BALMER LINES AND CONTINUUM EMISSION FOR TWO FLARES OF THE dMe STAR GLIESE 729*

A. Falchi[1], R. Falciani[2], L.A. Smaldone[3] and G.P. Tozzi[1]

[1] Osservatorio Astrofisico di Arcetri - L. E. Fermi 5 - 50125 Firenze
[2] Istituto di Astronomia - L. E. Fermi 5 - 50125 Firenze
[3] Dip. di Scienze Fisiche dell'Università - Pad. 19-20 Mostra d'oltremare 80125 Napoli

* Based on Observations collected at the European Southern Observatory, La Silla, Chile

Introduction.

It has been shown for solar flares (Donati-Falchi et al. 1985) that the continuum emission at the Balmer discontinuity (the blue "pseudo-continuum") is a very sensitive tool to determine the electron density. In order to use the same interpretative scheme for stellar flares (Falchi et al. 1988), spectroscopic observations of various flare stars have been performed in June 1987 at ESO observatory (Chile). In this paper we report the analysis of spectra of the star n. 729 (V 1216 Sgr) of the Gliese catalog.

Observations.

The star has been observed during the nights from 13 to 18 June 1987 for a total coverage of 13 hours and a time resolution varying from 10 to 15 minutes, depending on the seeing conditions.

We used the 1.5 m spectroscopic telescope in the f/7 Cassegrain configuration with a Boller & Chivens spectrograph. The entrance slit was 135 μm wide, corresponding to 2.7 arcsec on the sky. Particular care has been taken in choosing the grating and the detector, in order to obtain the highest efficiency at $\lambda < 4000$ Å, where the signal may be very low. The grating (400 l/mm with a blaze angle of 4°30′) had an efficiency at 1st order of about 60% at 3500 Å and 30% at 6000 Å with a dispersion of 171 Å/mm. The detector was a CCD RCA thinned, backside illuminated, sensitive up to 3000 Å, with 640x1024 pixels (100x1024 used). The pixel dimension was 15x15 μm corresponding to 1.3 arcsec and 2.6 Å along the slit and dispersion directions. The spectral coverage was from 3500 to 6000 Å and the measured instrumental FWHM was about 5 Å.

The exposure time (10-15 min) adopted for flare stars was a compromise between the time resolution we needed for eventual flares and the S/N ratio at the short wavelengths range.

The total spectral efficiency of the telescope, spectrograph and detector, measured with standard stars, shows a flat maximum between 4700 and 5700 Å, but it dropped down to about 1/10 of the maximum at 3600 Å.

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Data Analysis.

All the spectra have been analyzed by using the MIDAS package. After the usual CCD reduction procedure the two dimension spectra have been converted to monodimensional one by integrating the star signal along the slit direction. Absolute spectral calibration to flux units ($erg\ cm^{-2}Å^{-1}s^{-1}$) has been done with the efficiency curves obtained from standard stars HR 4963, LTT 3864 and HD 105590. The efficiency curves from different stars were in mutual agreement within 10%.

The equivalent width of H_β, H_γ and H_δ, assumed as an indicator of flare occurrence, has been measured and plotted vs time (Figs. 1 & 2). On the spectra of June 17 and 18 three flares have been detected. Unfortunately the first event of the latter day happened at the beginning or just before the observations. The mean quiescent spectrum was then obtained by averaging the spectra corresponding to the lower equivalent widths. Its standard deviation was 3% for $\lambda > 4500$ Å, 10 % at 4000 Å and increases more and more at shorter $\lambda\lambda$. The difference between the flare and quiescent spectra represents the net flare flux and it is shown in Figure 3 for the first event of June 18. Enhancements of the emission lines are evident, while the Balmer continuum variation is of the order of the noise.

In Table I the integrated flux over some emission lines and continuum windows have been reported for the quiescent spectra.

TABLE I
FLARES ENERGY BALANCE

Line	λ Å	Quiescent Flux	ΔFlux 17 10^{-13} erg	ΔFlux 18/1 $cm^{-2}s^{-1}$	ΔFlux 18/2
H_β	4861.3	3.29 ± 0.15	3.65 ± 0.3	3.85 ± 0.3	0.60 ± 0.15
H_γ	4340.5	3.06 ± 0.15	2.96 ± 0.3	3.04 ± 0.3	0.60 ± 0.15
H_δ	4101.8	1.12 ± 0.05	1.44 ± 0.2	1.68 ± 0.2	–
CaII(H)+H_ϵ	3970.3	2.52 ± 0.10	1.92 ± 0.4	1.88 ± 0.3	–
CaII(K)	3933.7	2.66 ± 0.10	–	0.20 ± 0.14	–
H_8	3889.1	0.96 ± 0.05	0.92 ± 0.2	0.84 ± 0.16	–
H_9	3835.4	–	0.60 ± 0.1	0.80 ± 0.16	–
H_{10}	3797.9	–	–	1.00 ± 0.5	–
Continuum	3500-3700	30 ± 30	–	30 ± 30	–
" "	4000-4200	80 ± 8	10 ± 8	10 ± 8	–
" "	4500-4700	280 ± 8	7 ± 8	10 ± 8	–
" "	5200-5400	500 ± 15	28 ± 15	20 ± 15	–
" "	5600-5800	580 ± 17	25 ± 17	24 ± 17	–
" "	3500-6000	3600 ± 100	150 ± 100	170 ± 100	–

For the three flares the detected flux increases (ΔFlux), integrated over the lines are also indicated. We can see that the flux of the Balmer lines increases of about a factor two for the two stronger flares. The CaII K line practically does not change intensity.

