THE FLARE ACTIVITY OF AD LEO 1972-1988

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ABSTRACT. Time resolved U-filter lightcurves of stellar flares on the dM4e star AD Leo have been measured to determine the flare frequency for individual observing seasons between 1972 and 1988. This report adds new data for 1984-1988. We use the number of flares with energy larger than 10**30 erg, and the number of flare maxima with amplitudes larger than 0.3 as separate parameters to estimate flare frequencies. Chi-square tests do not reveal statistically significant variations of the flare frequency with time for 1972-1988.

1. INTRODUCTION

AD Leo is one of the most extensively observed flare stars in the solar neighbourhood. In U-filter photometry with S/N>10 (referring to the quiet star) one detects an outburst on the average every 1 - 1.5 hours. In time the flares appear to occur at random. Flare importance, measured by the size of the flare amplitude or by the amount of energy emitted,

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span 4-5 orders of magnitude. Small flares are much more common than large flares, and in about 1/3 of the cases the event is composed of several individual flare-ups. Pettersen et al.(1984, 1986) have analyzed previous observations of AD Leo to investigate if the flare activity varies on a timescale of years, in analogy with the solar activity cycle. In the present paper we update the analysis, using new observations between 1984 and 1988 from efforts at several observatories.

2. OBSERVATIONS

U-filter photometry with a time resolution of 1-9 seconds was done with 0.5-1.0 m telescopes at National Astronomical Observatory, Rozhen, Bulgaria; Stephanion Observatory, Greece; Piszkéstetö, Hungary; Skibotn, Norway; Kitt Peak National Observatory, Arizona, USA; and McDonald Observatory, Texas, USA. Each observing season lasted from November till May, and the effort reported here took place between November 1984 and May 1988. The results are summarized in Table 1. We detected a total of 149 flares in 190 hours of observations. We rejected all observations with S/N<10, and usually had 20 < S/N < 50.

3. ANALYSIS AND RESULTS

We have extracted the following quantities from our observations: Flare coverage, i.e. the time actually spent monitoring the star for flares; the number of flares detected with a peak flux exceeding 3.8 10**28 erg/s (corresponding to a flare amplitude of $I_f/Io > 0.3$); and the number of flares (some with several maxima) where the emitted energy during the flare lifetime exceeded 10**30 erg. The limits of peak flux and flare energy were chosen to ensure complete statistical detection in our sample.

Since flares on AD Leo are randomly distributed in time we can estimate the flare frequency by $N/T \pm \sqrt{N}/T$, where N is the number of flares in the sample and T is the flare coverage in hours. We do this analysis on two separate datasets, one using the flare energy as a key parameter and the other using the flare amplitude. The two panels of Fig. 1 give the results, where data before 1985 are from Pettersen et al (1984, 1986). The 1973 point is slightly modified by including recently published data by Herr and Opie (1987).

The two flare parameters mimic each other extremely well. Although certain structures can be noticed in each diagram, no excursions are more than one or two error bars away from the average value (except for the 1973 point). Chi-square tests do not show conclusively that variability has been detected over the 1972-1988 baseline. The flare activity of AD Leo varies by less than a factor of two on a timescale of years and decades.

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TABLE 1. Summary of flare monitoring

Year	Coverage (hours)	Number of flares observed		
		Total	log $E_U \geq 30.0$	$\Delta U \geq 0.3$
1985.2	59.73	39	27	23
1986.2	55.85	47	34	39
1987.2	24.98	18	15	14
1988.2	49.06	45	36	41

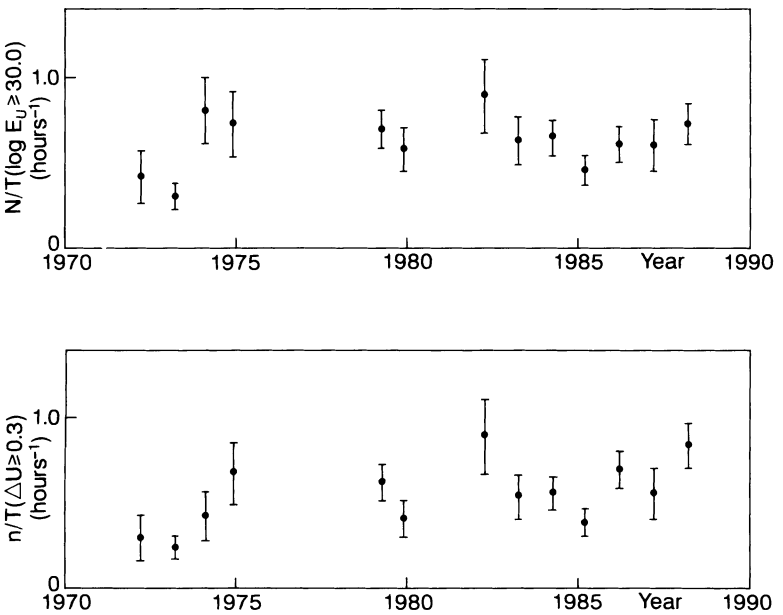

Figure 1. The flare activity of AD Leo as a function of time. The upper panel shows the frequency of flares with energy larger than 10^{30} erg. The lower panel shows the frequency of flare-ups with amplitudes exceeding $I_f/I_o=0.3$.

References

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GIAMPAPA: Do you observe pre-flare "dips" in the flare events on AD Leo?

PETTERSEN: In our data we have no significant detections of pre-flare dips for AD Leo. Most of our data are in the U-filter, but some observers also include BVRI-filters. Even in those we do not see any dips, and certainly not anything like your own beautiful result for EQ Peg (Astrophys. J. 252, L39).

PARSAMIAN: Would you like to say the magnitude increase of the largest flare amplitude of AD Leo?

PETTERSEN: As far as I recall the largest U-amplitude seen is 4.5 - 4.7 magnitudes.

GAHM: What is the maximum total flare energy observed on AD Leo?

PETTERSEN: The largest flare I can recall for AD Leo had an energy of 5 10**33 erg in the U-filter. Adding other optical filter results would imply an optical flare energy of several times 10**34 erg.

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