FLARES ON SINGLE ACTIVE GIANTS

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Flare activity in single late giants was studied as a part of the programme for chromospheric activity investigation in late-type evolved stars.
Electrophotometric UBV observations and U-filter patrol monitoring with an integration time of 1 sec were carried out at the Belogradchik Observatory, in the period 1993–1998.
The short-lived flares were observed during 3 nights on V390 Aur and HD112989. An event with a longer duration was detected on OP And. Some brightenings of HD112989 and OP And in the limits of one-two nights observations that seem to indicate for presence of flare-like events were observed too.
The reported results reveal that single active giants also exhibit flares with different duration, in spite of the fact that these stars flare more rarely than the active dwarfs and RS CVn binaries.

INTRODUCTION

Magnetic activity in the cool half of the H–R diagram presents in stars at different evolutionary stages, single and binary ones. There are much signatures of it, scattered throughout the electromagnetic spectrum. It is widely accepted that the dynamo, powered by the convection and catalyzed by the stellar rotation is the reason for this activity.

A scanty group of apparently single low and intermediate mass giants with evidences of dynamo-driven activity was formed in the beginning of the last decade. However, this group undergo slow enrichment with new members during the last years.

According to Simon & Drake (1989) such stars evolved to the red giant branch acquire magnetic activity due to rapid spin-up as their convection zones advance upon the faster rotating stellar interiors. An alternative recent hypothesis proposes the engulfment of the angular momentum of close-in brown dwarf or “hot Jupiter” on the ascent to the red giant tip or later ascent of the asymptotic giant branch (Siess & Livio, 1999) as the reason for the dynamo action in these stars.

The aim of our research was a systematic study of the activity properties in such single giants reached with our equipment – the 2-m telescope with Coude spectrograph at the Rozhen Observatory and the 60-cm telescope with electrophotometer at the Belogradchik Observatory.

Table 1: Data for the detected flares

Star	*Date*	*EventNo.*	*Filter*	Δm	σ	$U.T._{max}$	*Duration*
OP And	17.12.1993	1	U	0.24	0.015	$21^h50^m05^s$	$> 1^h$
			B	0.23	0.010	21 51 10	
			V	0.24	0.010	21 52 31	
V390 Aur	01.01.1998	1	U	0.12	0.015	$20^h47^m34^s$	11^s
		2	U	0.18	0.015	20 47 58	1^s
		3	U	0.17	0.015	20 48 18	9^s
		4	U	0.14	0.015	20 48 59	9^s
		5	U	0.13	0.015	20 52 09	3^s
		6	U	0.06	0.015	20 52 53	11^s
	22.02.1998	1	U	0.29	0.020	$21^h24^m07^s$	6^s
		2	U	0.18	0.020	21 24 11	2^s
		3	U	0.12	0.020	21 24 14	4^s
37 Com	22.02.1998	1	U	0.12	0.010	$01^h36^m25^s$	5^s

OBSERVATIONS

U-band patrol monitoring and UBV measurements were carried out for 5 known as active and suspected in activity single G and K giants. Spectral and photometric activity signatures were found in 4 of these stars. They are as follows: OP And=HD9746, V390 Aur=HD33798, 37 Com=HD112989 and HD145001. Their activity properties and evolutionary stage are described by Fekel & Marshall (1991), Fekel & Balachandran (1993), Konstantinova-Antova *et al.* (1995), De Medeiros (1999) and De Medeiros & Konstantinova-Antova (2000).

The photometric observations for these stars were carried out at the Belogradchik Observatory. The 60-cm Cassegrain telescope, with a single-channel electrophotometer (Antov & Konstantinova-Antova, 1995) was used. The integration time was 1 sec for all the observations. The differential photometry method was applied. The APR program package (Kirov *et al.*, 1991) was used for data processing.

RESULTS

The three of the active giants mentioned above were found to flare: OP And, V390 Aur and 37 Com.