We can compute the total energy emitted by all the measurable lines during the flare assuming the star distance equal to 2.9 pc (Gurzadyan, 1980) and a 4π symmetry. The results are $(7.0 \pm 0.9) * 10^{29}$ and $(8 \pm 1.2) * 10^{29}$ ergs for the two main events of 17 and 18.

Table I shows also the flux and ΔFlux integrated over some continuum windows 200 Å wide and over all the measured spectral region. The emission lines have been subtracted before the integration. The flux enhancements in the continuum are evident for the first two flares, even if at the limit of noise for $\lambda\lambda < 4700$ Å. In the third flare no continuum variation has been detected.

We can then compute the luminosity of the star and the energy emitted by the flares in the 3500-6000 Å range. The luminosity is $(3.5 \pm 0.1) * 10^{29}$ erg/s and the energies emitted by the events are $(0.9 \pm 0.7) * 10^{31}$ and $(1.0 \pm 0.7) * 10^{31}$ ergs respectively for the 17 and the first of 18 flares. The energy emitted by the quiescent star during the same interval time of the events is $(2.1 \pm 0.06) * 10^{32}$ ergs. These values should correspond to a ΔM_B equal to 0.01-0.04 and 0.02-0.09 for the first and second events of the table.

Conclusions.

For the studied flares it has been measured the continuum and lines emission contribution. No evidence of continuum enhancement at the Balmer discontinuity has been found. This can be explained with the intrinsic weakness of the observed flares. More detailed interpretations are still in progress.

References.

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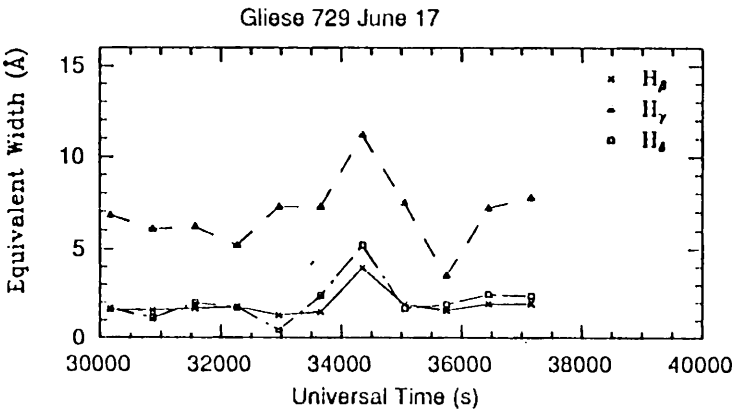

Fig 1) Equivalent width of H_β, H_γ and H_δ vs time for June 17 observations.

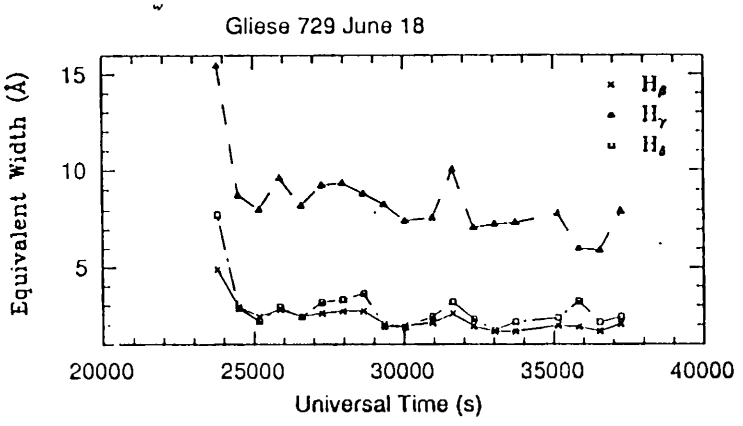

Fig 2) The same as fig 2) for June 18.

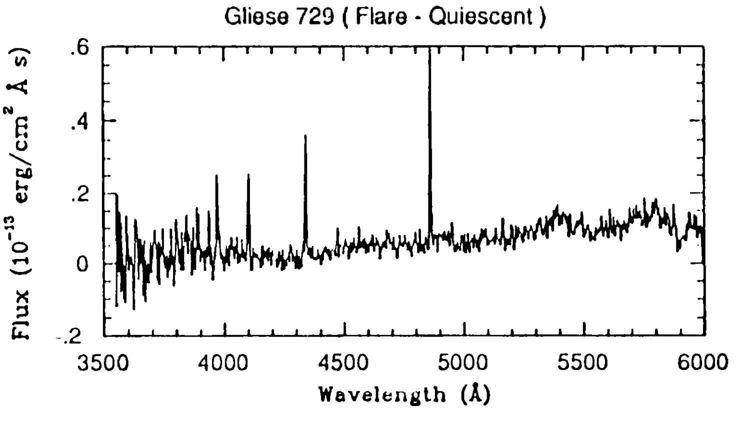

Fig 3) Difference of spectrum with flare minus the quiescent one for June 18. It represents the contribution of the flare to the spectrum.

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