**Second sight.** By studying old images, researchers like Ashley Pagnotta are stretching the time span of astronomical observation.

ASTRONOMY

# Stars in Dusty Filing Cabinets

**A campaign to digitize old sky photographs is squeezing new discoveries out of observations dating back to the mid–19th century**

In 1962, astronomers discovered a shining dot in the sky that appeared to be moving at an astonishing 47,000 kilometers per second, or one-sixth the speed of light. The velocity indicated that the object—named 3C 273—was a few billion light-years away, yet it was so bright it could have been a nearby star.

To study the object further, researchers delved into a trove of the astronomical past: a collection of photographic plates at Harvard University dating as far back as the 1860s. They spotted 3C 273 on some 600 photographs taken with a variety of telescopes over 70 years, some of them days apart. The images showed fluctuations in the object's brightness on time scales as short as a week. Because the object could not be dimming or brightening faster than light could traverse it, the researchers inferred that in spite of being more luminous than a billion suns, the object had to be less than a light-week across—the size of the solar system. The finding helped characterize 3C 273 as a new type of object known as a quasar, one of the most powerful energy sources in the universe.

The discovery shows the value of historical sky observations, says Harvard astronomer Jonathan Grindlay, who is leading an initiative to scan the 500,000 plates in the university's collection and put them online. The project—called Digital Access to a Sky Century at Harvard (DASCH)—is part of a movement by a small but persistent group of astronomers to preserve, digitize, and study old astronomical photographs in hope of doing new science.

Proponents argue that old plates provide the only way modern astronomers can study astrophysical phenomena on time scales longer than a few decades. "Why would you want to wait another 100 years to learn how certain stars might be varying in brightness and position over long time periods when we have this resource right here in front of us?" asks Grindlay, referring to the Harvard collection.

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>
> —GEOFFREY CLAYTON, LOUISIANA STATE UNIVERSITY

Preserving and scanning old plates, however, has been slow to win support from the broader astronomy community and funding agencies. Universities and observatories often discard plate collections when astronomers retire. Digitization projects in the United States and Europe—including DASCH—have proceeded in fits and starts on shoestring budgets.

"We live in a world where money is fixed—so the question is, what is the relative merit of the old data compared to new data?" says David Monet, an astronomer with the U.S. Naval Observatory's (USNO's) station in Flagstaff, Arizona, who until 2000 led the scanning of some 20,000 old plates for a searchable online sky catalog. Although he spent nearly 15 years on that project, Monet now thinks historical observations are of little value because of limitations on how accurately the brightness and position of objects can be determined on the images. "The thrill of going back 50 years" is one thing, he says, but "is the science case for doing so strong enough?"

Absolutely, say proponents, citing hundreds of newly identified variable stars in the tiny fraction of Harvard plates digitized to date. Meanwhile, the movement to digitize archives is getting a push from the Pisgah Astronomical Research Institute (PARI), a nonprofit in Rosman, North Carolina, which has started acquiring plate collections from institutions that no longer have room to house them. "Each of these collections is like a time machine. There's no substitute for having them," says Geoffrey Clayton, an astronomer at Louisiana State University (LSU) in Baton Rouge. "Even if you can't think of what can be done with them today, it's tremendously important that they be preserved."

## Galaxies on glass

The Harvard collection occupies parts of three floors of an old brick building at Harvard College Observatory. The plates, slabs of thin glass coated with photosensitive emulsion, sit in crowded rows of green metal cabinets. Each rests in a yellowish brown envelope marked with handwritten details such as when the photograph was taken and with what instrument. The oldest is an image of the moon from 1849. Many show galaxies—a dot with a milky swirl around it, tiny yet somehow perfect. One plate shows the brilliant tail of comet Halley streaking across the sky in 1910.

The photographs were taken with some 20 telescopes operated by Harvard astronomers at the observatory, in other parts of the United States, and at remote observing

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stations such as Arequipa Observatory on Monte Blanco, Peru. Around 1881, as more and more plates started coming in, the then-director of the observatory, Edward Pickering, realized that the work of documenting the positions and magnitudes of imaged objects had to be sped up. He put his Scottish maid, Williamina Fleming, on the job. She showed such talent that the observatory soon hired a legion of women, later known as the Harvard Computers, to catalog the observations.

