

Short-term Activity in Young Solar Analogs

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Abstract. Knowing the chromospheric and magnetic activity in Young Solar Analogs (YSAs) gives us an insight into the conditions in the early solar system when life was establishing a foothold on the earth. To complement an 8-year history of monitoring 31 YSAs on long and medium timescales, a program of high-cadence, high signal-to-noise spectroscopy started in 2013. Initial, spectacular results for flares are presented, together with flickering.

1. Introduction

The Young Solar Analogs (YSAs) Project is designed to answer a number of fundamental questions about the early Sun. Did the early Sun exhibit a sunspot cycle? How did the early Sun vary on time scales from minutes to years? How did the solar flux across the visible spectrum vary with solar activity? To answer these questions we are monitoring 31 young (0.3-1.5 Gyr) solar-type stars (F8-K2) both photometrically and spectroscopically.

The monitoring has been going on for eight years with telescopes at the Dark Sky Observatory, NC. Its long- and medium-duration phenomena are presented, with methods, in the [Gray et al. \(2014\)](#) and [Saken et al. \(2014\)](#) papers in these same Cool Stars 18 proceedings.

High-cadence spectroscopic observations, on timescales of minutes to hours, complement the above monitoring. These observations started in early 2013 at VATT, a 1.8-m telescope situated on Mt. Graham, AZ, where they are being carried out with VATTSpec. The

camera is a 2688x512 pixel, back illuminated STA0520A CCD. An Hg-Ar comparison lamp is used for wavelength calibrations. With a 1200 g/mm grating, VATTSpec delivers for these YSA stars spectra of high signal-to-noise at a rate of one every 1 or 2 minutes, having a resolution of 1Å in the region containing Ca II K & H and the G-band. These features detect, respectively, chromospheric activity and large-scale magnetic structure changes in the photosphere on timescales of minutes to hours. We shall be addressing the question of the energy output and frequency of flares on a subset (10) of our program stars. Here initial, spectacular results for flares are shown, together with flickering.

2. Flares

A powerful white-light flare in HD 76218 near the end of the 2011/12 season is shown in three photometric bands observed at the Dark Sky Observatory (Figure .1). The mid-flare was detected in the piggy-back data, but it appears that the robotic telescope picked up the end of the flare. Typical precisions in the Johnson bands are 0.005-0.007 mag.

Spectroscopic observations with the VATT of HD 82885 for one hour a night for four separate nights captured a flare on the second night (Figure .2). S_2 is VATTs instrumental version of chromospheric activity, based on Ca II K & H. It will be calibrated with the Mount Wilson S_{MW} index after sufficient observations have been made on different nights of Mount Wilson stars (Baliunas et al. 1995).

In a similar way, a flare for HD 101501, with an abrupt onset but this time with a slower and nearly linear decay, was captured on the third night of observations with the VATT (Figure .3).

3. Flickering

Figure .4 shows the instrumental S_2 variations for three active YSA stars over as long a period as possible during a single night, i.e., up to 7 hours. One inactive star, HD 207978, was observed on the same night as the observations for HD 130322. It is included in the lower-left plot for a control. This plot represents monitoring over about half an hour and, while its MJD scale is appropriately short, it has the same S_2 range as the others. The scatter in S_2 is ± 0.0004 , indicating the very small instrumental error achieved.

HD 16673, upper left, showed little variation, save a slight decline in activity level. However, the right-hand pair of stars enjoyed considerable flickering, with scatters in S_2 of ± 0.0016 for HD 76218 and ± 0.0015 for HD 130322. The flickering amplitude for HD 76218 even increased. Long-term data from our monitoring suggests this star, which in Figure .1 had almost a superflare, is returning to an uniform distribution of spots with longitude on its surface.

Micro-variability, or flickering, in stars is not well-understood, though it is ascribed to variations in surface granulation. It is receiving considerable interest since it occurs on timescales similar to exoplanet transits and can mask the signal from these (e.g., Aigrain et al. 2004). We are continuing this high-cadence, many hours monitoring on VATT for a subset of 10 YSAs.