OP AND = HD9746

This star is an appr. 6 magnitude single K1 giant of appr. 1.5 $M_{\odot}$, according to recent Hipparcos data and Schaller *et al.* (1992) evolutionary tracks for solar chemical composition.

Serious proofs for chromospheric activity and mass loss were found in this giant: strong CaII K&H emission cores, filled-in and variable H_{α}, presence of coronal and transition region emission lines and periodic photometric variability interpreted as presence of spots on the surface of the star. Changes in the spots configuration from season to season were found too.

UBV measurements and U-patrol monitoring were completed for OP And in the period 1993–1996. The effective total monitoring time was more than 30 hours. HD9057 was used as a comparison star during all these observations.

A flare was detected on December 17, 1993 during UBV patrol monitoring. Data for the event are presented in Table 1 and in Figures 1a and 1b, respectively. Despite we couldn't determine the exact duration of this flare it is visible that it is a long-lived one.

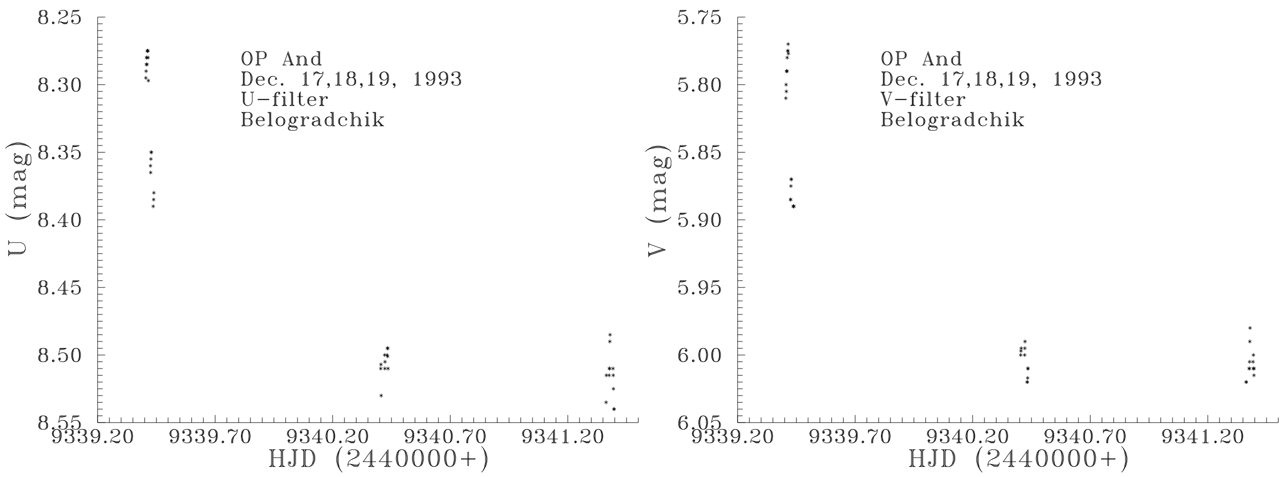

Figure 1: The detected flare on OP And, observed in U- and V-filters

An inspection of the OP And UBV measurements where the average values for the relevant nights are presented reveals that some other isolated points of brightening exist. Such kind brightenings of OP And are also shown by Strassmeier & Hall (1988). These events might be also flares similar to the detected by us.

Such brightenings are observed not only on OP And, but on another active giants too. An example is 37 COM.

37 COM = HD112989

This star is an appr. 5 magnitude G9 single giant of about 5 $M_{\odot}$, according to Hipparcos data. Activity signatures were also found on this star: moderate and variable CaII emission cores, fairly high X-ray emission and photometric variability interpreted as presence of spots. A long-term period was found for this star too (Donahue, 1996).

Our UBV observations were completed in the period of 1996–1998. HD113493 and HD113494 stars were used for comparison and clarification, respectively. We found one-two night brightenings with amplitudes 0.1–0.2 magnitude,which are similar to those ones reported in OP And. They also might be flares.

