

THE LIGHT CURVE OF CI CYGNI 1967 - 1992

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Abstract

The light curves of the symbiotic variable star CI Cygni are presented for the years 1967 through 1992. The data are from the plate collection of the Maria Mitchell Observatory (MMO) and from the visual observers of the AAVSO. Previously unpublished MMO data of CI Cygni are included for the era between 1967 and 1981. The light curve suggests the system experienced an approximately 5-year interval of nova-like outbursts which was preceded and followed by two-and-a-half decades or more of relative quiescence.

CI Cygni is a symbiotic variable star consisting of a cool, 1.5 M_⊙ M5 II star in orbit around a hotter, 0.5 M_⊙ main sequence dwarf (Kenyon *et al.* 1991). The system is an eclipsing binary of orbital period 855.25 days, with its brightness varying between 12th and 11th magnitude. However, the system undergoes violent eruptions of one to three magnitudes above this normal fluctuation. It has been suggested that the cause of the eruptions is an unstable accretion disk around the hotter companion. The disk is periodically fueled from matter streaming over from the bloated cooler companion. Apparently, as the system is not always eruptive, the accretion disk requires a certain amount of this matter before it become unstable. More investigation of this phenomenon is being undertaken by Kenyon and his colleagues (Kenyon *et al.* 1991).

CI Cyg was discovered by Annie J. Cannon in 1922 while studying spectral plates at the Harvard College Observatory. Cannon noticed that this variable could not be classified with any known spectral class and in fact could only be categorized using two superimposed spectral classes. This is the symbiotic nature of the system. With investigation of an odd eruption in 1911 of CI Cyg to around magnitude 10.7 from 12.1, Naomi Greenstein came to refer to CI Cyg as a Z Andromedae type variable (another term for a symbiotic star). In 1937, Greenstein plotted the known eclipsing period data to find a 900-day period of variability. Balfour Whitney's presently accepted period for CI Cyg came in 1953 when L. Aller published a paper with Whitney's period of $JD_{\min} = 2411902 + 855.25 E$ (Aller 1953).

In 1968, a light curve for CI Cyg was published by MMO Director Dorrit Hoffleit, using blue-sensitive plates taken at MMO 1919-1967. The curve included an impressive 1937 outburst which was followed by quiescence (Hoffleit 1968). This work instigated much interest in CI Cyg, and soon observing programs were established to archive its light curve. The MMO's and the AAVSO's were the largest of these programs.

The AAVSO Director Janet A. Mattei used the wealth of subsequent data to publish the continuing saga of CI Cyg in 1982 with a curve from that year back to 1967. Her multiwavelength light curve shows the dramatic eruption of CI Cyg which occurred in 1975 and was immediately followed by an eclipse (Mattei 1982). This was the last recorded eruption of the system to date.

This paper attempts to present two things: one, the latest installment of the saga, and two, previously unpublished photographic data of CI Cyg. Around four hundred more plates were discovered in the plate stacks at MMO to contain CI Cyg. I came

across this while reviewing Hoffleit's observations. She used all of the Cygnus plates in the stacks, seeing as CI Cyg was not given its own target field until after the publication of her 1968 paper. The MMO plates used cover regions on the sky of 17 by 13.5 degrees. The Cygnus targets overlap slightly but enough that CI Cyg has conveniently appeared on all of them somewhere in the vast coverage of each plate. I decided for this work, though a partial repetition of Mattei's 1967 - 1981 light curve, I should present the "new" data, ≈ 210 more photographic data points.

The reader will notice several things about the light curve in Figure 1. The photographic data has conspicuous yearly gaps of approximately 200 days. This is due to the traditional observing program at the MMO of summer through fall. The program at the MMO was historically designed for observations of shorter period variables, such as RR Lyrae stars and Cepheids. Half-year coverage is no obstacle for investigation of these stars. However, analysis of longer period variables like CI Cygni suffer from the yearly gaps. My attempts to fit periods to the photographic data resulted in beautiful period correspondence with one year, two years....This explains the superposition of the visual data generously offered to me by Dr. Mattei for this era. The period of 855.25 days fits to these data.

The visual data proved to be so extensive that binning over a two-day interval was used, which allowed clearer superposition and study of the curves. The two curves together give ample coverage and two-color analysis of CI Cyg from 1967 to 1992.

Let the reader also notice that there have been three outbursts of the system during this time frame, the largest occurring in 1975. Recent work on these data have involved scrutiny of the minimum which follows the 1975 outburst in an attempt to discern the size and shape of the eclipsed object, mainly the hotter companion. Other minima have been similarly analyzed. For this, the visual data have been invaluable. I hope to use B and V data from Dr. Kenyon to analyze this curious system further. I believe that from viewing the pattern in the historic light curve we can look forward to a new period of eruption in CI Cyg to occur within this decade.

