Flares and Flickering in the Cataclysmic Variable AE Aquarii

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1 Introduction

Detected from the radio to the γ-ray bands, AE Aquarii is an extraordinary cataclysmic variable. It is a relatively bright (V ~11.4), non-eclipsing binary with an orbital period of $9^{\rm h}_{.}9$. The mass-donor secondary star is of approximate spectral type K5V and contributes about $\sim$ 80% of the total flux in the optical. While the mass ratio is well determined at $q = M_2/M_1 = 0.646$, the individual stellar masses are poorly known since the inclination is unknown. AE Aqr's flickering behavior is unique among CVs, alternating from periods of very violent activity to near total quiescence. Large amplitude flares have been detected in the radio, optical and UV. Previous work has shown the optical flare spectrum to be similar to stellar flare spectra.

2 The data (the "cable experiment")

Four nights of exactly simultaneous Hα spectroscopy and photometry were obtained on the 2.5 and 1.5m telescopes at Mt. Wilson on 27–30 July 1982. The simultaneity allowed us to renomalize the spectroscopy to agree with the photometry, giving us spectrophotometric data (spectral resolution $\sim$ 50 km s^{-1}, time resolution $\sim 6^{\rm s}$). A total of $\sim 17^{\rm h}$ of data were obtained, resulting in 10,098 spectra.

3 Preliminary findings

Large flares in both the line and continuum are easily seen. Changes of a factor of two in the continuum and a factor of three in the integrated line flux can occur on a timescale of a few hours. The variations in the Hα emission are highly structured and it is clear that the Hα emission is not simply a linear function of the continuum emission (the light curves are not scaled versions of each other). It appears that the Hα variations contain more power on shorter timescales than the continuum variations.

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The Hα line does not act as a single entity; rather the wings and core can exhibit different behaviour (e.g. a flare was seen in the red wing but is absent in the core, blue wing and continuum). If we assume the flares arise in an accretion disk (perhaps not a good assumption given AE Aqr's peculiarities!), this localization in velocity space corresponds to localization in position space, implying the flares come from localized regions in the disk.

The rise time of a particularly clean flare was seen to be about 6 min, with an exponential-like decay. The decay from the peak takes longer for Hα than for the continuum. Closer scrutiny suggests that there can be a delay between the maxima, with the continuum leading the line emission. Thus it appears that the Hα emission is a delayed and smeared version of the continuum.

"Cross-correlations images" were constructed (ccfs between the mean continuum light curve and the light curves for each pixel in the spectrum, displayed as an image). The ccfs do not remain the same across the line profile, but rather show a striking change in behavior. *The fact that correlation strength between the continuum and the line changes dramatically across the line profile implies that the variations are not global, but rather are localized in velocity space.*

Night 4 exhibits a somewhat different ccf image than the other nights, showing a noticeable trend across the core of the line profile — the peak of the ccf occurs at larger lags moving from negative to positive velocities. This behavior can be interpreted as meaning the continuum and blue wing vary synchronously, while the core and red wing lag behind, with the lag increasing to positive velocities. A maximum delay of $\sim 25 - 30$ min is present.

The Hα flux was plotted versus the mean continuum flux for each night. While Night 1 shows some structure, Nights 2 and 3 show little more than what appears to be random fluctuations. On Night 4 a linear correlation at low continuum flux levels is seen, as well as an apparent Hα saturation effect during flares. A loop structure was seen, indicating a strong hysteresis effect in the large flares on this night.

4 Summary

The relationship between the continuum fluctuations and the Hα fluctuations is complicated and varies from night to night. Flickering and flaring in the wings and the line core do not behave in identical fashion. This localization in velocity space may correspond to localization in position space, implying the flares come from localized regions in the accretion flow. The data suggest that the Hα emission decays slower than the continuum emission after a flare, additional evidence that the flares in CVs are analagous to those of stellar flares. No 33 sec oscillation was seen in Hα.

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