Tapping Out a Beat

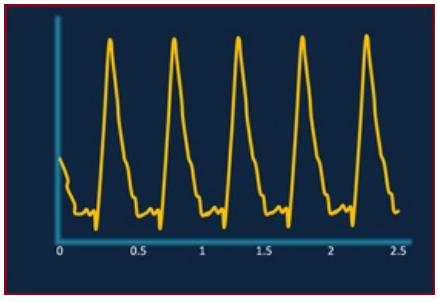
Most stars shine steadily — their size and brightness seldom change by more than a tiny bit. But a star in the constellation Lyra, RR Lyrae, undergoes major changes every few hours. Its diameter increases and decreases by hundreds of thousands of miles, causing its brightness to wax and wane dramatically, too — at its brightest, the star is twice as bright as at its faintest.

Ground-based view of RR Lyrae. [ESO Online Digitized Sky Survey]

RR Lyrae changes because it's nearing the end of its life.

Nuclear reactions have created a shell of helium around the star's core. That traps the core's heat like a lid atop a pot of boiling water. The energy in the core is still trying to escape, however, so it pushes the helium outward, causing RR Lyrae's outer layers to expand as well. As they do so, the energy escapes into space, the helium cools, and the outer layers fall back inward. Each of these in-and-out "beats" takes less than 14 hours.

RR Lyrae is the prototype of an entire class of stars. And as with their more famous variable-star cousins, the Cepheids, observations have shown that there is a relationship between the length of an RR Lyrae star's beat and the star's true brightness. Astronomers can use that relationship to measure how far away these stars are.



A simple diagram shows the in-and-out ‘pulsations’ of an RR Lyrae star, which pulses about twice per day.

For the technique to work, though, astronomers first must use parallax to find the distances to a few RR Lyrae stars. Fritz Benedict, Barbara McArthur, and their colleagues did that for RR Lyrae itself and four other stars. The team used Hubble Space Telescope’s Fine Guidance Sensors to measure the position of each star at different times during Earth’s orbit around the Sun, providing slightly different viewing angles with each observation.

Before this project, astronomers had a good measurement for only one RR Lyrae star — the prototype, RR Lyrae itself (that measurement was also made by Benedict and colleagues, in 2002). The measurements of more stars help make that rung on the distance ladder a good bit sturdier.

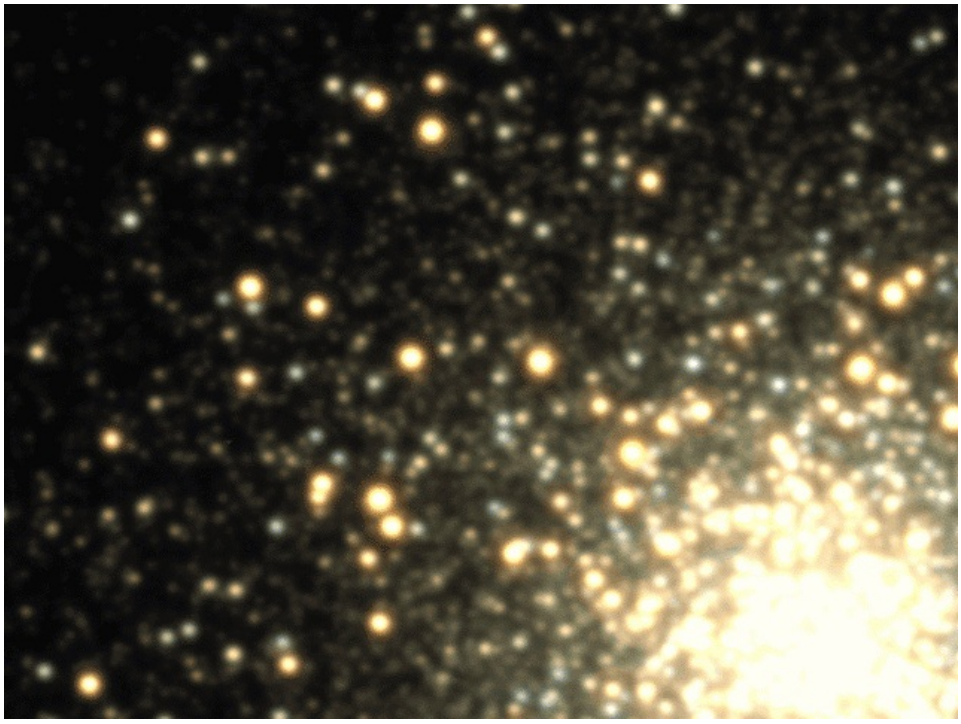
M3, a globular cluster. The Hubble RR Lyrae observations will help measure the distance to this and other globulars with unprecedented accuracy. [Robert J. Vanderbei/WIKI]

The astronomers acquired 13 to 23 sets of observations for each of the target stars, with each set of observations requiring about a half-hour of HST time. For each set of observations, the astronomers plotted the position of the target stars compared to a well-known set of background stars. That provided parallax measurements that were accurate to within one millisecond of arc — an angle that’s equivalent to the size of an American quarter at a distance of 1,500 miles.

The precise distances to the target RR Lyrae stars provides the most accurate calibration to date of the period-luminosity relationship (the variation in brightness over time) for the entire class of stars.

That calibration is particularly important because RR Lyrae stars are more common than Cepheids, making them in some ways better “standard candles” for measuring cosmic distances.

RR Lyraes also are common in globular clusters, which contain some of the oldest stars in the entire galaxy. Measuring the precise ages of globular clusters requires accurate measurements of the clusters’ distances. So the RR Lyrae observations will help astronomers plot the ages of stars that are as old as the galaxy itself — and almost as old as the entire universe.



An animation shows the variations of RR Lyrae stars in the globular cluster M3 [J.Hartman (Harvard CfA/K.Stanek (Ohio State)]

Links

RR Lyrae

RR Lyrae at STARS

RR Lyrae Stars

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