FLARE STARS IN THE ETA TAURI FIELDS
SIGNIFICANT LONG-TERM VARIATIONS OF THEIR FLARING ACTIVITY

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Photographic surveys completed during the past 30 years yielded data of about 600 flare stars in these fields. Although their average flare number is very low 17 of the stars produced 10...120 flare ups. In order to investigate the possible long-term activity changes of these objects a new method - which is described below – was developed. Making use of it significant flare frequency variations were found at two out of three 'active' flare stars.

Introduction

In the last decades there has been a great deal of work on photographic flare star surveys. Much of this effort has been devoted to fields containing relatively young and nearby open clusters. The effective exposure time of those survey plates which cover the central regions of the Pleiades totals up to 3300 hours. The optical axis of each survey instrument was set to the star Eta Tauri (Alcyone) which is very close to the virtual centre of the cluster. Although the photographic method was standardized to a certain extent the survey material is not perfectly homogeneous. The field of view of the half a score of telescopes used in seven countries were not exactly the same and as a consequence of their unequal focal ratios and differences in sky brightness at the observatories participating in this work the limiting magnitudes and the S/N rates of the photographic plates are fairly different. For these reasons the fainter flare stars and low amplitude flare ups as well as phenomena which occur on objects lying in remote corners of the widest fields are underrepresented and sometimes even omitted (Szécsényi-Nagy, 1983).

To overcome these kind of difficulties a statistical method based on a new time-like parameter has been developed.

The definition of the time parameter

For most of the observers did not publish detailed time coverage of their survey work it was absolutely necessary to find a suitable time-like parameter. Aiming at this, first of all the richest and most reliable flare catalogue of the region the CPFS (Haro et al. 1982)

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had to be trimmed. The huge cluster of data referring to flare events discovered in the heterogeneous survey material was filtered. All flare ups of the most active star of the field II Tauri (H II 2411) were excluded because its flaring frequency proved to be variable on the long run (Szécsényi-Nagy, 1986a). Then all flares of each of the outlying flare stars were also omitted. For that purpose the largest common field of the Eta Tauri fields (LCF) had to be defined. According to our best knowledge this area could be defined by the common part of the 3°.75 by 3°.75 square field of the 40-inch Byurakan Schmidt and the 4°.75 diameter circular field of the Schmidt camera of the Konkoly Observatory. 86 per cent of the CPFS objects remained on the abridged list which contains information on 448 flare stars and their 1414 flare ups. A detailed list of the excluded 71 outlying flare stars was published elsewhere (Szécsényi-Nagy, 1986b).

It was demonstrated too that these objects are apparently less active than flare stars of the LCF. While in the omitted annular field 38 per cent of the flare stars only contributed a single flare up to the CPFS the percentage of single-flare stars in the LCF is 15.5. This is of course the result of selection effects and indicates that observational conditions are definitely different in the cases of the LCF and the annular region surrounding it. Hereupon 1296 flare ups recorded in the LCF but those of II Tauri were arranged into a database according to the moment of their appearance. Accepting that the distribution of the flare survey exposures is random and that the above procedure does not involve any systematic time-selection the correlation between the original set of data (flare events listed in the CPFS) and those of the trimmed catalogue will demonstrate the randomness of the latter.

The coefficient of the regression line describing the above correlation (computed by the least squares method) is :

$$b = 0.907544$$

with a standard error of :

$$s = 0.000207$$

The goodness of fit of the regression line is given by the coefficient of determination :

$$r^2 = 0.999932$$

It indicates an almost perfect fit i.e. the abridged list of flare ups is as random (in time) as the CPFS list was. Furthermore the longer we observe the field the more flare ups we will detect. Consequently the reduced number of flare ups observed in a given time interval (F) is strictly proportional to the length of the interval and therefore it can be used as a time-parameter in the course of our statistical analysis.

