<u>Directors' Perspective: Old data and new discoveries</u> Final

We measure the success of the Hubble Space Telescope by its impact on scientific research and by its public impact. So we take pride when the two coincide as they have recently in discoveries from the Hubble archive. Perhaps most noteworthy is that the two most recent discoveries of public acclaim came from old data, not new.

Joseph Dolan at Goddard Space Flight Center uncovered evidence for accretion onto a black hole by examining High Speed Photometer data nearly ten years old and applying a technique to search for the signature of matter disappearing beyond an event horizon (Dolan, J. *Bull. AAS*, 197-118.05). The signature in this case was a series of pulses emitted by clumps of gas as they break away from the innermost stable orbit around a black hole – about 3 Schwarzschild radii out – and spiral in along a set of orbits with decreasing radii. As the gas streams away from us in its orbit, its emission is redshifted and dimmed. As it circles and comes toward us, it becomes blueshifted and brightens. Each successive circle creates a pulse of decreasing magnitude, increasing width, and decreasing period until the gas descends below the event horizon and disappears without further trace. The signature is unique, because if the gas encountered a compact surface, such as that of a neutron star, the final pulse would end in a burst of energy as the gas came to a sudden stop.

Dolan searched for such pulse trains in observations of Cyg X-1, the first candidate black hole to come from early x-ray telescopes. He found two series that matched the characteristic shape and timing expected for gas going into a black hole of 10 $M_\odot$ or so. This was the first time such a pulse train had been seen, and it lent impetus to further observations at x-ray wavelengths, where the signatures should be even more pronounced (the signal to noise ratios of the old HSP data certainly need improvement before this work is accepted by everyone). Dolan's work found its way to the New York Times science news section in January of this year, once again stimulating public interest in astronomy.

Adam Riess and his colleagues (Riess et al. 2001, *Ap. J.*, in press) added even more support for a non-zero cosmological constant, the "dark energy" that accelerates the expansion of the universe, with their study of a high redshift supernova discovered by Ron Gilliland (Gilliland *et al.* 1999, *Ap. J.*, **521**, 30) in Hubble observations from 1997. SN 1997ff was identified in the Hubble Deep Field early on, and it popped up in the deep infrared images of the Hubble Deep Field north by Rodger Thomspon's NICMOS team. Because the images were taken in regularly spaced observations over a few months, it is possible to get information about the supernova light curve and the change in its spectral energy distribution just after peak brightness. Photometric data on the host galaxy place SN 1997ff at a redshift of about 1.7, the highest redshift supernova ever seen.

Because it is very distant, this supernova emitted its light when the acceleration of the universe was just starting, and the effect of the dark energy should be small when comparing the supernova's apparent brightness to its redshift distance. If the dark energy did not exist, and the light from less distant supernovae were affected by intergalactic extinction (gray dust) or an evolution in the character of supernovae over cosmic times, SN 1997ff would have uncovered these effects, since they would have changed the brightness vs. redshift relationship in opposite ways to the dark energy. But the brightness of SN 1997ff is consistent with the effect of the dark energy interpretation and not the other effects, and Riess and his colleagues have provided compelling evidence that the dark energy must be taken seriously.

Many of us suspect that data archives will play an increasingly important role in astronomy, as the sizes of the archives grow. The National Academy of Sciences' Survey on Astronomy and Astrophysics, the decadal survey of 2000, recommended establishing a National Virtual Observatory, linking together many data banks covering many wavelengths and instruments to enable archival research on a scale far greater that presently possible. A Virtual Observatory will be a grand experiment. No one has demonstrated that archival research will be important enough to justify the expenditure – some tens of millions of dollars. We have already invested several billions of dollars to get the data, including Hubble, Compton, Chandra, and SIRTF in the space community, and Gemini, the Keck telescopes, and the VLT, to mention but a few on the ground. It would seem that investing a few percent of the capital expenditures to enable future astronomers to mine the data is well worth the cost.

It is interesting that the recent archival discoveries cited above are so important to their respective research fields. The likelihood of finding a high redshift supernova in a field the size of NICMOS (55 seconds of arc) during a few months of observation would seem to be very small, unless the events are more common than we think. Many events may be more common than we think; we will not know until we have surveyed the universe over time as well as wavelength and space. If we can discover the previously unknown but common events by combing through data taken for other purposes, archival research may be the most efficient path to discovering new phenomena, now that preliminary exploration of the spectrum has been done. The exciting discoveries from old data sets portend a bright future for old data.

Steven Beckwith
Baltimore, March 26, 2001