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The role of flares for terrestrial planets

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Abstract

Flares, especially giant ones affect the atmospheres of terrestrial planets. In order to better understand the processes involved we have initiated a study of flares in the CoRoT–database. In our survey we have detected several active stars with flares. These show the usual behaviour: a rapid increase followed by a slow decay. The obtained cumulative frequency diagram follows a power law. In addition to these flares we found 50 huge flare-like events on otherwise inactive stars. In contrast to the flares which have blue colours these events show a mixture of different colours and shapes. They thus resemble the events on a sample of solar-like stars first noticed by Schaefer et al. more than 10 years ago.

1. Introduction

More than ten years ago Rubenstein & Schaefer ([1]) and Schaefer et al. ([2]) concluded from an analysis of archived data that ordinary main-sequence F8-G8 stars have flares that are about 100 to 10^7 times larger than solar ones. They estimate that a solar-like star has such a flare every 600 years. Since normal flares already affect the atmospheres, and the habitability of planets [3,4], such gigantic flares should cause dramatic effects. It would thus be highly important to discover whether ordinary solar-like stars actually have such events.

Not only giant flares are important for planetary atmospheres but also small ones, because they are related to Coronal-Mass-Ejections (CMEs) and the emission of hard X-rays. Therefore it is important to study the light curve of stars in general as well.

2. CoRoT observations

We thus started a survey studying the light curve of stars with CoRoT. As a first step, we developed a code that allowed us to detect flares in the three colour light curves obtained by CoRoT. We only used the three colour light curves, because these allow us to distinguish flares from other events. Due to the fact that CoRoT provides us with color information at all times we are able to rule out that any of the events are caused by a micro-lensing event

Since CoRoT has monitored 10034 G-type stars for 0.41 years in three colours, the CoRoT-database should contain the order of at least 10 such events. CoRoT is not only ideal for studying giant flares but due to its high photometric accuracy and its capability of obtaining colour-information, CoRoT is also perfect for studying the light curve of stars in general.

Last but not least CoRoT has observed different fields in the sky, including the star-formation region NGC 2264 (age 3 Myr, distance 760pc), which allows us to study the change of the light curve with age.

3. Light curves of stars

Figure. 1 shows the active star IRa01 E2 0828 which is covered with at least one huge spot. Numerous flares can be seen. They have the typical characteristics of a rapid increase and slow decline of the flux. Thanks to the fact that CoRoT obtains light curves in three colours we can study the flares in three different spectral ranges (shown from top to bottom in red, green, blue and white light). The increase in flux is larger in the blue than in the red, which again is typical for flares. We verify the typical power law distribution given by:

$$\frac{df(E)}{dE} \approx f_0 E^{-\alpha} \quad (1)$$

for all colours and an α-value of about 2.7 for this star. Recent studies claim values of 2-2.5 for G to M dwarfs and T Tauri stars. Flare-stars should lead to values in the range from 1.4 to 2.0 [3].

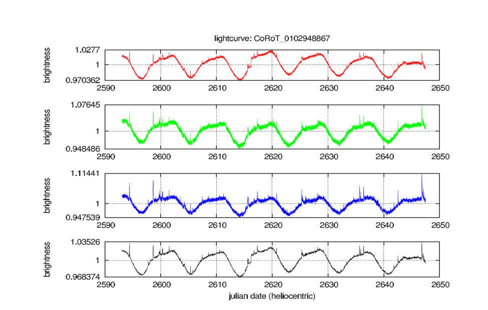

Figure 1: IRa01 E2 0828 an active star with flares

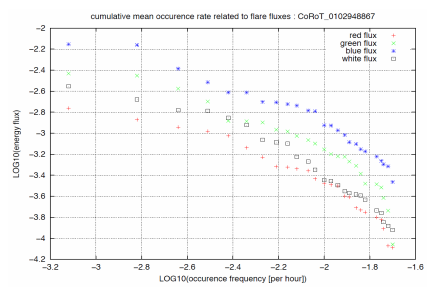

Figure 2.: Cumulative frequency diagram for the flares of IRa01 E2 0828.

Figure 2 shows the cumulative frequency diagram of flares detected on this star. Referring to Byrnes et al. ([5]) the cumulative mean flare occurence rate with respect to the emitted flare energy flux follows a power law:

$$\lg E_{\text{vis}} = -\beta \lg f \left[\text{h}^{-1}\right] + \lg E_0 \quad (2)$$

Our example can confirm this relation with a β-value of about 0.9.

4. Giant flares

The light curve of SRa01 E1 0288 does not show the typical signature of large spots or a continuous flare activity like IRa01 E2 0828. On the contrary we see only one large flare during which the brightness of the star increases by about 30% in the blue light. Nevertheless, more detailed studies have to be done before we draw any conclusion. We note however that the star is only about one degree away from the Conus cluster, an active star-forming region indicating that it could be a young star.

In total we have discovered 50 large events on otherwise inactive stars. Quite surprisingly, not all of these events have the characteristic blue colours of flares. Some have even red colours. Interestingly, the same strange colours were also found for the events described by Rubenstein & Schaefer [1] and Schaefer et al. [2]. We thus conclude that we have detected the same kind of events as these authors. The next step is to determine which types of stars produce such events. We have already taken spectra of eight of these stars with spectral types between A and K.

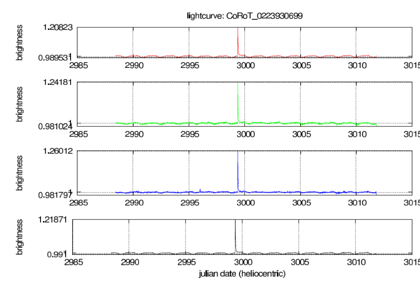

Figure 3.: A giant flare in SRa01 E1 0288.

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