Results

Flare ups of each LCF object which contributed at least 10 outbursts to the database were chronologically ordered into 17 individual sequences. Rankings of all of the flares of these stars were plotted against their F-number and the distributions of the points representing every single phenomenon were analysed. In some cases these points were spread over the whole range (1...1296) practically at random but more often a specific pattern became distinct (see Fig.1) or the distribution was improbably uneven (see Fig.2). These kind of irregularities were found in the time-distribution of at least 10 stars. This means that relatively short periods (some years) of enhanced flare activity are embedded in far longer ones (decades) during which the star seems to be very much alike its low-activity neighbours. Activity variations of this kind which convert them into quiescent red dwarfs temporarily probably screen a lot of flare stars from the astronomers' view.
There are two additional peculiar stars in the LCF : CPFS 91 and CPFS 377 (neither of them is a Pleiades cluster member). The latter one is the above-mentioned II Tau which contributed 120 events to the CPFS. These flare ups are located along a wavy line which has about 5-6 more or less distinct crests representing the higher activity sections of this star's life during the past 25 years. The other object's 32 outbursts plotted versus F show an almost symmetrical curve. Its steepest sections which cover 1/10 of the F range correspond to a 25 times higher flare frequency than the central section extending over 1/4 of

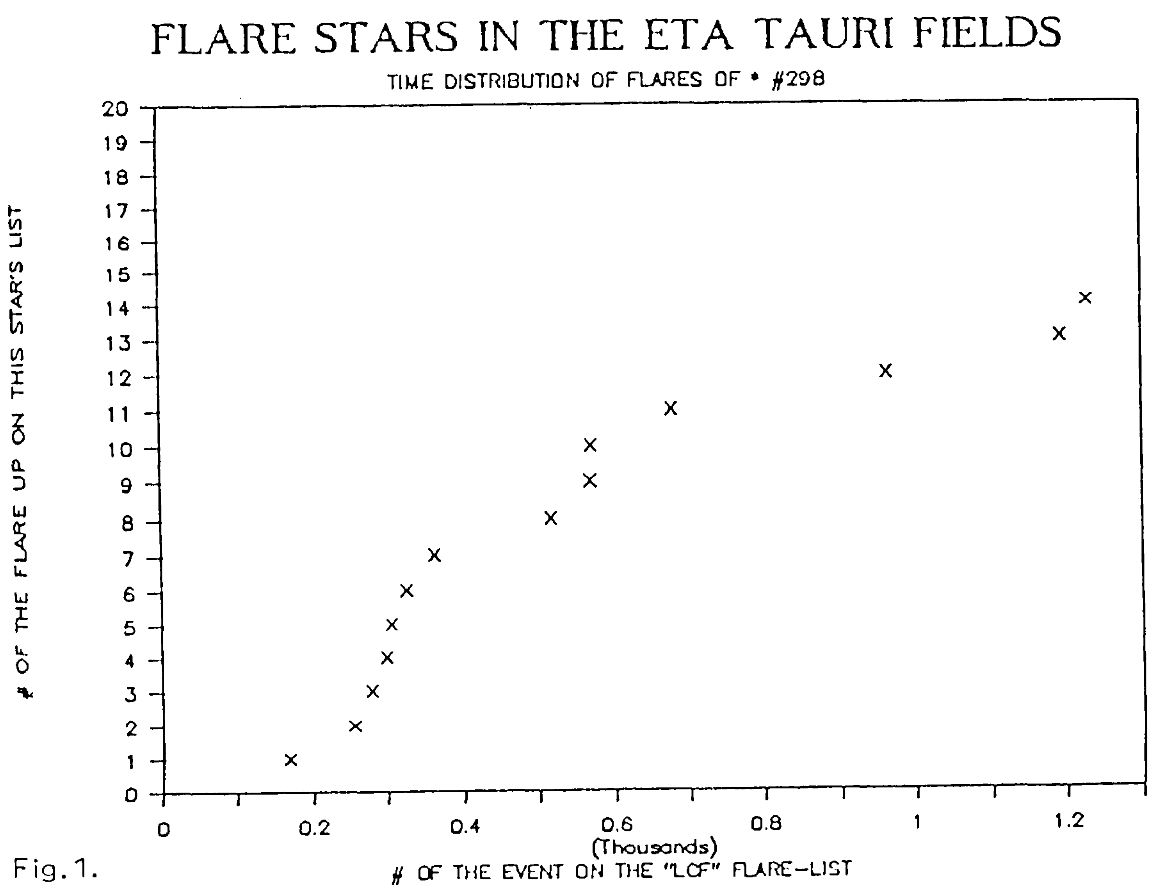

Fig.1.

