing to show up when the plate was developed. Hubble wrote additional information on the emulsion side of the plate as well in ink (emulsion used, seeing conditions, and hour angle).

Hubble had been hired by the Director of Mount Wilson, George Ellery Hale, to do exactly what he was doing: to use the power of the world's largest telescope to study the size and structure of our Universe. Hale himself is best known for his pioneering work in solar physics at Mount Wilson, but he knew talent when he saw it, and Edwin Hubble was a very capable young astronomer. Hale was a gifted impressario of astronomy who pursued ground-breaking work of his own (particularly on solar magnetism) and who could enlist the assistance of people like Andrew Carnegie, a major supporter of Mount Wilson and the institutions that succeeded it under the aegis of the Carnegie Institution of Washington.

Hubble was hoping to find Cepheids in M31 because that would make it possible to determine its distance. To understand why that mattered, you need to take yourself back to the early 1920s. The big event for astronomy was the

Curtis-Shapley debate, held at the Smithsonian Museum of Natural History, in Washington, D.C., in April 1920. Virginia Trimble (1995) has written a particularly good account of the debate and its context that you should read in order to understand why Hubble made his observations. At the time, no one was sure how big our Galaxy is, where we are in it, or if there were other galaxies like ours.

Cepheids, of course, are variable stars of a particular type. They are intrinsically very bright, and so relatively easy to detect even in other galaxies. Also, the range of variation is a magnitude or more, also easily detectable even looking by eye at photographic plates. What makes them so valuable to cosmologists is that Cepheids are pulsating stars (as we know now) that have a definite relationship between the observed period and the star's intrinsic luminosity (the composition of the star also matters, but that wasn't known then). This period-luminosity relation for Cepheids had been measured by Henrietta Leavitt (Figure 2) at the Harvard College Observatory, using observations of the Magellanic Clouds. The distance to the Clouds wasn't known, but it was reasonable to assume all the stars were the same distance.

Leavitt's period-luminosity relation was published in 1912 (Leavitt and Pickering 1912) and was well known. A year later Ejnar Hertzsprung (1913) used observations of Cepheids in the Milky Way to calibrate the relationship so that absolute distances could be derived. If an object like M31 were indeed a separate, external galaxy and not part of the Milky Way (the crux of the debate), finding Cepheids was the way to do it, and only Hubble had the needed access to the telescope that could detect stars that faint.

Edwin Hubble's effort took years, being published in 1929. That was because he needed dozens of separate exposures well-spaced over time, followed by careful effort to determine magnitudes (Hubble 1929). But the critical first step was finding Cepheids to measure in the first instance, and that's why his excitement ("VAR!") showed.

2. The Hubble plate revisited

Why am I telling you this? The reason goes back more than twenty-five years for me. When I started working at the Space Telescope Science Institute, in May 1984, the launch of HST was scheduled for 1986, and I was especially thrilled because a friend from graduate school, Steve Hawley, had been named to the astronaut crew that would deploy the telescope on that flight of the space shuttle. It occurred to me that it would be a nice thing to carry something along on the deployment mission that would tie Hubble the man to Hubble the telescope: a memento. The first thing that came to mind in thinking about Hubble the man was his pipe (Figure 3), which seems to show up in almost every photo of him. I contacted Allan Sandage, himself an observational cosmologist and a protege of Edwin Hubble in the early 1950s at Mount Wilson. Sandage was probably the one person most familiar with Edwin Hubble and his work, and he suggested the photographic plate shown in Figure 1. Indeed, it is pretty much the perfect Hubble memento: It was taken with Hubble's own hands and it embodies both the key science he pursued in his career and one of the primary goals for building the Space Telescope that was named after him, and it marked a key moment in modern science history.

I arranged to borrow the 4 × 5-inch original plate from the Mount Wilson archives (by then part of The Observatories, in Pasadena, California, and now known as the Carnegie Observatories), and a first question I asked myself was: Should we fly the original plate, or a copy of it? David De Vorkin at the Smithsonian's Air and Space Museum answered by noting that flying the original plate didn't really add to its historical value, and it's an important artifact in its own right, one worth preserving. Given that, and the likely reluctance of NASA to have something made of glass on the space shuttle, I opted to make film copies. Our staff photographer at STScI, John Bedke, had himself worked for years with Sandage in Pasadena and had helped to preserve many of Hubble's original plates by reprocessing them (Hubble was impatient and would pull plates from the fixer prematurely).