Several tons of gratitude go out to many people who made this work possible. I thank Dr. Dorrit Hoffleit for introducing me to variable stars, this crazy one in particular. She has been a terrific role model and good friend. Dr. Scott Kenyon has been instrumental as my adviser; his many hours of instruction and patience have helped me beyond his knowing. Thanks to Dr. Eileen Friel for giving me the opportunity to experience an internship at the MMO and for allowing me to use the plate collection. Thank you Dr. Janet Mattei for granting me use of the extensive and vital AAVSO visual data. Thank you and the office of the AAVSO also for being so patient with me and my computer difficulties! And, for those who braved my frustrations with the aforementioned difficulties, I thank Dr. Guillermo Torres, Jeffrey Breen, Dr. Jonathan McDowell, Peter Challis, Dr. Seth Digel, and Raph Hix. A special thanks to Dr. Dave Latham for being an editor, a critic, a resource, and an honest friend. This work was made possible by NSF grant AST-8922809 awarded to Dr. Emilia Belserene.

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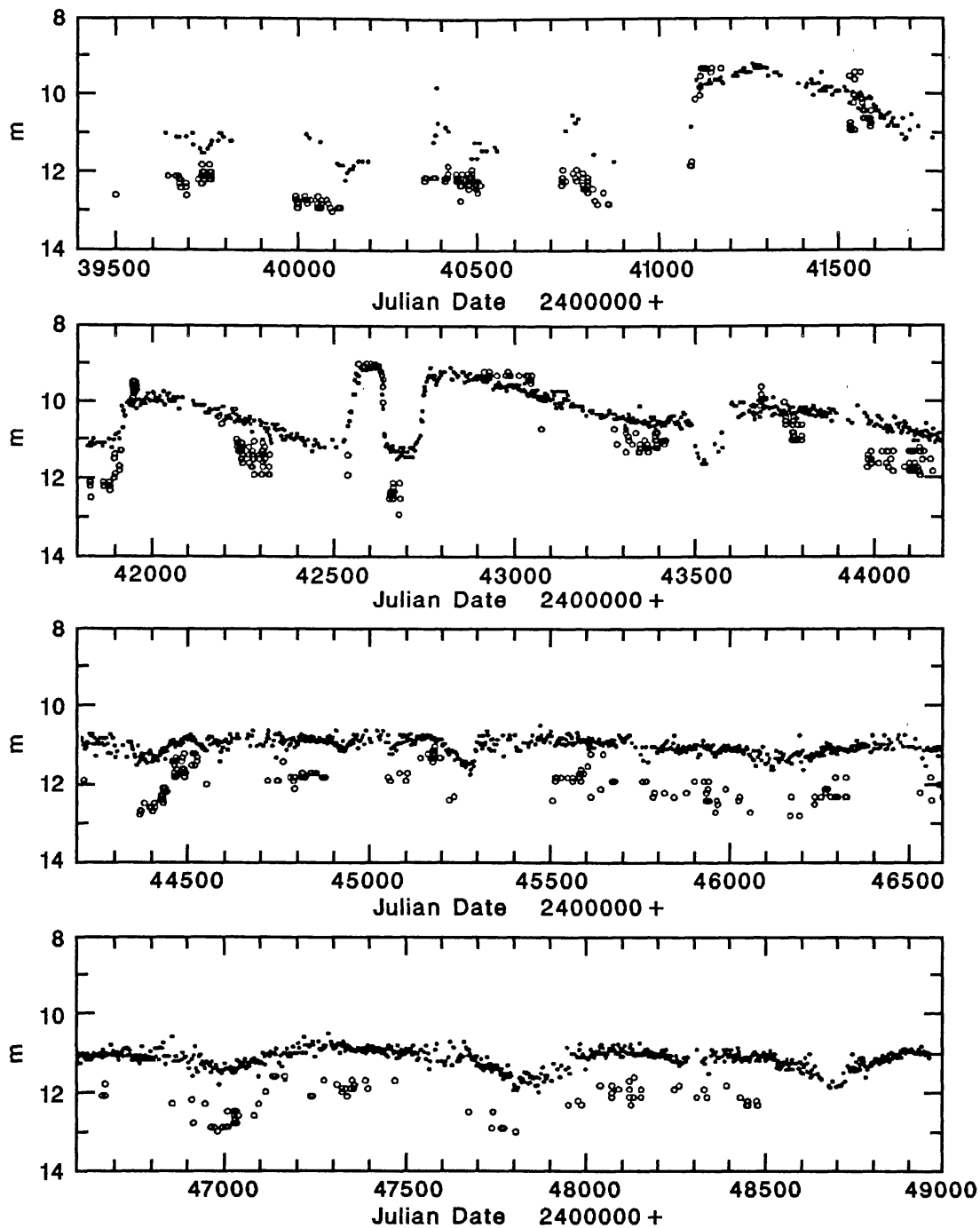


Figure 1. The photographic and visual light curve of CI Cygni for the years 1967 through 1992. The MMO blue photographic data are plotted with open circles. The two-day means of AAVSO visual data are plotted with filled circles.