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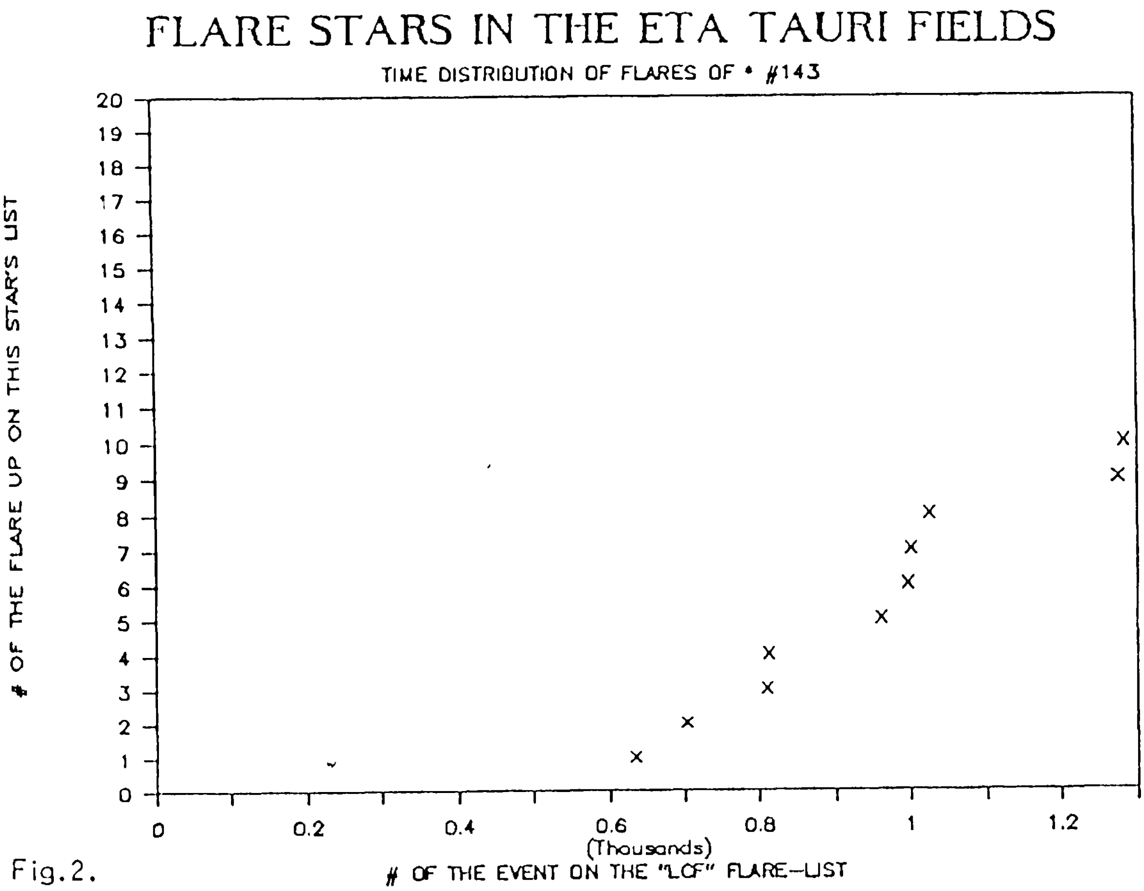

Fig.2.

the whole range. It can not be ruled out that the activity variations of CPFS 91 are cyclic with a 'period' of approximately 20 years.

Conclusions

Flare up distributions of the 17 most active flare stars of the LCF were investigated. Random distributions of the events over the whole F range were only found in the case of 5 stars (CPFS 16, 68, 169, 275 and 499) while the rest of the objects (CPFS 91, 143, 150, 194, 211, 256, 298, 354, 377, 435, 454 and 477) showed hints of changing activity. This means that the flaring frequency of at least two out of three 'active' flare stars - irrespective of their cluster membership probability, apparent brightness or average flare frequency - can vary by a factor of 10.

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