UCSC astronomers find way to see star's surface

Astronomers at the University of California's Lick Observatory have developed a new technique for studying stars and have produced the first images of the surface of a star.

The technique, developed by UC-Santa Cruz astronomer Steven Vogt and astronomy graduate student Don Penrod, allows scientists to see what is taking place on the surfaces of stars more than a hundred light years from earth — so far away that they appear only as pinpoints of light in even the largest telescopes.

The images, produced by computer, are not what we typically think of as pictures, but show patterns of light and dark that tell astronomers about features, such as spots, on a star's surface or about objects orbiting the star.

Vogt and Penrod are using the method to study very large star-spots, thought to be similar to sunspots, which appear as massive dark areas on the surfaces of certain relatively cool stars.

The astronomers hope their studies will reveal more about sunspots and about the internal workings both of our sun and of the stars they are studying.

Being able to resolve the image of a spot on a star is comparable to being able to clearly discern Lincoln's ear on a penny 3,000 miles away, Vogt says.

This degree of resolution is equivalent to having a telescope with a mirror that is a half mile in diameter, more than a hundred times larger than the world's largest — 236-inch — telescope in the U.S.S.R.

The new technique, known as "Doppler imaging," makes use of the fact that light from a star is shifted toward the red end of the spectrum if the star is receding from us and toward the blue end of the spectrum if it is moving toward us.

This shifting is known as the "Doppler effect" and is more familiar in everyday life as the change in pitch of a train whistle as the train speeds past an observer.

Astronomers analyze the light from a star using a spectrometer to spread out the star's component colors into a spectrum. These spectra generally show absorption lines, narrow, dark lines crossing the spectrum.

Absorption lines are caused by absorption of light from the star's interior at specific wavelengths by elements such as iron or calcium in the outermost layers of the star.

When a star rotates, lines from the side turning away from earth are shifted toward the red end of the spectrum, while lines from the side turning towards us are shifted toward the blue end.

This shifting effect causes each absorption line in the spectrum of a rapidly spinning star to broaden, Vogt says. Each broadened line then serves as a one-demensional representaion of the star's surface, with each position along the line corresponding on a one-to-one basis to locations across the suface of the star.

Vogt and Penrod discovered their new technique when, using an extremely high-precision spectrometer, they detected a bump in the broadened spectral line of a star they were studying.

The bump, which moved across the line during the course of several hours of observation, turned out to be caused by a dark object orbiting the star, which passed in front of the star as it circled in its orbit.

More recently,, the two astronomers have been using the new technique to study huge dark star-spots on the surfaces of certain cool stars. These sunspots can also be seen as bumps moving across stars' spectral lines.

By feeding into a computer information on the changing heights and positions of a bump, Vogt and Penrod have been able to determine not only how the spot moves across the star but how far it lies from the equator.

The computer can then construct an image of the surface of the star, providing scientists with their first view of what a spotted star actually looks like.

"We never thought we would actually be able to directly view any of the phenomena occurring on the surfaces of distant stars," Vogt says, "and the fact that we can is a very exciting and unique opportunity."

The two astronomers hope to determine whether spots on stars are simply gigiantic versions of the spots on the sun. If so, studies of the spots should help shed light on the formation of spots on our sun.

"We want to know how a star makes spots," Vogt says. "We think we know, but it's a terribly complex problem that involves an understanding of the physical processes inside the star.

"Of course, we can't see inside the star, so we're trying to use starspots as a probe to tell us indirectly what the star is doing inside."

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