ULTRA-SHORT VARIABILITY IN CH CYGNI

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Abstract

CH Cygni is a star system well known for multiple coexisting variable periods on widely-varying time scales. This paper focuses on a little-known aspect of its variability, on a time scale of several minutes. Data are presented that show CH Cygni varies by 0.15 magnitude over a short time span—3 to 8 minutes—and this variability is most pronounced in the blue part of the spectrum.

1. Introduction

CH Cygni is a well-known star system in the constellation Cygnus, known to be variable for many years. It is believed to be a symbiotic star comprised of a semiregular red giant star in orbit with a white dwarf star. There may also be a third star, a blue star, in orbit around these two, though this is not known with certainty. The variability is attributed to the fluctuations of the semiregular red giant, along with the accumulation of an accretion disc around the white dwarf resulting from the outflow of outer atmospheric gases from the red giant star. In addition, as the stellar wind from the red giant falls onto the accretion disc, there is presumed to be a shock front, which may account for the ultra-short variability.

This variability is manifest on many time scales. A review of the AAVSO International Database (AAVSO 1999) and the British Astronomical Association, Variable Star Section database (BAA, VSS 2000) over the past 30 years reveals what appears to be a 900-day long-term variability ranging from 5th magnitude to magnitude 10.5. There is a shorter variability of 100–120 days, and there is also multiple shorter variability that ranges from a few to many days. All of this variability is highly irregular in both magnitude and time scale. Dr. Margarita Karovska had previously presented to the AAVSO some very short-term variability on the order of hours or minutes (Karovska and Mattei 1992). With the urging and support of Dr. Karovska and Dr. Janet Mattei, we have undertaken a project to determine the ultra-short variability of this challenging star system.

2. Data acquisition and results

Two telescopes were used to obtain the data. A 16-inch f/4.5 Newtonian telescope in Lynnfield, Massachusetts, and a 32-inch f/4 Newtonian in M. Motta's observatory in Center Harbor, New Hampshire, both of M. Motta's own design, were utilized at various times over the autumn of 1999. These telescopes were coupled to an Apogee AM13 CCD camera, equipped with a Kodak 1300 chip with 16-micron square pixels, generally binned 3x3 to increase the sensitivity and the speed of downloading the images through the system. An image can be downloaded every 8 seconds using this modality, though most of the data runs were obtained with an image recorded every 30 seconds, with the runs lasting three to four hours. The Johnson-Cousins filter system was used in both Visual and Blue, with the Blue filter showing the greatest variability on the short time scale. All images were dark, bias, and flat corrected, and then the data were reduced by photometric software by Software Bisque (CCD Soft). Each data frame was reduced by comparison with the magnitude 9.4 comparison star on the AAVSO Standard "c" scale chart for CH Cygni, as well as with a second comparison star of known magnitude on the "c" chart, the 8.6. An analysis was then performed using VSTAR software from the AAVSO.

Numerous data collection runs were performed. CH Cygni emits a very considerable amount of infrared energy, so the unfiltered CCD measured it at 4th magnitude (averaged from several observations made on October 7) with no appreciable short-term variability seen. With a V filter, the system measured an average magnitude 7.4, with some variability detected, though just barely above the noise level. However, with a Blue filter, CH Cygni was measured at 9.2 magnitude, with an unmistakable variability of 0.15 magnitude (averaged from several magnitudes October 7). Analysis of the data using VSTAR gives a frequency of 43.3, leading to a period of 36 minutes. There is also a period of 4.8 hours having a power value (P) of 16.3 (any value over 5 is considered significant). There was, however, an ultra-short variability noted at 7.4 minutes (frequency of 430 per day), with a P value of 23.66. Figure 1 shows a typical 50-minute section of a run taken on 10/7/99 with a B filter, and demonstrates this ultra-short variability. This variability was highly irregular in nature, however, and in reviewing the the data, it became clear that there were also ultra-short spikes of as short as 1 minute that occurred randomly. CH Cygni never fails to surprise, however, and there were times when standstill was noted, exhibiting an essentially flat magnitude curve over the course of an hour or more, which would then abruptly terminate and switch to an ultra-variable mode. Figure 2 shows data from the night of 10/16/99, demonstrating standstill from variability for over 1 hour, with the termination abruptly swinging into an ultra-variable mode, with periods of 3–8 minutes on the order of 0.15 magnitude.