But why? Why do this at all? My idea at the time was that I would arrange to fly about ten copies of Hubble's plate, and, once they were returned, we'd have prints made from each, nicely matted and framed. Then we'd give these to the institutions that had played key roles in the development, construction, and launch of HST and send an astronomer to those places to say thanks for building us such a wonderful instrument, and here are some of the things we're doing with it. In other words, the idea was to reach back to the people who built HST.

But could you just ask NASA to fly something like that on the shuttle? Well, yes, actually you could. When a NASA facility like the Marshall Space Flight Center (MSFC), in Huntsville, Alabama, used the space shuttle to launch a mission that it had developed, they got to put on board something called the Official Flight Kit (OFK; you knew we were going to get into the three-letter abbreviations, right?). Also, the astronauts for a given flight got to take along personal items that could include just about anything, subject to size and weight limits. I could have given one of the film copies of Hubble's plate to Steve Hawley, but it didn't seem reasonable to ask him to take ten, and besides, I wanted to do this through official channels.

Once I had the copies of the plate I contacted the HST Project Manager at MSFC, Fred Wojtalik, and explained what I wanted to do. He agreed to include the film copies in the MSFC OFK, and so I sent them off to him. That gets us to the end of the beginning of this story.

Those of you of a certain age will recall vividly that after HST was launched it quickly became clear that Hubble's primary mirror was highly flawed and had significant spherical aberration. Instead of being an object of great pride, Hubble turned into a huge embarrassment for NASA. Going to parties and seeing neighbors was an exercise in damage control, combined with a bit of spin ("It's not that bad." It really was that bad.). Nevertheless, I contacted Mr. Wojtalik at MSFC to get the flown negatives returned. He requested a description of how they would be used, given that they were now official NASA materials, and I provided that. But the negatives didn't come. Under the circumstances, my immediate enthusiasm for the project had diminished and I didn't ever get them (I should have tried harder). Over the subsequent years I would make inquiries of NASA people I would meet who might have information, all without success.

That gets us to the beginning of the end. In 2006, new NASA Administrator Mike Griffin reinstated Servicing Mission 4 (SM4) for HST. The history of servicing Hubble with the space shuttle involves lots of stories waiting to be told, but one particular aspect of SM4 was that NASA declared that it would be the last shuttle mission to the observatory, period. Obviously I had to find those missing negatives because if I could, and if I could refly them on SM4 then we would achieve a rare case of cosmic symmetry: artifacts flown on missions that bookended Hubble's connection to human spaceflight.

I called and e-mailed lots and lots of people, many involved in the HST project in the 1980s. I found lots of new friends—every single person I talked to was enthusiastic about what I was trying to do—but I never found the negatives. Over many months new leads would pop up, but all proved futile. At one point I ran into Steve Hawley while he was here at STScI attending a conference and we talked. He mentioned that there was a person at Johnson Space Center, in Houston, who was the OFK Coordinator, Ms. Abby Cassell. I called her in May, 2008, and explained why. I knew that the items flown in MSFC's OFK in 1990 had been returned to Marshall, and she confirmed that, noting that their OFK included a plaque, 7,000 American flags, and ten negatives. I at least had proof my negatives had flown! I asked her if something flown in an OFK would be recognizable if it were sitting on a shelf somewhere, and she said "Yes, we shrink-wrap everything in pink polyethylene before it's put on board the shuttle." But then a thought came to her and she asked me to wait while she looked in her vault. She came back in a few minutes to tell me that back in 1990, when the negatives were flown, they would have been shrink wrapped in lavender polyethylene. That is probably a completely useless piece of information, yet I treasure it.