On the other hand, one short-lived flare-like event was detected on 37 Com during about 11-hours total monitoring time in U-filter, obtained in the period of 1997–1998. The data are presented in Table 1 and the detail lightcurve could be found by De Medeiros *et al.* (1999). The short life and unusual structure of this event are somewhat unexpected for a giant star. According to the gas-dynamic model (Katsova & Livshits, 1991) giants should not demonstrate such kind of short-duration flares.

However, events with a similar duration were also detected on another active giant – V390 Aur.

V390 AUR = HD33798

This appr. 7 magnitude star of about 2 $M_{\odot}$ was classified as chromospherically active giant by Fekel & Marshall (1991). Moderately strong CaII emission cores and a periodic photometric variability were reported for it. Photometric data are presented by Hooten & Hall (1990) and an isolated night of brightening was detected by them too.

UBV observations and patrol U-monitoring were carried out for this star in the period of December, 1997 – March, 1999. HD34533A was used as a comparison star. The short-lived flares were detected during appr. 24-hours total monitoring time. More than 9 such events were observed during 2 nights. The data are presented in Table 1 and in Figs. 2 and 3, respectively.

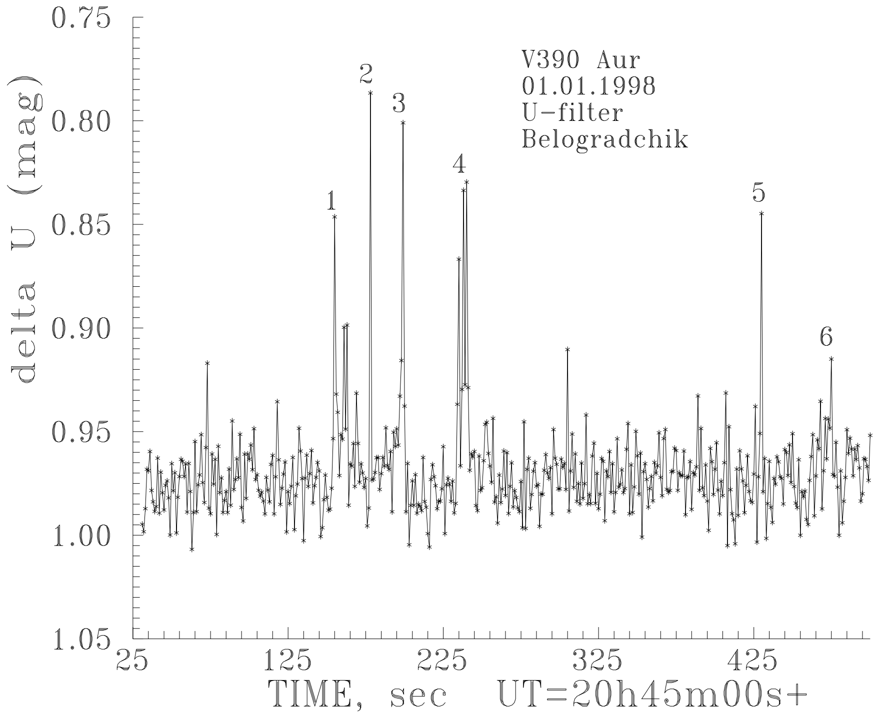

Figure 2: Flares detected on V390 Aur on January 1, 1998

However, a secondary star located at 0.4 arcsec away from V390 Aur with amplitude fainter 3.3 magnitude was reported by Van Biesbroeck (1974) and the Hipparcos mission confirmed his measurement. These stars cannot be separated in the photometer diaphragm. They were observed together with our equipment. But, taking into account the duration of events, the shape of the lightcurves and the fact that the secondary star should be late F or early G dwarf we came to the conclusion that it is more likely for these events to be happened on the primary star, V390 Aur. Moreover, if we assume that flares with such resulting amplitudes are produced by the secondary star, then their real amplitudes should be greater (or equal) 1.5 magnitude. Flares with similar U-amplitudes and a duration of appr. 10 sec were detected on active red dwarf stars. However, a set of events with such characteristics occurs very rarely and moreover on early G dwarfs.

