

SIMULTANEOUS MULTI-WAVELENGTH OBSERVATIONS
OF AN INTENSE FLARE ON AD LEONIS *

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ABSTRACT - We report on the first successful coordinated observations of stellar flares carried out on March 28, 1984 simultaneously over a wide range of wavelengths, from UV to microwaves, using the IUE satellite, three ESO telescopes at La Silla (Chile) and the VLA at Socorro (NM, USA).

1. INTRODUCTION

The observations presented in this paper were organized within a large collaborative project to study rotational modulation and flares on RS CVn, BY Dra and UV Cet flare stars (see Rodono' et al. 1986, Butler et al. 1987, Rodono' et al. 1987, Walter et al. 1987, Haisch et al. 1987, Byrne et al. 1987, Doyle et al. 1988, Andrews et al. 1988, Linsky et al. 1988, Neff et al. 1988). The present campaign was organized to obtain time-resolved quantitative data on the flare radiation flux versus wavelength and on its temporal behaviour in the different wavebands. These data can allow us to test the available flare models and to study the physical characteristic and the dynamical response of the plasma at different atmospheric levels to the flare impulsive energy inputs (Houdebine et al. 1988). One of the programme stars was the dm3.5e flare star AD Leonis (= Gliese 388 = BD +20 2465 = SAO 81292), which was chosen because of its brightness ($m_v=9.4$, $B-V=1.5$), high activity level and accessibility to both northern and southern ground-based facilities. The telescopes we used and the wavelength coverages are listed in Tab.1. In this paper we presented the principal results we obtained on an intense flare observed on March 28, 1984. A more detailed and complete analysis, including all other observed flares, will be presented in a forthcoming paper.

* Based on observations collected at the European Southern Observatory La Silla (Chile), and with IUE at the ESA Satellite Tracking Station Villafranca (Spain).

TABLE 1

TELESCOPE	WAVELENGTH RANGE	OBSERVATIONS TYPE	TIME RESOLUTION
IUE	2500-3200 Å	LWP low-dispersion spectra	15 min
ESO 0.5m	U Band	Photoelectric photometry	10 s
ESO 1.0m	K Band (2.2 μm)	InSb photometry	45 s
ESO 3.6m	3600-4400 Å	IDS spectra (dispersion ~40 Å/mm)	60 s
VLA	2-, 6- and 20-cm	Short Y configuration microwave fluxes	1 s