Grindlay and his colleagues began digitizing the plates in 2008, using a souped-up commercial scanner and software specially written to translate the scanned images into crunchable data. The first step in the scanning process is cleaning each plate. "There's 100 years of Cambridge grime on them. If we didn't clean them, there would be 10,000 more stars per plate," says Alison Doane, curator of the collection. Doane and her assistant then transfer the plates to the scanning room where Edward Los, a retired software engineer, loads two at a time onto the machine. The plates move on a cushion of air, like a puck on an air-hockey table, for precise alignment. After 90 seconds, an image of each plate appears on a nearby computer screen.

**Old and new.** Curator Alison Doane preps plates before they are loaded onto a scanner customized for Harvard's digitization project.

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### Digital haystacks

Usually, as in the search for 3C 273, researchers turn to archival plates in search of specific objects that have grabbed their attention. Bradley Schaefer, an LSU astronomer, is typical. In recent years, he has searched the Harvard archives and the collection of 300,000 plates at the 84-year-old Sonneberg Observatory in Germany for past records of recurrent novae. Recurrent novae (RNe) are white dwarfs that erupt in brilliance every few years or decades as they capture material from an orbiting companion star.

Schaefer says he studied thousands of images of sky regions where sightings of any of the 10 known galactic RNes had been reported. The tedious task paid handsome dividends, Schaefer reported at the American Astronomical Society meeting in Long Beach, California, in January. He and colleagues, including his student Ashley Pagnotta, discovered six previously unknown eruptions, established the orbital periods for all RNes except one, and predicted when they would erupt next. Schaefer says the most significant result was detecting long-term changes in the orbital periods of two RNes, evidence that both white dwarfs were gaining mass between successive eruptions. He concludes that these two RNes will "soon enough collapse" as Type 1a supernovae—white dwarfs that burn with an extraordinarily high but fixed amount of incandescence because they've reached a critical mass from the matter acquired from the companion. He says the finding supports the idea that Type 1as are born from RNes.

Grindlay says digitizing old plates can allow researchers to find interesting phenomena instead of being limited to searching for specific objects. "Once you've identified your needle in the haystack, then you can figure out what's going on with it," he says. His doctoral student, Sumin Tang, has been trying out the approach using an algorithm to search for variable stars on the 1500 or so plates that have been scanned so far at Harvard. Among three long-term variable stars she has found is one that appears to have dimmed significantly over the past 90 years. "One hypothesis is that the star is throwing off a dust shell to make itself obscured. Maybe we are seeing the star in an interesting stage in its evolution," says Tang, who is following up with targeted spectroscopic measurements.

### Old data, new science

So far, the $4 million needed to scan the whole Harvard collection hasn't materialized. However, Grindlay is optimistic about persuading university administrators to make the funds available, not least because digitizing the plates would allow Harvard to reclaim the room the collection currently occupies. "You'll never find a more inexpensive way to clear out that much office space in Cambridge," he points out. The project has until now been supported by $600,000 from the National Science Foundation, used primarily to build the scanner and develop software to handle and analyze images.

Digitization efforts are under way at other places as well. More than a third of the 300,000 plates at the Sonneberg Observatory have been scanned in the past 5 years. The scanned images are sitting on compact discs, says astronomer Peter Kroll, who formerly worked at the observatory and now heads a software company—4pi Systeme GmbH—that has run the institution since late 2003. The company, which has bankrolled the project with profits from its other ventures, hopes to put the image database on the Web in the coming months, Kroll says.

The Royal Observatory of Belgium (ROB) in Ukkel, which like Harvard has developed a special scanner for old photographic plates, is digitizing a collection of some 3000 images of the moons of Jupiter and Saturn. The observations, made by Dan Pascu of USNO in Washington, D.C., will help "recalculate the orbital parameters" of the moons and study how the orbits of certain moons like Io "have changed over time," says Jean-Pierre de Cuyper, an astronomer at ROB, which is collaborating with USNO and the Paris Observatory.

For every collection being scanned, many others are gathering dust, says Michael Castelaz of PARI. In the past 5 years, the nonprofit has "rescued" half a dozen collections from institutions that could no longer house them. One example: some 10,000 plates from the Warner and Swasey Observatory at Case Western Reserve University in Cleveland, Ohio, which were sitting in shrink-wrapped cabinets in "the back of a large university storage room behind old office and classroom furniture," Castelaz says.

Castelaz says it will take a lot of time and tedium to put the images online. But to him and other proponents of archival astronomy, the effort is entirely worthwhile. As they see it, the future of astronomy would be poorer without revisiting its past.

**–YUDHIJIT BHATTACHARJEE**





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