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THE SECOND SUPERCYCLE OF THE HELIUM ER UMa STAR, CR Boo

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CR Boo is the prototype of the helium dwarf novae (for a review of helium cataclysmic variables, or AM CVn stars, see Warner 1995), which show very frequent outbursts and superoutbursts. The characters of outbursts in CR Boo is regarded as equivalent to ER UMa stars (for a review, see Kato et al. 1999) in hydrogen-rich cataclysmic variables. Kato et al. (2000) showed that the overall light behavior of CR Boo is well represented by a supercycle (the recurrence time of superoutbursts) of $46^{\rm d}.3$. The shortness of the supercycle qualifies CR Boo as a helium counterpart to hydrogen-rich ER UMa stars (Kato et al. 2000). The observed properties are in good agreement with the theoretical light curve (Tsugawa and Osaki 1997).

During the extensive observing campaign by the VSNET Collaboration (http://www.kusastro.kyoto-u.ac.jp/vsnet/), we noticed a significant change in the outburst pattern in CR Boo. Figure 1 shows the light curves drawn from visual observations. The observations used comparison stars calibrated in the V-band, and the typical error of a single estimate is $\sim 0^{\rm m}.2$, which will not affect the following discussion. There is already evident cyclic variations with a period remarkably shorter than previously reported.

Figure 2 shows the result of period analysis, using the Phase Dispersion Minimization (PDM) method (Stellingwerf 1978). The best period is $14^{\rm d}.7$, which is remarkably shorter than the $46^{\rm d}.3$ period. Figure 3 shows the folded light curve by this period. The light curve clearly shows the slowly declining plateau portion between phase 0.0 and 0.6, and a

