Finding stars that vanished—by scouring old photos

First you see it (top left) then you don’t.

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Before the advent of digital imaging, astronomy was done using photographic plates. The results look a bit like biology experiments gone bad (of which I’ve perpetrated more than a few), with a sea of dark speckles of different intensities scattered randomly about. To separate the real stars from any noise, astronomers would take multiple images, often at different colors, and analyze the results by eye before labeling anything an actual *star*. Sounds tough, but by 50 years ago, astronomers had already managed to catalog hundreds of millions of stars in all areas of the sky.

These days, automated telescopes, digital imaging, and software pipelines mean that we can do equivalent surveys with greater sensitivity in a fraction of the time. But that doesn’t mean the old surveys have lost their value. The original photographs provide data on how the sky looked before the relative motion of objects (and their occasional explosions) rearranged the sky. To get a better sense of just how much the sky has changed, a group of researchers has been comparing the old photographs and the modern survey data to figure out what stars went missing.

After whittling down a large list of candidates, the team came up with 100 things that looked like stars a century ago but no longer seem to be with us.

In the Navy (and not elsewhere)

There have been several large-scale, all-sky surveys done, and it's possible to compare the results to find objects that have changed between them. There are also dedicated efforts to find short-term "transient" events—objects that brighten or dim on the scale of weeks to months. But these may miss changes that take place gradually over longer time periods or events that happened before modern digital surveys.

To get a better sense of these events, some astronomers have formed a project called VASCO, for "Vanishing and Appearing Sources during a Century of Observations." Their goal is to compare data from the first surveys done on photographic plates to what we've been getting from modern surveys, and then to identify objects that have changed. The hope is that, among other things, having a longer time window will increase the odds of finding an extremely rare event, one that might not occur in the handful of years that separate the digital surveys.

To go back far enough in time, the VASCO team relied on the US Naval Observatory's catalog of objects, which combines the results of several surveys done on photographic plates. All told, this catalog contains over a billion objects. For modern data, the team used the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) database, which contains even more objects.

Conceptually, the study was simple: it worked by identifying the objects of the earlier catalog and checked whether they were still present in the later one. But there are a number of complications. First, you need to know that the object in the earlier catalog was *actually there*, not a bit of noise or

something misidentified (like an asteroid mislabeled as a star). Then, you must be certain that the modern observations are at the right location to see the object if it’s still there.

Finally, you have to make sure the object hasn’t moved too much in the intervening time. While that’s not an issue for distant stars or even for further galaxies, stars closer to Earth will have a larger relative motion over the sorts of time involved here. You need to choose a search window large enough to make sure local stars are identified, but not so large that it becomes easy to pick the wrong star as “matching” the missing one.

Finding what’s not there

For a first pass, computing time limited the team to examining a bit over half the sky, or about 600 million objects. From that, they come up with about 150,000 potential mismatches, a rate within the known range of data processing errors in sky surveys. So, figuring out what’s real in that 150,000 is a substantial challenge, one limited by bringing in data from the Sloan Digital Sky Survey. This immediately found matches for about 65,000 objects, while allowing for relative motion cut the list of potential vanishing acts down to only 23,667 objects. At this point, the researchers examined them all visually.

This allowed the team to identify stuck pixels in the modern digital data or to see imaging artifacts from nearby bright stars. Further elimination eventually produced a final list of 1,691 candidates for vanishing stars.

At this point, the authors analyzed the average properties of the vanishers, finding that they were a bit redder, they varied more between images when multiple images were available, and they had a higher relative motion, suggesting that many were relatively close to Earth.

Those properties suggest one possible explanation for the vanishing act. Red dwarfs in the area of Earth would be dim, have high relative motion, and have light biased toward the red end of the spectrum. They're also prone to extended outbursts, which could have made them detectable at some time points but not others.

In any case, the authors continued to whittle their list down, eliminating 200 objects because of dead pixels in some telescope hardware and a large number where the star is actually present in both old and new images but is slightly offset. This nudged the list down to about 1,000 candidates that seem worth following up on.

What might these be? Aside from red dwarfs, we have a number of possible explanations. It has been proposed (though not verified) that some large stars, rather than exploding in a supernova, may directly collapse into a black hole, swallowing the remains of the star and avoiding the messy (and bright) debris fields that supernovae create. This could cause a star to essentially vanish. Supermassive black holes can disrupt stars or increase or decrease their intake of matter on years-to-decades scales, potentially causing them to brighten and dim dramatically. A bright star eclipsed by a dim companion could also cause stars to briefly vanish.

Then there are known variable types of stars, including Cephids and RR Lyrae stars, both of which brighten and dim regularly. There's also the extremely rare variable R Coronae Borealis stars, of which only 150 are estimated to exist in the Milky Way.

All of these make viable candidates for stars that appear to vanish, as they can simply drop below the detection limits of various telescopes. And, since they're interesting stars, it's worth doing follow-up observations of their former locations to see whether there might be anything dim now residing there.

But the team behind the new paper indicates that the project started with a far more exotic inspiration: Dyson spheres, structures that alien civilizations might build to enclose an entire star and harvest all of its energy. These would obviously cause a star to vanish, though the timescale of its dimming and eventual disappearance would be anyone’s guess.

Regardless of the inspiration, the team has identified a large number of objects that might be interesting to astronomers. And that’s only with surveying a bit more than half the sky. There also remains the follow-on work of doing the converse analysis—looking for objects that are in present surveys but weren’t detected decades ago.

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