Evidence of an Upcoming Stellar Merger and Luminous Red Nova

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Introduction
In 2008, the star V1309 Sco brightened by a factor of 10,000 while gradually cooling, an explosion known as a luminous red nova. Prediscovery images showed V1309 Sco to have previously been a binary star system with an exponentially decreasing orbital period. To learn why such mergers occur, we need to study a binary just before it explodes, something that has never been done. Last summer our group identified the binary KIC 9832227 as a merger candidate based on observed period changes. This summer we tested this hypothesis with new photometric and spectroscopic observations.

Photometric Evidence

Photometry is the study of changes in brightness over time. Binaries are brightest when you can see both stars and dimmest when one is eclipsing the other. A light curve, like Figure 3 on the right, is a plot of the changing brightness over one orbit. Photometric observations can precisely determine the times of eclipses.

Over the past ten years, the period of KIC 9832227 has been getting shorter at a faster and faster rate. This implies that the stars are orbiting faster and getting closer together.

Figure 4 above shows observed eclipse times relative to those of a fixed period. The solid line is the exponential fit our group computed last summer. Note how our data from the past year agree beautifully with this fit. The degree of curvature in the plot, an indicator of the rate of period change, now exceeds that of all other observed close binaries.

However, since last summer we devised an alternative interpretation of this plot: a third star orbiting the binary in an approximately 20 year period could gravitationally influence the observed period of the binary, mimicking the merging star pattern for a time.

Spectroscopic Evidence

As a definitive test of the alternative, third body hypothesis, we turned to spectroscopic observations. By observing shifts in the wavelengths of spectral features, we can learn how fast stars spin on their axes and orbit each other. We used large telescopes at the WIRO observatory in Wyoming and the APO observatory in New Mexico to obtain the necessary data. We expected to see the broadened signature of a binary, as illustrated in Figure 5 below, with the addition of a narrow spike in the center (if there is in fact a third star).

In Figures 6 and 7 we display the spectra ordered by orbital phase. We clearly see the two broad stars orbiting around each other, but see no sign of a third body.

Conclusion

Our merging star hypothesis from last summer has passed two strong tests: our spectroscopy rules out the possibility of a third star, while our new photometry continues on the trajectory of a decreasing orbital period. Even stiffer tests lie ahead as the rate of period decrease is predicted to hasten in the next few years.

If correct, we expect to see a merger and explosion within the next three to five years, incredibly soon by astronomical timescales. Such an event would be visible even to the naked eye as a fourth light in the crossbar of Cygnus, perpendicular to the plane of the Milky Way. Figure 8 is a chart of the constellation of Cygnus about 30 degrees across, with our binary highlighted in red. We hope that extensive observations made in the time remaining will yield the key to what causes binary stars to merge.