By that time in 2008, the launch of SM4 was only months away and there was no longer time to go through the effort of including the negatives even if I found them. I had to give up. But I still had five copies left, and so this time I made sure that there was redundancy. I gave one to John Grunsfeld for him to carry personally as a member of the SM4 crew, and another to Dave Leckrone, the HST Project Scientist at Goddard Space Flight Center, for him to include in GSFC's OFK. I got both of them back, the first from John Grunsfeld (Figure 4); I was a happy guy.

3. The Hubble discovery reaffirmed

Once they were returned an obvious question came to mind: Had HST ever observed that Cepheid that Edwin Hubble discovered back in 1923? That star could be called the most significant object in the history of cosmology because of its key role in establishing the cosmic distance scale. But how could I tell? A blue-sensitive plate from 1923 can look a lot different from a modern digital sky image, and Hubble's published coordinates were rough. I could tell that Hubble's plate included M31's nucleus, but it was hard to say just what the scale or orientation was. Photographic plates do not come with World Coordinate System headers! Fortunately, here at STScI we have Tom Brown, an astronomer who has studied M31 extensively, particularly its outer regions. It was easy for him to pinpoint the coordinates and so we could then see that several recent HST/WFPC2 exposures were very close to Hubble's Variable no. 1, but not on it.

The Hubble Heritage Program here at STScI helped by using some of their HST time to observe the star and its field with the new WFC3 camera on HST. Hubble Heritage is well known for their extraordinary images that have captured the public's attention and delight. We wanted to catch the Cepheid both when it was near its brightest and faintest, but the star had not been observed in a very long time (since the 1960s) and so the phase was unknown. That's when the AAVSO stepped in to help by providing ground-based observations of the field to re-establish the light curve (Templeton *et al.* 2011; NASA 2011).

The result was released at the May 2011 joint meeting of the AAVSO and the American Astronomical Society (AAS) held in Boston. One poignant aspect to me is that in the 21st century, citizen-scientists have access to and can afford the means to put telescopes and instruments in their backyards that can do better than Edwin Hubble could with the world's largest telescope in 1923. We have come so very far.

So that's the story, pretty much to its end. Despite initial setbacks, HST has been an enormous success and continues to advance astronomy in ways that amaze. We now use it in ways its original proposers could not even conceive of, answering questions they could even yet ask. It deserves commemoration.

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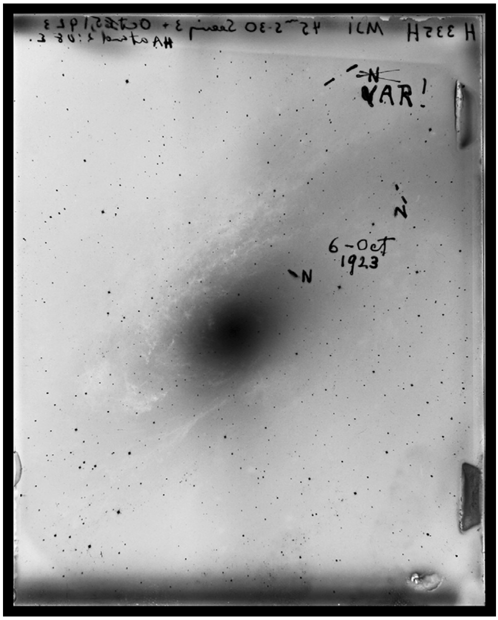

Figure 1. Hubble's plate of 1923.

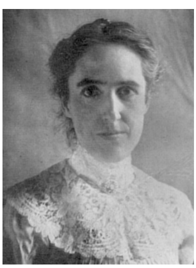

Figure 2. Henrietta S. Leavitt.

Figure 3. Edwin Hubble and his pipe.

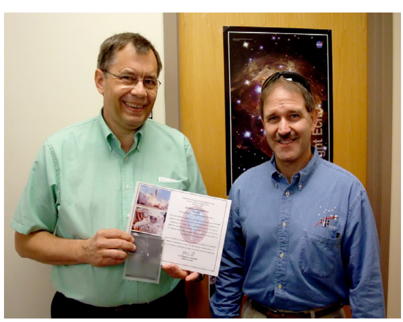

Figure 4. The author (left) and astronaut John Grunsfeld after one of the negatives was returned to me.