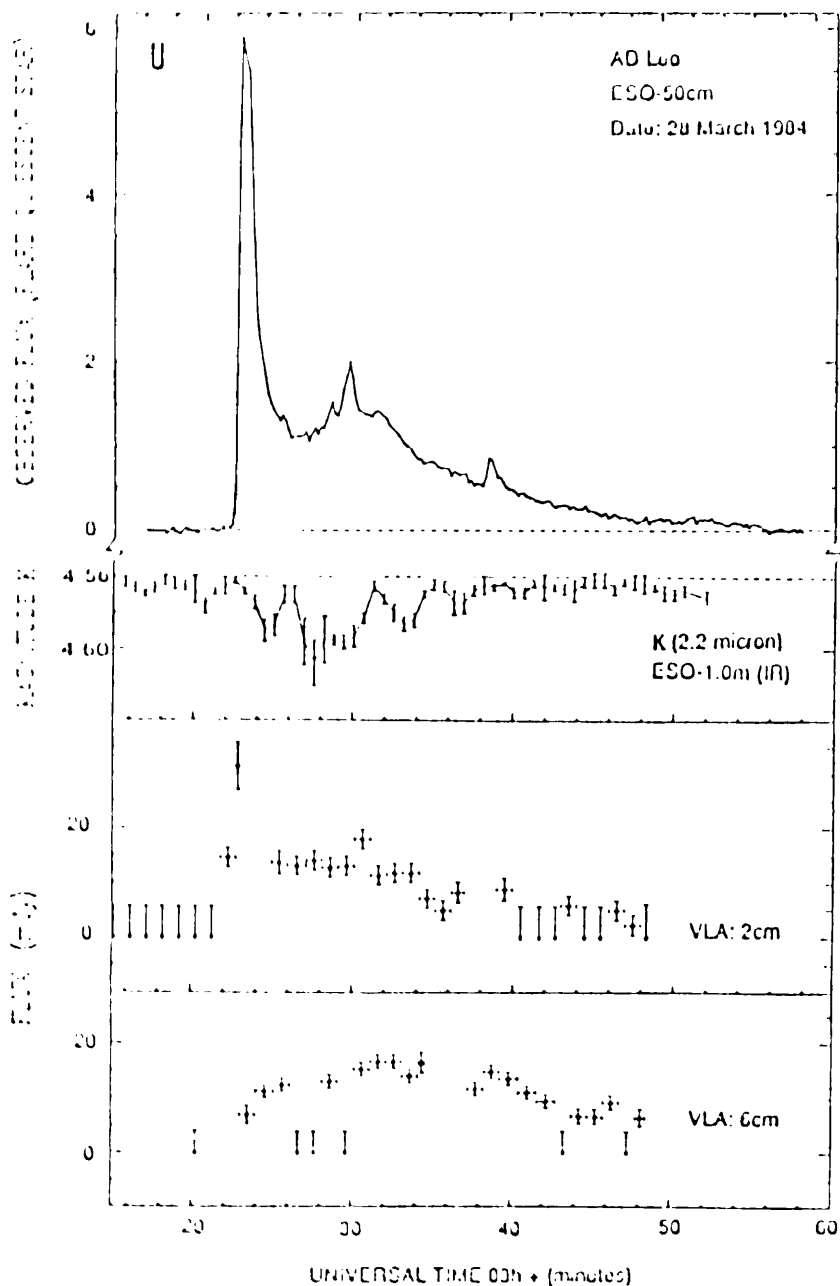


Figure 1 - Simultaneous U, K, 2-cm, and 6-cm observations of an intense flare of AD Leonis.

2 OBSERVATIONS AND RESULTS

AD Leonis was observed simultaneously with the telescopes in Table 1 for about 10 hours from March 24 to March 28, 1984. Several flares were detected. The major flare, here described, was observed on March 28, 1984. Fig.1 shows the optical (U-band), infrared (K-band) and radio (2- and 6-cm) light curves. In the U-band the flare appears to be a complex one with a primary impulsive peak ($\Delta U=2.1$ mag) followed by several secondary peaks. In coincidence with the primary and secondary peaks in the U-band, smooth global flux decreases ("negative flares") were clearly detected for the first time at $2.2 \mu\text{m}$ (K-band). The occurrence of "negative flares" at wavelengths above 1 micron was first predicted by Gurzadian (cf. his 1977 review and references therein) in the framework of the so called fast electron flare model. More recently Grinin (1976) has proposed quite a different model based on negative hydrogen absorption before or during the very first phase of the flare onset. From a quantitative analysis of these IR data Rodono' and Cutispoto (1988) concluded that both models only qualitatively agree with our observations. Actually, the complex development of the observed flare or, better, of the sequence of rapidly following flares are not adequate for a stringent test of the available models, because of their complex time profiles at all wavelengths. Intense, but less complex flare events need to be observed for this purpose.

It is important to notice that the missing, time-integrated energy in the IR K-band is about 7 times the total energy release in the U-band. Taking into account typical ratios of the energy release in the U-band to other optical bands (≈ 1.8), to microwaves (≈ 0.01) and to X-rays (1-10), it appears that the missing energy, in the K-band only, can at least account for the energy release at all other wavebands. However, flare phenomena are quite unique and the quoted typical energy ratios may be misleading.

The VLA microwave flare shows different time-behaviours at 2- and 6-cm, the time profile of the former being more impulsive than the latter. We note that this flare was not detected at 20-cm, i.e. the bulk of flare emission occurred at low coronal levels.

With the IDS (Image Dissector Scanner) fed by the ESO 3.6m we obtained the best time-resolved (time-resolution = 60s) low-dispersion flare spectra ever obtained in the region 3600-4400 Å. From these spectra we extracted integrated line fluxes for HI Balmer lines, CaII H and K and HeI (4026 Å). The different time-behaviour of H δ , CaII K and HeI line fluxes and of the optical continuum are shown in Fig.2. We note that the impulsive behaviours of H δ and HeI lines (and of the other H I Balmer lines not shown in the figure) are similar to those in the U-band and 2-cm, including the complex structure of the variation, while the Ca II K line shows a smother variation similar to the 6-cm variation. The quiescent and one of the pure flare spectra (the quiescent spectrum being subtracted from the flare one) are also shown in Fig.3.

