Period Changes in the Mira Variable TY Cassiopeiae

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Abstract We studied the period changes from 1888 to mid-2002 in the long period, Mira-type variable star TY Cassiopeiae by combining 275 photographic magnitudes and useful upper limits of brightness from the Harvard College Observatory plate collection with more than 1750 visual, photovisual, and CCD(V) magnitude measurements and upper limits from the AAVSO International Database. The star is shown to have a period decrease from 645 to 550 days during the early years of the 1900s, then the period steadily increased to 645 days until the 1980s, and then it stabilized. These changes are qualitatively similar to the predictions of helium-shell flash models of Wood and Zarro (1981). Thus, TY Cas may be an excellent candidate for a star undergoing a helium-shell flash.

1. Introduction

The Mira-type variable star TY Cassiopeiae was discovered in 1913 by C. R. D'Esterre (1913). In the 4th edition of the *General Catalogue of Variable Stars* (GCVS) (Kholopov *et al.* 1985) TY Cas is listed as being of spectral type M6, and varying from magnitude 11.5 to fainter than 17.5 photographically, with a period of 645 days. The observations in the AAVSO International Database show the star to be varying from magnitude 10.3 to 17.9 visually and with CCD(V) filter. The notes to the GCVS indicate that from 1911 to 1928 (JD 2419200–2425300) the star showed a period of 545 days and from 1932 to 1972 (JD 2427000–2441500) a period of 623 days. This apparent increase in period was also detected in the AAVSO data and suggested that a search through the plate collection of the Harvard College Observatory, combined with data from the AAVSO International Database, might produce valuable results in the study of the evolution of the period.

2. Observations, Analysis, and Results

In the Harvard College Observatory photographic plate collection, 275 photographic magnitudes and useful upper limits to brightness from 1888 to 1980 (the collection actually ends in 1989) were found. The AAVSO International Database provided more than 1750 visual, photovisual, and CCD(V) magnitudes and useful upper limits to brightness from 137 observers worldwide from 1968 to mid-2002.

We have analyzed the time evolution of the period using two techniques. First, we used the period search algorithm CLEANEST Fourier analysis (Foster 1995) developed at the AAVSO and designed to analyze unevenly time-spaced data. Because of large gaps in the data, particularly in the photographic data, we divided the data into chunks and analyzed the period within each chunk. Second, we used the weighted wavelet Z-transform technique, or WWZ (Foster 1996), another software developed at AAVSO which is specifically designed to compensate for the difficulties of irregularly-spaced data. In Figure 1 we plot the period and the uncertainty of the strongest peak of the Fourier spectrum using CLEANEST as a function of time together with WWZ results wherever it is applicable. The plot shows that the period in the last decade of the 19th century was around 645 days, then there was a steep drop to 550 days in the early 1900s, followed by a steady rise until the late 1970s, when the period stabilized. Since 1980 the period has been fluctuating between 625 and 675 days with a mean of 645 days.

The amplitude and the mean magnitude of the star may be expected to show a change along with the period change. However, confirmation of this behavior has not been possible. TY Cas is very faint when at minimum—below the Harvard plate limit and the visual detection threshold of most amateur telescopes—and until recently there have not been positive observations submitted to the AAVSO International Database at or near the minimum of TY Cas. Over the last few cycles positive observations have been obtained at minimum with CCDs and submitted to the AAVSO, but since only a few cycles have been observed so far and the past minimum magnitude of TY Cas is not known, no correlation can be made between amplitude or mean magnitude and period change.

Wood and Zarro (1981) published a series of models of Mira-type variable stars of varying core masses undergoing a helium-shell flash, showing the behavior of surface luminosity as a function of time. The models indicate that at the start of a helium-shell flash, the luminosity undergoes a steep decline, followed by a slower brightening, and then followed by a slow decline. Since the period of the star is directly related to the luminosity, the period would be expected to change in the same manner. This behavior is qualitatively similar to the behavior of the period in TY Cas. Thus, this star may be an excellent candidate for a Mira variable undergoing a helium-shell flash.

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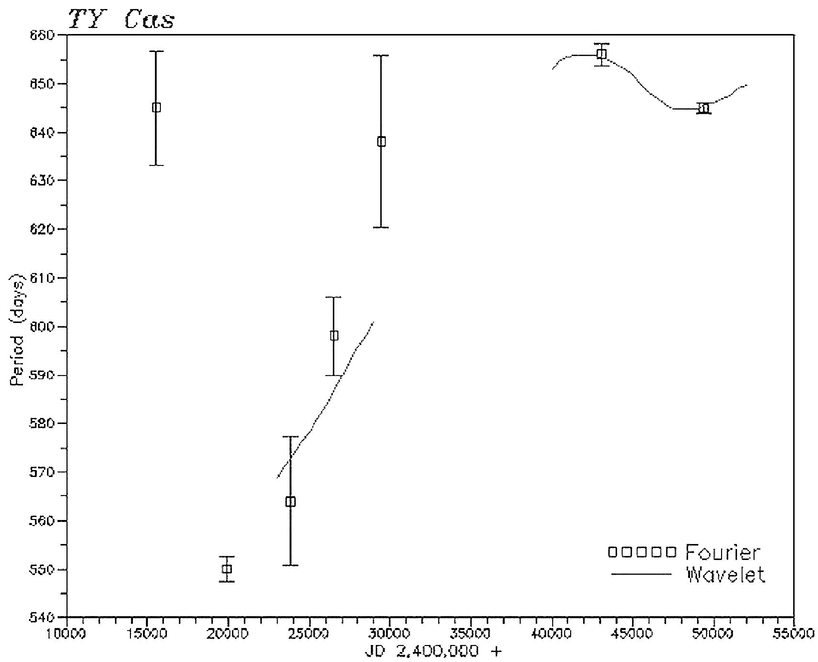

Figure 1. Periodogram for TY Cas, 1888–2001, from the Harvard and AAVSO data.

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