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Clues for periodic energy releases during a stellar flare

Introduction:

Observations of flares on the Sun have shown the very tight evolution of the white light, γ-ray, X-ray and microwave emissions. This highlights the direct link between the locations of white light emission and energy deposition in the atmosphere. By analogy to the solar case, one may expect the stellar white light flare emission to be a meaningful tracer of the energy release and deposition processes. Notably, observations by Beskin et al. (1989) have shown that the continuum emission is essentially thermal in character.

On the other hand, observations of quasi-periodic changes in the light curves may provide an interesting set of information and constraints, so as to model the energy release processes and magnetic field topology (e.g. Tajima et al., 1987). This seems an interesting opportunity in the stellar case since no spatial resolution is yet possible. Clues for quasi-periodicities were discovered by Rodonò (1974), Roĭzman and Kabichev (1985), Chugainov (1987) and Zalinian and Tovmassian (1987). Here we report on evidence for periodic brightness variations during a white light flare on Wolf 424 AB (dM5.5e).

Observations:

The observations were acquired at the European Southern Observatory with the 1m telescope and its standard photometric equipment. This flare was observed only in the U-band with a time resolution of about 4s. Weather conditions were excellent at the time of the observations.

We show an enlargement of the flare in Figure 1. The flare reached 2.50 mag at maximum. The complete light curve may be found in Houdebine (1990).

The analysis of the strip chart and the recorded light curves allowed us to identify 12 "bursts" occurring during this flare (see Figure 1). The first five bursts display very sharp enhancements and decays. The luminosity increase reached a value of 0.46 magnitude per second for the fourth event, which suggests that we are dealing with rather compact sources.

We listed in Table 1 the Universal Time, approximate duration and fluxes of each event, and the time delay Δt between two successive events. Assuming that two and one undetected events occurred respectively between the bursts No 8 and No 9, and the bursts No 9 and No 10, we inferred the evolution of Δt as given in Figure 2. This figure highlights the periodic character of these bursts, and further shows a rapid decrease in the period - i.e. increase in the bursts frequency - during the *preflare phase* and a rather constant value later.

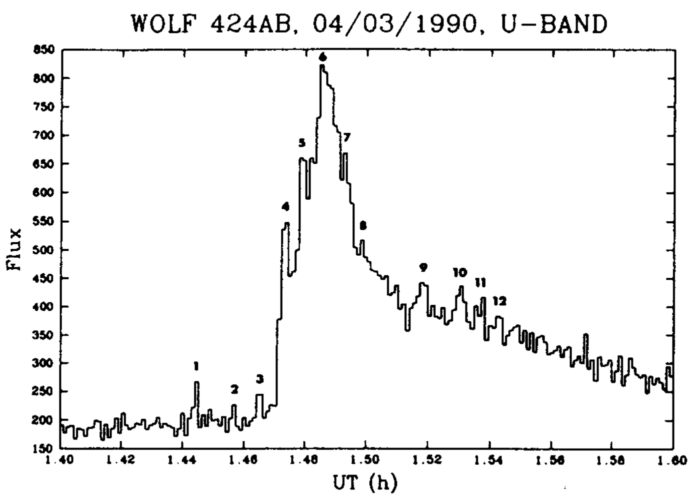

fig. 1: Flare light curve showing the identification of the flare bursts.

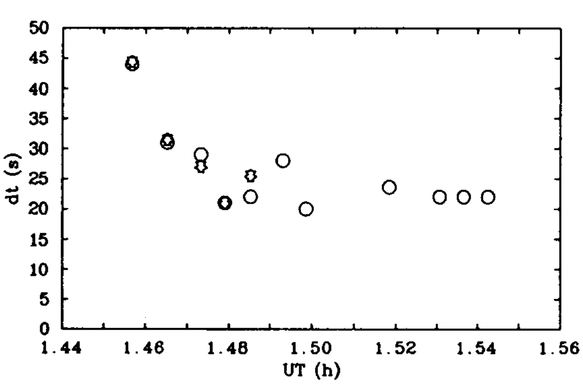

fig. 2: Evolution of the time delays between two successive burts. Circles indicate measurements using the curve in fig. 1, whereas stars relate to measurements from the strip chart recording (see Houdebine, 1990).

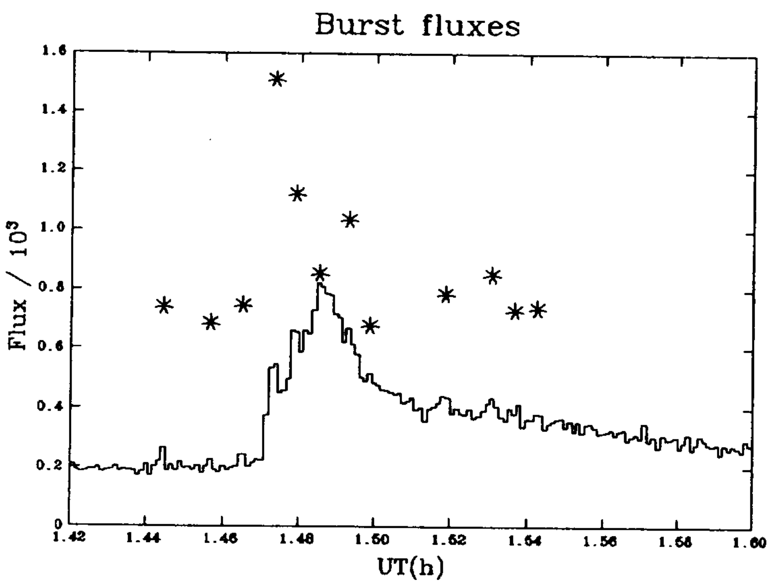

fig. 3: Flare U-band curve and burst flux variations. One notes that the burst's maximum is reached at the very beginning of the slow U-band rise.

Table 1: Parameters of the "bursts".

No.	UT	Duration (s)	$\Delta t^\dagger$ (s)	$\Delta t^\ddagger$ (s)	Flux Arbitrary unit
1	01:26:40	6	0	0	8.5
2	01:27:24	5	44	44.4	5.1
3	01:27:55	8	31	31.5	8.8
4	01:28:24	8	29	27	54.7
5	01:28:45	8	21	21	31.3
6	01:29:07	-	22	25.5	15.3
7	01:29:35	4	28	-	26.1
8	01:29:55	4	20	-	4.7
9	01:31:06	9	71	-	11.2
10	01:31:50	9	44	-	15.1
11	01:32:12	12	22	-	7.8
12	01:32:33	12	22	-	8.3

† Time delay from previous burst (data)

‡ Time delay from previous burst (strip chart)

The burst fluxes are superimposed on the global light curve in figure 3. The former increased sharply immediately before the flare onset that we define as the start of the slowly evolving component. We believe that we observed evidence for a periodic energy release phenomenon during a stellar white light flare.

Owing to the very high frequency of white light flares on flare stars, we expect that observations with a time resolution better than 3s in a given band will allow a statistical investigation of these events of great interest.

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