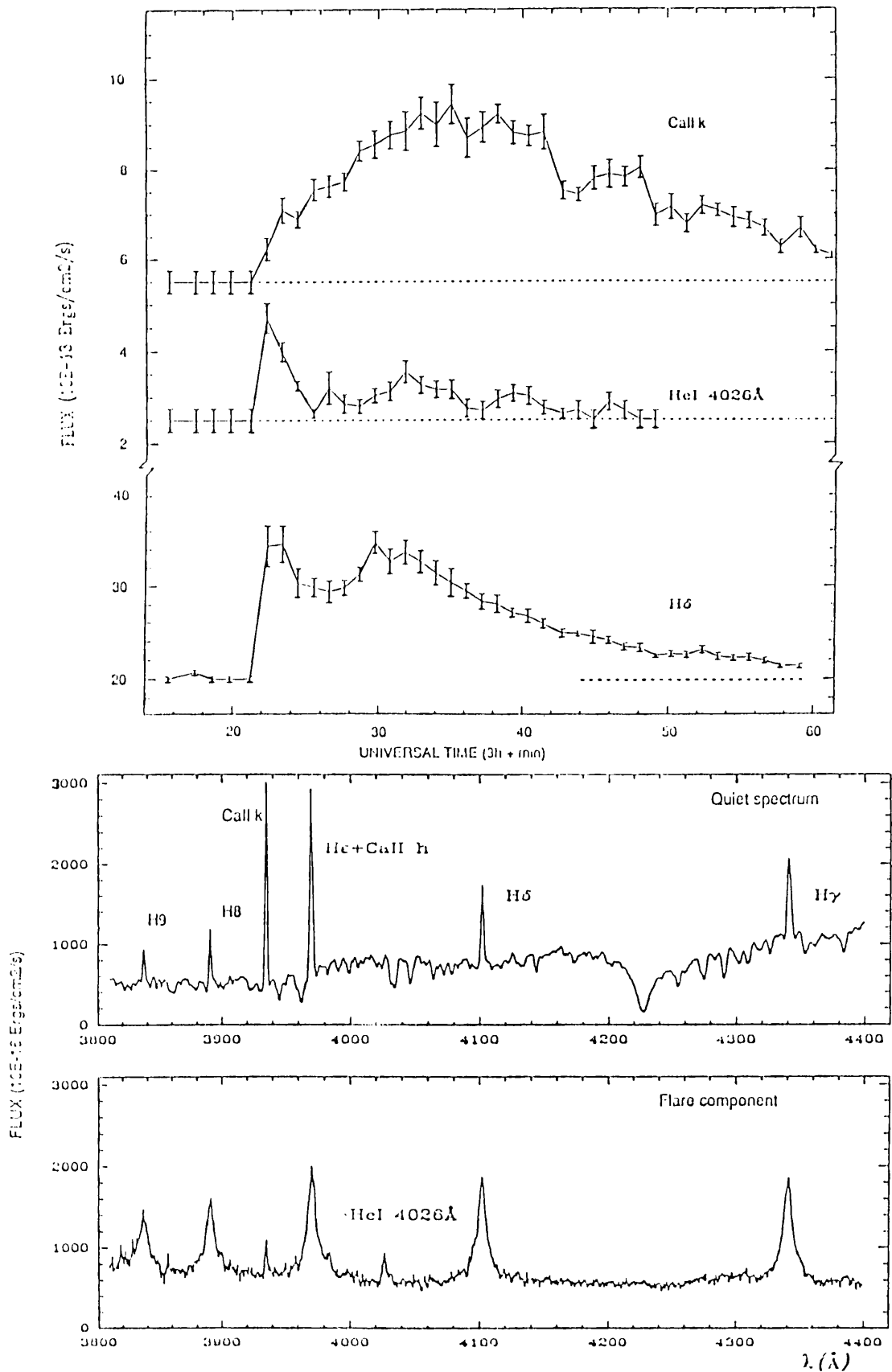


Figure 2 - Upper panel: CaII K, HeI, and H δ integrated line fluxes during the development of AD Leo flare in Fig.1; Middle panel: quiescent spectrum of AD Leo; Bottom panel: representative pure flare spectrum (quiescent spectrum subtracted).

From multiple-exposure LWP low dispersion IUE spectra it was also possible to derive the behaviour of Mg II, Fe II multiplet blends and of the continua at 2660-2720 and 2915-2980 Å during the decay phase. These IUE observations missed the main flare peak, but include the secondary flare at 19h40m UT. Moreover, the poor time resolution does not allow us any detailed consideration except that a clear flux decay was in progress after about 20 minutes the main flare impulsive phase. The observed peak flux increases were about 100 percent for the MgII lines, and about 300 percent for the FeII multiplet and the UV continua.

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