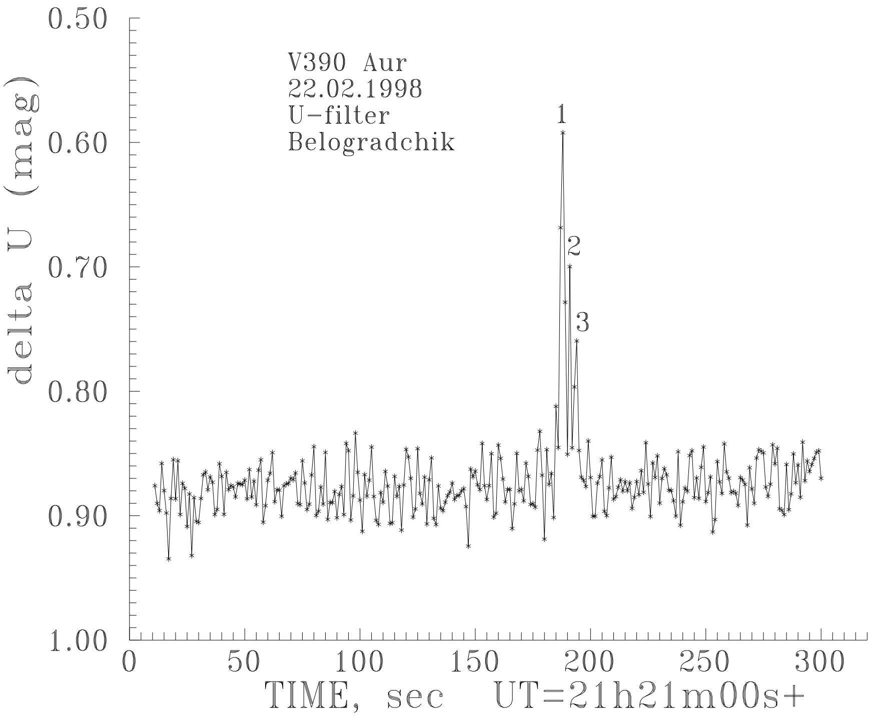

Figure 3: The events observed on V390 Aur on February 22, 1998

DISCUSSION

Our results revealed that both short-lived and longer duration flares appear in single active G and K giants but these events happen not very often.

The bibliographic search also confirms this result. A few events in X-ray and in some UV lines, that seems to be flares are reported by Huensch & Reimers (1995), Haish & Schmitt (1994), Ambruster *et al.* (1997) and Ayres *et al.* (1999). No firmly proofs for optical flares in single giants were reported till now. The earlier reviews on this topic by Pettersen (1989) and Schaefer (1989) pointed out a few stars (ν Oph, τ CrB, V654 Her) as flaring giants candidates. Our study of the chromospheric activity indicators and U-patrol monitoring revealed no sign of activity and flares in these stars (Konstantinova-Antova *et al.*, 1995). So, after a careful analysis we could not exclude the possibility for these events to be artificial ones.

Our recent systematic photometric study of active single giants found that optical flares happen on them, but RARELY. This fact could be explained either with their lower activity level, or with the specific properties and structure of the active regions in these stars.

Short-lived optical flares, especially, could not be easily explained by the Katsova and Livshits gas-dynamic model. A possible explanation could be given under the assumption of influence of accelerated particles into the more dense chromospheric and upper photospheric layers. Their unusual spike structure needs a further investigation. In future, a high-speed simultaneous patrol monitoring is required to refine our knowledge on the properties of these events.

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The Hipparcos Catalogue was used.

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