

FLARE STARS INVESTIGATIONS AT THE DEPARTMENT OF ASTRONOMY  
AND THE ROZHEN NATIONAL ASTRONOMICAL OBSERVATORY

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In the frames of the programme of nonstable star investigations in the Department of Astronomy and National Astronomical Observatory the investigations of flare stars - stars of spectral type  $dK - dM$  whose nonstability appears first of all through the quick brightness increases take an essential place. The programme of systematic observations was initiated in 1979 with setting into operation of the telescopes of the Rozhen National Observatory.

The main purpose of the flare star investigations in Bulgaria is to obtain new data to carry out a thorough study of flare events and to elucidate their nature and role in stellar evolution applying mainly the observational approach. As a result of the flare star investigations in the period 1979-1988, 52 papers have been published (their list is given in the Appendix).

The investigation of flare stars in the solar neighbourhood began in 1980 with patrol observations with the one-channel  $UBV$  - electrophotometer attached to the 60-cm telescope at the National Astronomical Observatory - Rozhen (Panov and Tsvetkov, 1981). Already in the first 3 years 71<sup>h</sup> effective observations of the flare stars  $AD$  Leo,  $EV$  Lac, and  $UV$  Cet, were carried out and 52 flare events were discovered. The observations by this programme became traditional the next years and were the basis of active participation in international observations of flare stars in the solar neighbourhood. Such are the observations with the astronomers from the Department of the Geodetic Astronomy of the Thessaloniki University (Prof. L. Mavridis, Dr. G. Asteriadis), from the Institute of Theoretical Astrophysics of the Oslo University (Dr. B. Pettersen) from the astronomical observatories of the Universities of Helsinki and Turku (Dr. V. Pirola, Dr. T. Korhonen),

the Crimean Observatory of the USSR Academy of Sciences (Dr.R.Gershberg), and the Byurakan Observatory of the Armenian Academy of Sciences ( Dr.N.Melikian ).

Some important results in this respect are the detections of fast spike flare events in the  $U$ - band of EV Lac and AD Leo with a duration of 1-3 sec (at time resolution 1 sec) [ *Tsvetkov et al.1985a., Pettersen et al. ,1986a* ]. The understanding of the nature of the type of flare event is of particular importance to the physical conditions accompanying the flare event process. From the analysis of more than 200 flare events of AD Leo, observed at the Mac Donald and Rozhen Observatories was possible to propose an 8-year cycle as an eventual explanation of the flare near-frequency change [ *Pettersen et al.,1986b* ].

The collaboration with the astronomers from Helsinki and Berlin allowed us to use their 5-channel electrophotometer - polarimeter with simultaneous recording in  $UBVRI$ - bands during flare star observations at Rozhen. Thus recorded flare event of EV Lac on 11/12 Sept. 1985 with  $\Delta m = 2.5^m$  yielded information about the colour changes  $U-B/B-V$  during the flare event. These changes indicate strong nonstability in the physical process during the flare event. Similar changes were mentioned for the flare events in the Pleiades stellar cluster by *Chavushian et al 1980.*

We can also note the obtaining of the 8 solar neighbourhood flare star spectra [ *Pettersen and Tsvetkov , 1985* ]. In four of them no emission lines in minimum have been observed. Different from the rest, the star V 654 Her showed characteristics of giant star [ *Tsvetkov and Pettersen, 1985* ]. The complex spectral and photometric investigation of the star V 1589 Cyg located in the direction of the NGC 7000 proved its belonging to the UV Cet type stars - the distance is  $\approx 32$  pc [ *Tsvetkov et al. 1988* ].