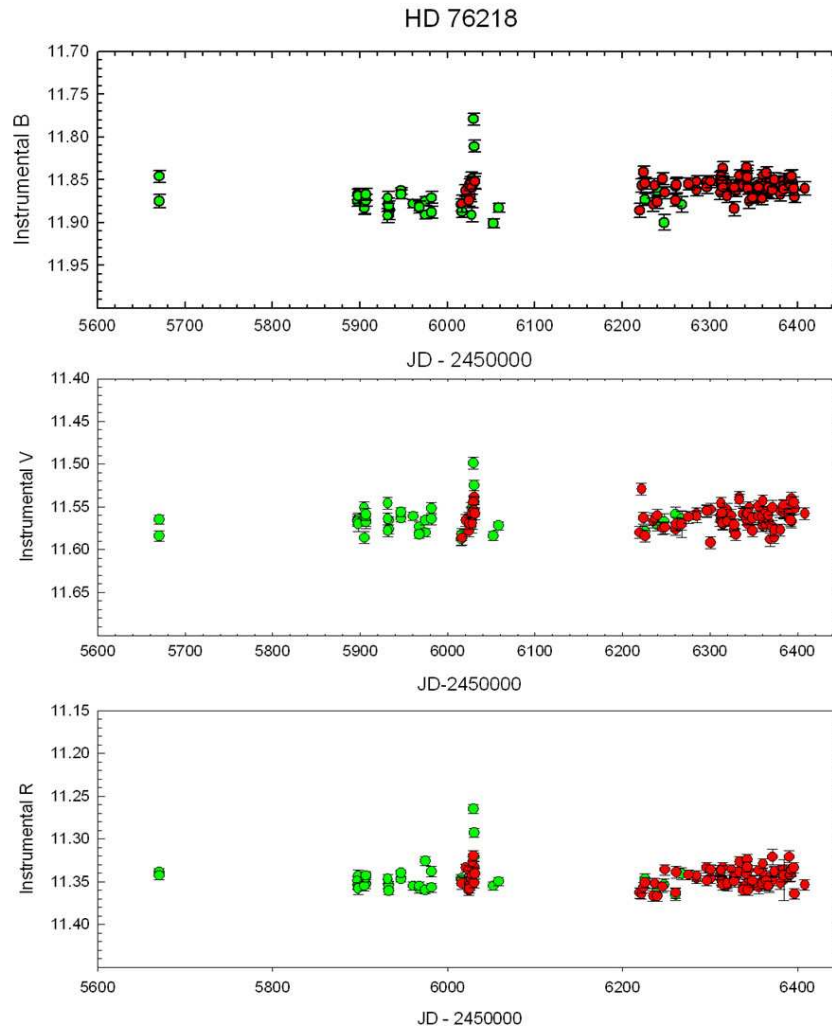


Figure 1: Photometric observations in three bands of a powerful white-light flare in HD 76218. Data from the piggy-back photometer are the green symbols, the robotic data the red.

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References

- Aigrain, S., Favata, F., & Gilmore, G. 2004, *A&A*, 414, 1139
- Baliunas, S. L., Donahue, R. A., Soon, W. H., et al. 1995, *ApJ*, 438, 269

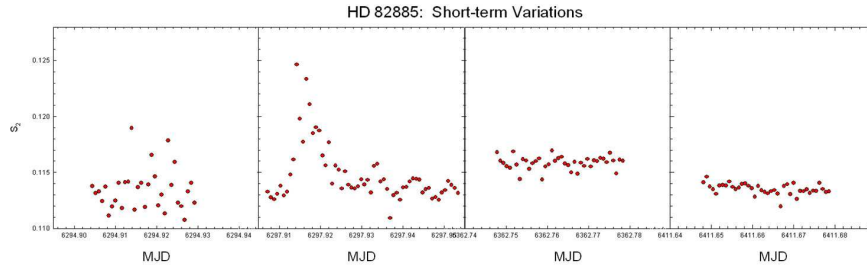


Figure .2: VATT's short-term spectroscopic Ca II K & H observations of HD 82885 capture, on the second night, a flare with an abrupt onset and decay.

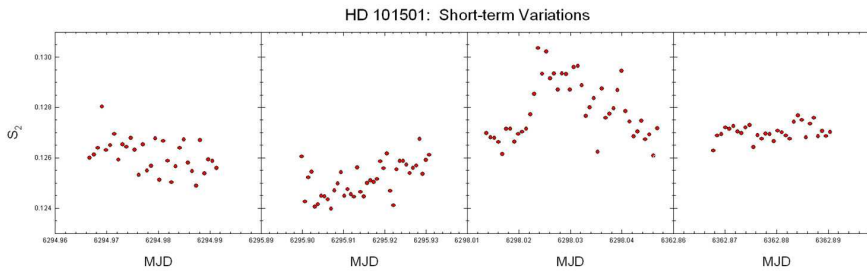


Figure .3: Similar to Figure .2 but for a flare on the third night for HD 101501.

Gray, R.O., Saken, J.M., Corbally, C.J., Briley, M.M., Fuller, V.A., Lambert, R.A., Newsome, I.M., & Childers, M.J. 2014, *The Young Solar Analogs Project*, in 18th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, Proceedings of Lowell Observatory, eds G. van Belle & H. Harris

Saken, J.M., Gray, R.O., Corbally, C.J., & Briley, M.M. 2014, *The Young Solar Analogs Project: Observations & Analysis*, in 18th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, Proceedings of Lowell Observatory, eds. G. van Belle & H. Harris

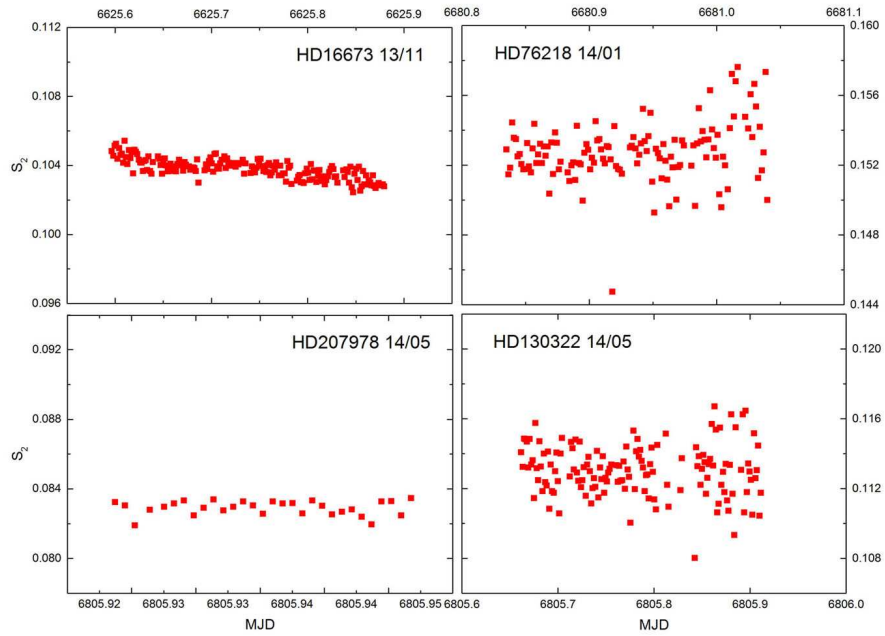


Figure .4: VATTs short-term spectroscopic observations of three active and one inactive star, HD 207978.

