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Photospheric stellar activity cycles

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Abstract. Cycle lengths of active stars are derived from long-term photometric monitoring of their secular light variability. With the help of photographic data archives the lengths of the datasets are extended for HK Lac and V833 Tau. Using time-frequency analysis it is shown that the cycles are continuously changing in time. Thus, the reported cycle lengths derived by simple Fourier analysis are mean values that are valid only for a given time interval.

Keywords. stars: spots , stars: activity, stars: atmospheres, stars: late-type, stars: magnetic fields

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The photospheric solar activity cycles, like the ∼ 11 yr long Schwabe and the ∼ 80 yr long Gleissberg cycles, as the sunspot data reveal, are continuously changing in time, e.g., the Gleissberg cycle is getting steadily longer during the last few hundred years (Oláh & Strassmeier 2002). Activity cycles, sometimes multiple cycles, are derived for several active stars, from long-term photometric data, see Oláh *et al.* (2000) and Oláh & Strassmeier (2002) for more. The resulting cycle lengths are usually just 'quasiperiods', with high scatter around the mean period values, or are just marginal detections. The reason of these results well could be that the cycle periods are not stable but changing in time like on the Sun. To find such changes, however, very long uninterrupted datasets are necessary. We show results of analyzing long-term datasets which are compiled from archival photographic and continuous photoelectric observations using the time-frequency analysis program package TiFrAn created by Kolláth (2006). This method uses evenly sampled data, therefore, the observations first should be averaged and interpolated to get a suitable dataset for the analysis.

On the left side of Fig. 1 the time behavior of the cycle periods of HK Lac during 48 yr, is given. Recently, Fröhlich *et al.* (2006) found 6.8, 9.65 and 13.0 yr cycle periods from the same dataset as was presently used. Earlier, from a shorter dataset, and without the archival photographic data Oláh & Strassmeier (2002) derived 6.4 and 13.2 yr long cycles. The difference between the two results is the markedly present 9.65 yr long cycle, which is dominant in the beginning of the dataset, and which later gradually changed to about 13 yr as is seen in the bottom panel of Fig. 1.

The 108 yr long dataset of V833 Tau shows continuous presence of about 5.8 and 8.6 yr long cycles found earlier by Oláh & Strassmeier (2002) who also derived the shortest cycle as of 2.3 yr. However, this shortest cycle was around 3.4 yr in the first half of the 20th century, and later it showed continuous change between 2 - 2.7 yr, lasting till the present. Thus it is clear why the photometric data alone, which span only for the last 20 years, result in a 2.3 yr long cycle from the simple Fourier analysis.

All cycle periods, even marginal detections, that were derived earlier for the studied active stars by Oláh & Strassmeier (2002) are confirmed. However, it is found that the cycle lengths are varying in time on HK Lac and on V833 Tau. This result shows that the detection of cycles could be problematic with conventional methods, like the simple periodogram analysis. On the other hand, the time-frequency analysis needs more continuous and longer datasets than those existing at present for most active stars.

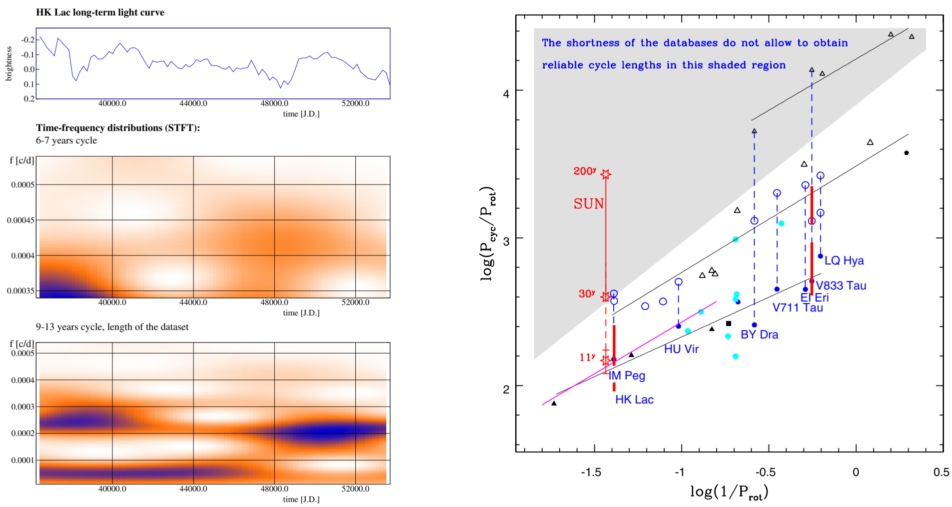

Figure 1. *Left:* time-frequency result for HK Lac. *Upper panel:* data; *middle panel:* cycle around 6 - 7 yr (0.00045 - 0.00030 cycle/d); *lower panel:* continuously growing cycle between 9 - 13 years (0.0003 - 0.0002 cycle/d). *Right:* rotation-activity cycle diagram based on Oláh & Strassmeier (2002). Also given are the cycles from Messina & Guinan (2002) for single solar type stars. The relation from Baliunas *et al.* (1996) is represented by a thick line at the long period part of the diagram. The continuous vertical lines show the ranges of the cycle length variations for the Sun, HK Lac and V833 Tau.

The right side of Fig. 1 shows the rotation - activity cycle diagram based on the work of Oláh & Strassmeier (2002). Additional cycles for solar type single stars are added from the work of Messina & Guinan (2002), which agree with the general trend between the rotational period and activity cycle. A thick line in the longer period regime represent the relation from Baliunas *et al.* (1996), based on Ca II H & K measurements for a large sample of single lower main sequence stars. Vertical continuous lines show the range of the derived cycle lengths for HK Lac, V833 Tau and for the Sun. The extended ranges of the cycle lengths may explain the large scatter towards the longer cycles. Oláh & Strassmeier (2002) suggested that the cycle lengths derived by simple Fourier analysis could be just snapshots valid for a given time interval. The present results seem to confirm this idea. Stars can have a wide range of possible cycle lengths, thus the determination of the shortest value is very important, since that would show clearly the relation between the rotational and cycle periods.

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