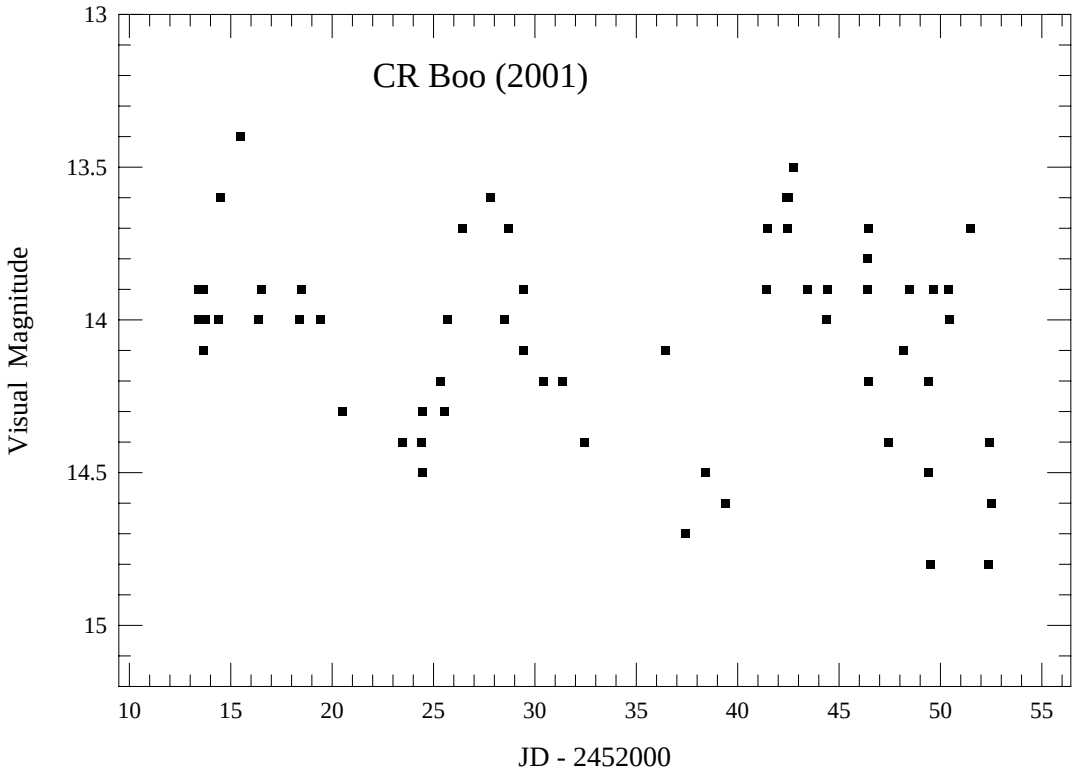

Figure 1. Light curve of CR Boo

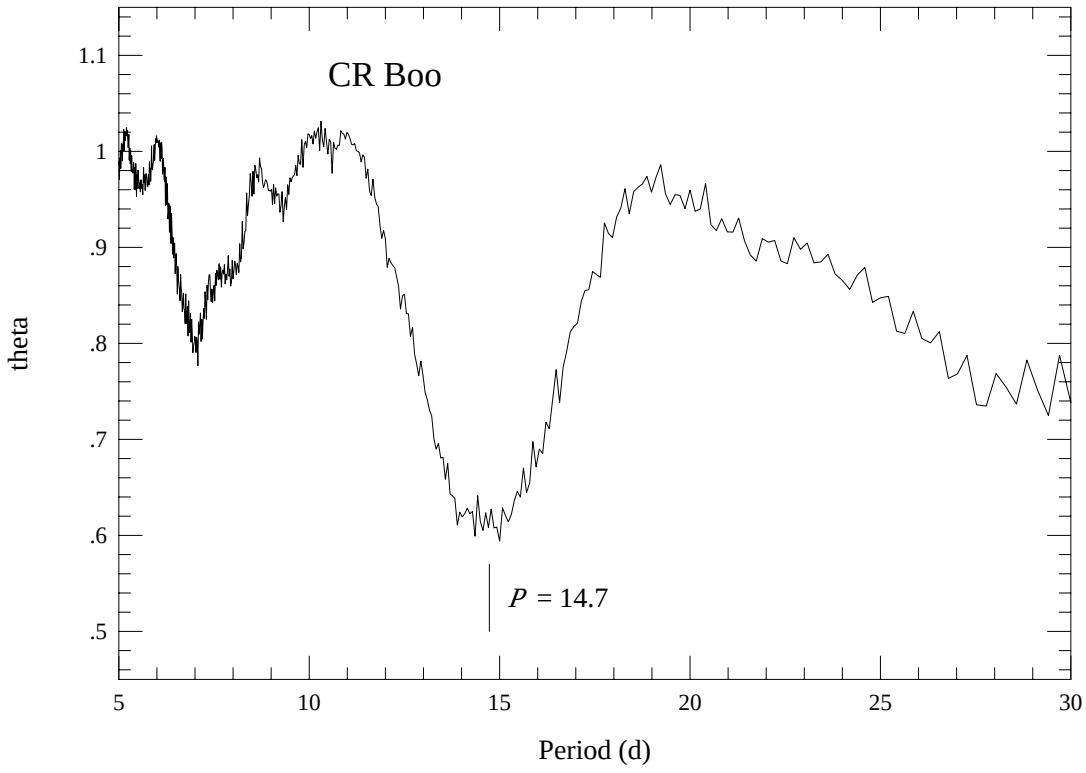

Figure 2. Periodogram of CR Boo

faint state between 0.6 and 0.8. The linear decline observed in the section of the outburst between phase 0.0 and 0.6 closely resembles superoutburst plateau observed in other ER UMa stars and helium ER UMa stars. Thus we have found a second supercycle in CR Boo, with an extremely high superoutburst duty cycle of 0.6.

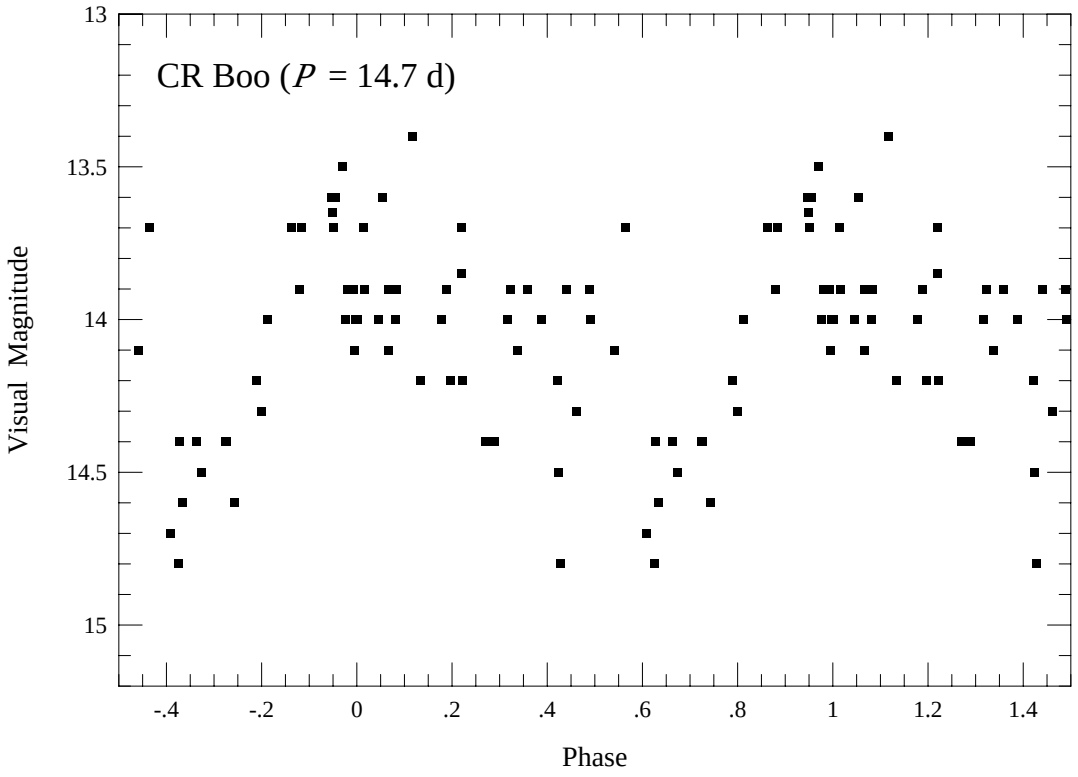

Figure 3. Folded light curve of CR Boo

Among hydrogen-rich ER UMa stars, RZ LMi (Robertson et al. 1995; Nogami et al. 1995) and DI UMa (Kato et al. 1996) have extremely short supercycles of 19–25 d. They are sometimes called RZ LMi stars, because of their peculiar characters. In hydrogen-rich systems, such a short supercycle cannot be explained by simply increasing the mass-transfer rate from the secondary star. Osaki (1995) proposed that a low tidal torque by the secondary is responsible for such short supercycles. It is not yet clear whether the same argument applies in helium ER UMa stars. If the newly discovered supercycle is explained by a temporary increase of mass-transfer rate, this would provide an evidence of changing mass-transfer rates in helium ER UMa stars. Otherwise, the present detection of a new supercycle would provide the first evidence of an alternation between usual ER UMa-state and peculiar RZ LMi-state in the same system.

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