The flare star activity investigations in the regions of stellar aggregates have been carried out in close collaboration with astronomers from the Byurakan and Konkoly Observatories. As a result of the joint observations new observational material has been obtained in the Pleiades, Praesepe, NGC 7000, etc. With putting into operation the 50/70/172 cm Schmidt telescope (given as a present by the DDR Academy of Sciences) we began a programme of

systematic monitoring of flare stars in stellar aggregates. Thirty three flare stars and 65 flare events in 55 stars in the Pleiades, Orion,  $\gamma$  Cygni, NGC 7000, Praesepe and Tauri Dark Clouds (TDC) in the period 1979 - 1988 were discovered (shown in Table 1.). The flare stars in the dark and emission nebulae in the direction of Cygni were studied in detail in collaboration with the astronomers from the Byurakan Observatory. For more than 300<sup>h</sup> effective observations 15 flare stars were discovered. For the lower limit of the flare star total number in this region the estimated number is more than 100 flare stars. It was found that by the characteristics of the flare stars, the frequency of the flare events, the luminosity, etc. this aggregate is similar to the aggregate in the NGC 7000 emission nebula [ *Tsvetkova, 1985* ].

TABLE 1.

The Flare Star Observations in the Stellar Aggregates  
in the Rozhen National Astronomical Observatory  
in the period 1979- 1988

Aggregate	Total Numbers of Flare Stars Observed	Observed Fl.-Ups	T <sub>eff</sub> (hours)	Rozhen Flare Stars
Pleiades	26	35	235	9
Orion	16	16	58	11
$\gamma$ Cygni	12	13	208	12
NGC 7000	1	1	16	1
TDC	-	-	80	-
Praesepe	-	-	30	-
Total	55	65	627	33

In 1985 we started a joint work with the astronomers from the Astronomical Institute of the Muenster University (Prof.W.Seitter) in the programme of flare star investigation in South aggregates with the ESO- GFO astrograph at La Silla. According to this programme, in Orion ( M42-43 ) 9 flare events and 7 new flare stars were discovered which prove the efficiency of the programme [ *Tsvetkov et al., 1985b* ]. Up to now more than 400 GFO-plates in the South aggregates :  $\alpha$  Vel,  $\Theta$  Car, Cha T1, were carried out, and in

the preliminary survey of the observational material 2 flare stars in the region of stellar cluster  $\alpha$  Vel (IC 2391) were discovered. Now the work on the automatic processing of the multi-exposure plates through the scanning on the FDS 2020 GM puls microdensitometer in the Astronomical Institute in Muenster is being performed.

Another part of the flare star investigations at the Department of Astronomy in Sofia is the creation of catalogues and data collection for flare stars in stellar aggregates of different ages. The first step was the development of a machine-readable version of the Tonantzintla catalogue of the Pleiades [Tsvetkov *et al.*, 1987], its further supplementing, specifying and preliminary analysing the data complex. Thus the development of a complete data basis for the flare stars in aggregates will facilitate and intensify the work of astronomers involved in these investigations and open new potentials of a thorough and efficient processing.

#### REFERENCES

- Chavushian, H.S., Erastova, L.K., Melikian, N.D., Tsvetkov, M.K., Iankovics, J., 1980, *Comm. Byurakan Obs.*, 52, 79.
- Panov, K.P. and Tsvetkov, M.K., 1981, *IBVS*, No 1971.
- Petterson, B.R., Tsvetkov, M.K., 1985, *IBVS*, No 2660.
- Petterson, B.R., Panov, K.P., Sandmann, W., Ivanova, M.G., 1986a, *Aph. Suppl. Ser.*, 66, 235.
- Petterson, B.R., Panov, K.P., 1986b, *Lecture Notes in Ph.*, Springer-Verlag, 254, 91.
- Tsvetkov, M.K., Petterson, B.R., 1985, *Aph*, 150, 160.
- Tsvetkov, M.K., Antov, A.P. and Tsvetkova, A.G., 1985a, *Proceedings of the Symposium "Eruptive Phenomena in Stars"*, Ed. L. Szabados, Budapest, p. 423.
- Tsvetkov, M.K., Seitter, W., Duerbeck, H., 1985b, *idem*, p. 429.
- Tsvetkov, M.K., Stavrev, K.Y., Tsvetkova, K.P., 1987, *Bull. d'Inform. Centre de Donnees Stellaires*, 33, 137.
- Tsvetkov, M.K., Petterson, B.R., Hawley, S.L., 1988, "Activity in Cool Star Envelopes", Eds. O. Havnes *et al.*, Kluwer Acad. Publishers, p. 77.
- Tsvetkova, K.P., 1985, *Ph. D. Thesis*, Sofia.