IUE AND OPTICAL SPECTRA OF RZ LMI AND ER UMA THROUGHOUT THEIR 19 AND 43 DAY CYCLES

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Abstract. IUE and optical data were obtained throughout the supercycles of RZ LMi and ER UMa during 1993/94. While most of the spectral and photometric characteristics are consistent with disk changes in systems with a relatively high accretion rate and low inclination, the cause of the high accretion rate in this subset of SU UMa stars is not known.

1. Introduction

In the past year, it has become apparent that the 3 CVs RZ LMi, ER UMa and V1159 Ori exhibit a unique pattern of behavior similar to the normal SU UMa stars, but at extreme minima of time-scale and amplitude (Robertson, Honeycutt & Turner 1995). These 3 objects show very short (19...45 day) supercycles, have very low $\dot{P}$ (10^{-3}) and very low amplitude (3 mag) superoutbursts. Between superoutbursts, they have regular 2 mag outbursts at about 4 day intervals. In order to determine if these objects can be interpreted within the scenario of disk instability and tidal changes invoked to explain the systems below the period gap (Osaki 1989), we obtained IUE and optical spectroscopic and photometric observations throughout the supercycles of RZ LMi and ER UMa.

2. Observations

The photometric cycles of RZ LMi and ER UMa were monitored with the Roboscope (Honeycutt & Turner 1992) as well as with CCD frames obtained coincident with the optical spectra. The University of Washington (UW) 30 inch telescope at Manastash Ridge Observatory (MRO) was used on 4 nights to obtain time-resolved photometry of RZ LMi during decline

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from superoutburst and at minimum following a normal outburst. The IUE satellite was used to obtain spectra at 4 times during the cycle of RZ LMi and 7 times during the cycle of ER UMa. Optical spectra were obtained with the UW 3.5 m telescope at Apache Point Observatory (APO), using the Double Imaging Spectrograph (DIS). The flexible scheduling available on this telescope allowed for 1 h runs on different nights at low resolution (10 Å) covering 3900...9000 Å to obtain data throughout the cycles. A few nights were scheduled in high resolution mode (2 Å) to obtain radial velocity curves for orbital period determination. Overall, 10 phase points in the superoutburst period were sampled for RZ LMi and 7 for ER UMa.

3. Results

The IUE data on ER UMa show large flux changes throughout the cycle with corresponding large line changes (Fig. 1). The continuum flux at 1500 Å increased by a factor of 13 from quiescence to supermaximum, while the optical flux at 5500 Å increased by a factor of 8. The slope of the IUE flux distribution (in log wavelength units) was −2.1 during the 5th minimum (April 17) and steepened to −2.6 during supermaximum (May 5). P Cygni profiles for C IV are evident in most of the spectra near outburst and superoutburst (March 26, April 3, 12, 25). The lines change from absorption at outburst to emission at quiescence (April 17). While these changes are 'normal' for SU UMa stars, the amplitude of the UV flux increase is much less than in systems such as SW UMa (where the UV increases by a factor of 1000 and the optical by a factor of 400; Szkody, Osborne & Hassall 1988). In RZ LMi, the IUE spectral distribution shows no change in slope in data obtained during the faintest magnitudes compared with data near superoutburst and the flux changes are even smaller than for ER UMa (a factor of 4 at 1500 Å and a factor of 6 at 5500 Å).

In the optical, the Hβ and Hγ lines of ER UMa undergo a transition from absorption at superoutburst, to absorption with emission cores during the normal outbursts, to pure emission at the minimum magnitudes (Fig. 2). Except for a brief hint of absorption wings at superoutburst, Hα is always in emission, with increased strength at fainter magnitudes. The lines in RZ LMi are in absorption at the superoutburst and normal outbursts, and only turn into emission during minima. In addition, the emission lines in RZ LMi are very narrow, being only half the full width zero intensity of ER UMa and V1159 Ori (Jablonski & Cieslinski 1992). In general, the equivalent widths of the emission (at mimina times) of Hβ in both ER UMa and RZ LMi are factors of 4...5 smaller than typical for SU UMa stars (Szkody 1987).