3. Conclusions

CH Cygni continues to surprise and show variability on enormous time scales ranging from years to shorter periods of 100 days to hours, and now variability has been demonstrated on the order of minutes. The nature of this variability is unclear, and much work remains in order to elucidate this phenomenon. Certainly, long term variability is most likely related to the nature of the red giant itself. However, the ultra-short variability noted on the order of minutes is unlikely to be related to a system as large as a star, or even an accretion disc, and is most likely to be related to the flaring of the shock front and the stellar wind as it impacts on the shock front itself. Other contributing factors to consider are accretion fall-in and magnetic effects of the white dwarf system. Further data acquisition and analysis, of course, will be needed to validate this. This star system is well suited to CCD observers with moderate-size equipment, and further data accumulation and analysis will help determine the nature of this fascinating system. Combined B and V filtering, and possibly simultaneous x-ray satellite data, may help to elucidate the nature of the physics involved. Studies of other symbiotic star systems would also be of great value to help explain the nature of the variability of this general class of star system.

References

AAVSO. 1999, visual observations from the AAVSO International Database, viewed via the light curve generator on the AAVSO website (http://www.aavso.org).

BAA, VSS. 2000, lont-term visual light curve of CH Cygni, viewed on BAA, VSS website (http://www.telf-ast.demon.co.uk/gifl/00118.gif).

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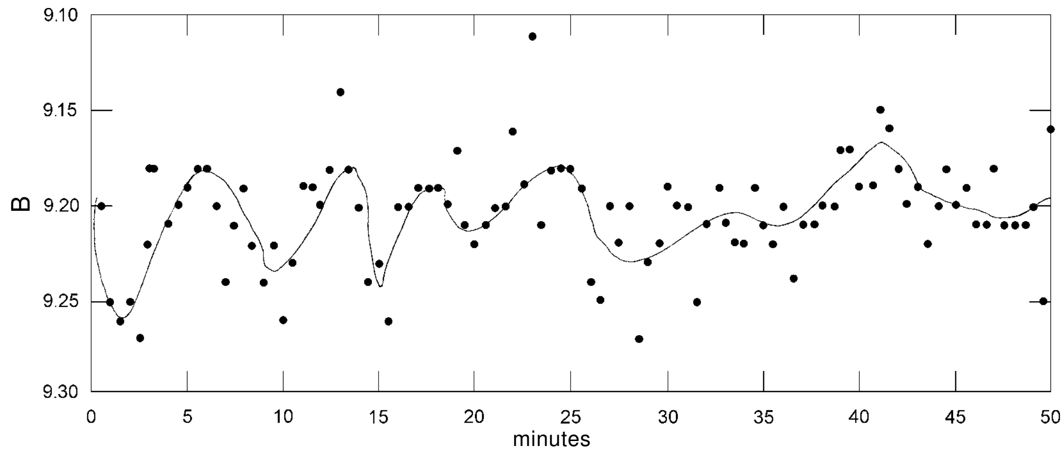

Figure 1. 50-minute plot of CH Cygni from 10/7/99 taken with a Johnson Blue filter (section of a 4-hour data run). Line representing average brightness fit by eye.

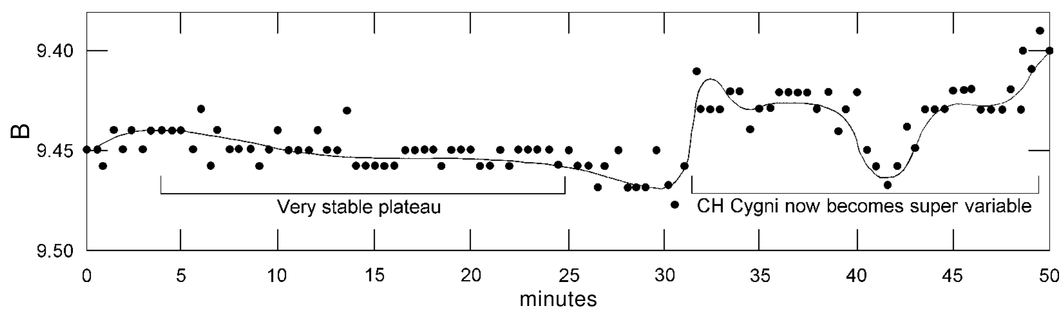

Figure 2. 50-minute plot of CH Cygni from 10/16/99 showing "quiescent" period that abruptly ends with marked variability. Line representing average brightness fit by eye.