

New R Coronae Borealis Stars in the LMC Discovered in the MACHO Photometry Database

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Abstract. An extensive search has been made in the MACHO photometry database for new R Coronae Borealis (RCB) stars in the LMC. Only three such stars were known previously. Nine new LMC RCB stars have been spectroscopically confirmed so far.

1. Introduction

We report the discovery of several new R Coronae Borealis (RCB) stars in the Large Magellanic Cloud (LMC) using the MACHO project photometry database (Alcock et al. 1996, 1999). RCB stars have a wide range of temperature, but they can be divided simply into three subgroups, cool (5000 K), warm (7000 K) and hot (20,000 K). The identification of at least nine new RCB stars has now been confirmed spectroscopically. Six are cool RCB stars characterized by very strong Swan bands of C₂, violet bands of CN, and weak or absent Balmer lines, G-band and ¹²C¹³C bands. Two are warm RCB stars having weaker Swan bands. One star is an example of a hot RCB star of which only 3 were previously known to exist in the Galaxy and none in the LMC. All of the stars have shown deep declines in brightness typical of RCB stars (Clayton 1996). The discovery of these new stars increases the number of known RCB stars in the LMC by a factor of four (to 12) and demonstrates the utility of the MACHO photometric database for the discovery of new RCB stars.

2. Absolute Luminosity of RCB Stars

Two interesting trends are present in the characteristics of the new stars. First, they tend to be significantly fainter at maximum light than the three previously known LMC RCB stars. They seem to have absolute luminosities, M_V , about a magnitude fainter than the other three stars. Second, the stars discovered thus far are mostly members of the cool subgroup of the RCB stars. Most RCB stars in the Galaxy fall in the warm subgroup. The new observations presented here suggest that there is a wider range of absolute luminosity than given by the

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canonical, $M_V = -4$ to -5 mag. Therefore, the absolute luminosities of RCB stars are now uncertain since they are based solely on the LMC stars. The Hipparcos data for the Galactic RCB stars provided only lower limits on distances, so the LMC sample is the only source of distances and absolute luminosities (Cottrell & Lawson 1998).

3. RCB Stars as Final Helium Shell Flash Stars

The evolutionary history of RCB stars remains mysterious. There are two major evolutionary models for the origin of RCB stars: the double degenerate model and the final helium shell flash model. In the final flash model, there is a close relationship between RCB stars and planetary nebulae. Only about 10% of RCB stars are known to have shells, but no systematic survey has been done. A link between RCB stars and planetary nebulae, if it can be established, will be an important step forward in understanding the evolution of post-AGB stars. We are now making a survey of the RCB stars to look for shells. One shell, around UW Cen, has been studied so far (Clayton et al. 1999).

Only three stars have been observed while going through a final helium shell flash since the advent of modern instrumentation, FG Sagittae (in 1894), V605 Aql (in 1919) and Sakurai's object (in 1996). The only spectrum taken of V605 Aql while it was in its cool giant phase in 1921 is identical to a typical cool RCB star and very similar to the present spectrum of Sakurai's object (Clayton, & De Marco 1997). Both show strong Swan bands of C_2 and violet CN bands, as well as weak hydrogen features and little or no evidence of ^{13}C . V605 Aql today provides a unique opportunity to investigate the evolution of a final flash star over a period of 75 yr. The star is very faint, but shows a WC spectrum. It has been suggested that it has already returned to its pre-outburst brightness, in disagreement with model time scales which predict several thousand years. However, it is more likely that the star is still $10^3 - 10^4 L_{\odot}$, but obscured by dust. V605 Aql lies at the center of the planetary nebula, A58. The central knot is hydrogen deficient.

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