The high resolution spectra were used to construct radial velocity curves,

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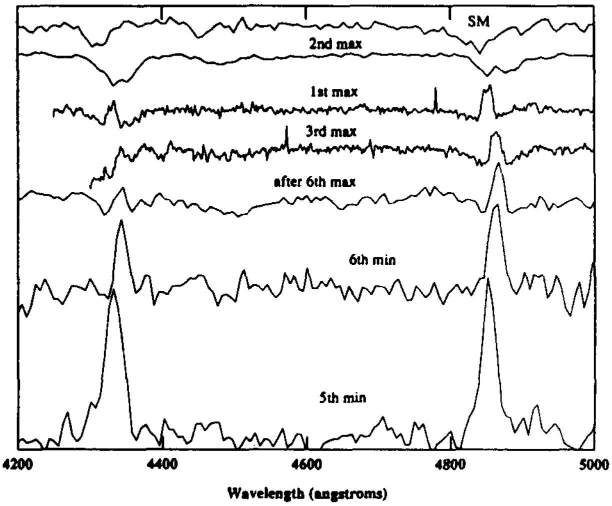

Figure 1. Representative IUE spectra of ER UMa plotted with arbitrary vertical offsets

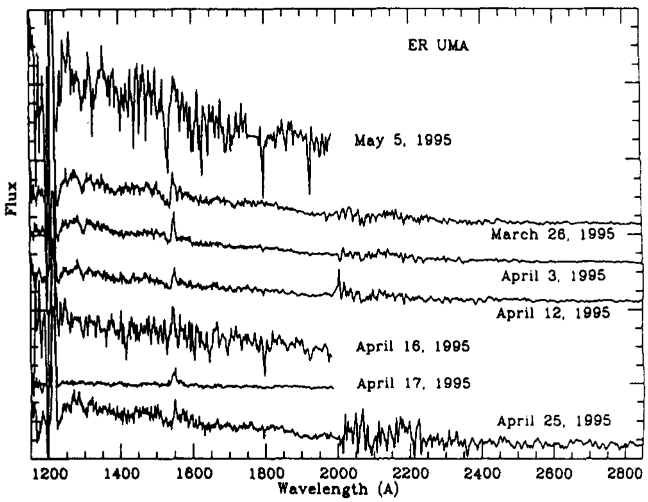

Figure 2. Representative low and high resolution blue spectra of ER UMa

using a double Gaussian fitting procedure on the emission line wings. A sine fit to the ER UMa data determines an orbital period of 90±3 m and a semi-amplitude, K, of 57±8 km s^{-1}. The data on RZ LMi could not be fit with any sine curve, to a K limit near 20 km s^{-1}. However, the MRO photometry at minimum showed a periodic modulation over 2 nights at a period of 80.9±0.1 m. As these periods are shorter than the superhump periods

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(95 m for ER UMa and 85.6 m for RZ LMi; Robertson et al. 1995), and are close to those expected from the superhump-orbital period relationships of SU UMa stars in general (Howell & Hurst 1994), it is reasonable to assume that these are the observed orbital periods.

4. Conclusions

In comparison to other SU UMa stars, our IUE and optical data on ER UMa and RZ LMi have shown similar IUE slopes and spectra, optical spectral changes similar to SU UMa quiescent, outburst and superoutburst states, and orbital periods that are shorter than the superhump periods. In these respects, this group of 3 objects are typical of SU UMa stars. However, distinct differences remain. The identical 3 mag amplitude from minimum to superoutburst for all 3 is very low. The 20...45 d for the supercycles are extremely short. The supercycle times are very stable compared to normal SU UMa stars. The radial velocity amplitudes of all 3 are very low and the line equivalent widths are abnormally small. The IUE and optical flux changes during outburst are very small compared to normal SU UMa-type behavior. Whereas the line widths, small equivalent widths, and low radial velocity amplitudes could be explained by low inclinations, it is not clear why this is such a strong selection effect for this group. Osaki (1995) and Kato & Kunjaya (1995) have suggested that their mass transfer rates are larger than for typical SU UMa stars. In addition, Osaki had to decrease the tidal torque operating in RZ LMi in order to achieve a supercycle as short as 19 d. The models produced in this manner can reproduce the low amplitudes, short periods and correct number of normal outbursts between superoutbursts. Whereas these are the physical parameters needed to match the observed light curves, it is less clear how many systems really exist at this high mass transfer rate regime below the gap and what the mechanism providing this high rate is.

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References

Honeycutt, R.K., Turner, G.W., 1992, in "Robotic Telescopes in the 1990's", ed. A. Filippenko (San Francisco, ASP), p77
Howell, S.B., Hurst, G.M., 1994, IBVS, 4043
Jablonski, F.J., Cieslinski, D., 1992, A&A, **259**, 198
Kato, T., Kunjaya, C., 1995, PASJ, **47**, 163
Osaki, Y., 1989, PASJ, **41**, 1005
Osaki, Y., 1995, PASJ, **47**, L25
Robertson, J.W., Honeycutt, R.K., Turner, G.W., 1995, PASP, **107**, 443
Szkody, P., 1987, Ap. J. Supp., **63**, 685
Szkody, P., Osborne, J., Hassall, B.J.M., 1988, Ap. J., **328**, 243