The Vienna-KPNO search for Doppler-imaging candidate stars. II. First photometric results

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Abstract. Following our spectroscopic CaII H&K survey (Strassmeier et al. 1999), we used the University of Vienna Twin Automatic Photoelectric Telescope (APT) located in southern Arizona to monitor 198 of the 371 newly discovered H&K emission stars. After an observation period of roughly four months we are ready to present preliminary light curves for 96 targets, 66 of them show a photometric period. Typical periods are 7-8 days, while the amplitudes observed peak around 0.05m.

1. The University of Vienna Twin-APTs

In early 1996 the University of Vienna acquired two almost identical 0.75m APTs from Fairborn Observatory that we named WOLFGANG-AMEDEUS (Strassmeier et al. 1997). The telescopes are well-designed for continuous monitoring of stars brighter than $m_V \approx 10^m$. Amplitude variations even below 0.01m can be detected. Since early October 1998, one telescope has been entirely dedicated to monitor continuously 198 stars showing H&K emission found during our recent H&K emission survey.

1.1. Data acquisition

The standard observing sequence common to the vast majority of all the groups consists of three measurements of the variable star accompanied by four measurement of a comparison star, two measurements of a check star and two sky measurements. Although the pointing-and-centering algorithm is normally very reliable, it is sometimes advisable to include an optional (bright) navigation star at the beginning of the sequence. Offsets of a few degrees from the navigation star normally lead to a pointing accuracy of one arc minute and centering problems are therefore not likely for stars without a close companion.

1.2. Data reduction

The standard output contains the time at the center of the group integration with an accuracy of 1 sec. and the total photoelectric events along with Geneva statistics Q, R, and G. In addition to the target groups, standard stars are also observed on a nightly basis. In a first step the observations of the standard stars are used to determine the nightly extinction coefficients. In a second step the observations of the target groups are reduced to the standard system using the extinction coefficients obtained in the first step. When a night does
not have photometric quality, averaged extinction coefficients of the last three photometric nights are used.

2. Observations

WOLFGANG, the APT which is the primary telescope for time-limited, high-frequency observations, has been loaded with 198 groups, each consisting of the target star, a comparison and a check star for differential measurements. The high number of newly discovered H&K emission stars (371) made it necessary to restrict the photometric observations to high-emission targets, i.e. stars with H&K emission of at least 50% of the continuum. Measurements started in early October 1998, and continued till summer shutdown in early July 1999.

The primary goal of the whole campaign is to detect photometric variations of the H&K-emission stars and to determine, if possible, their photometric period. If the light variations are caused by stellar spots, the photometric period is the rotational period. To observe as many targets as possible, only the Strömgren y-filter band was used, with integration times of 20 sec. on each star. This rather short integration time already suffices to push the typical standard error to mean below 0.01; enough to trace the expected amplitude variations of $\Delta m \gtrsim 0.01$. Most targets are observed on a one-per-night basis, with the exception of stars with a high $v \sin i$ and therefore probably short rotational periods. These targets are measured on a bi-nightly basis. This policy allows us to observe up to 100 targets per night.

For 96 stars that have just passed the observing window, the light curves can be found at http://www.astro.univie.ac.at/~kgs/APT/. Out of the preliminary sample, only 3 stars have photometric amplitudes less than 0.01 and may therefore be considered constant. 69% or 66 stars show periodic photometric variation, while the remaining targets do show light variation, but their light change proved either erratic or periodical with periods well above the observational time base. 23 of these variable stars are not an original part of the survey, but are former check or comparison stars, that turned out to be variable during our observations. We show two newly discovered variables in Fig. 1. The left Panel shows the periodic variable HD 7590, the right Panel HD 220949, where we could not find a photometric period.

Three stars show photometric amplitudes above 0.3, their light curves are given in Fig. 2. HD 553 is a known eclipsing binary of $\beta$-Lyrae type. SAO 151224
Figure 2. Light curves and phase plots of HD 553, SAO 151224 and HD 190642. HD 553 and SAO 151224 may be eclipsing binaries.

Figure 3. Histogram of observed amplitude variations in Strömgren y (a) and of the observed photometric periods (b). Only stars part of our H&K-emission survey are included, giving a total number of 76 stars in panel a and 59 in panel b. The population to the right end in panel b is mainly occupied by giants and subgiants.

may also be an eclipsing binary. The light variation of HD 190642 appears to be erratic during our observation.

3. Statistics

Though the photometric part of the survey will not be completed until July 1999, we present here some preliminary statistics. Fig. 3a shows a histogram of the photometric amplitudes, Fig. 3b a histogram for the photometric periods found. Only stars part of the H&K emission survey have been considered.

Except for a few cases, we interpret the photometric periods to be the stellar rotation period. The periods peak around 7-8 days, only one fourth of the Sun’s rotational period. This is understandable if the shorter rotational period is linked to higher dynamo activity stimulating high H&K fluxes. The 13 stars showing rotational periods $P \geq 15 \text{d}$ are mainly giants and subgiants: 69% of these stars belong to luminosity class III or IV.

The steep decline in the amplitude plot (Fig. 3a) below $0^m03$ may either be due to our detection limit which is close to $0^m01$ or may indicate that stars with strong H&K emission ($\geq 50\%$ of the continuum for our photometric sample) show generally a variability of $\Delta m \gtrsim 0^m03$. The increase in numbers for $\Delta m \gtrsim 0.07^m$
Figure 4. Photometric amplitude (Strømgren y) against photometric period for the main sequence stars in our H&K sample (44 stars). Note the trend to lower amplitude for increasing period.

may indicate a different variability reason, like stellar pulsations. Two stars are eclipsing binaries, refer chapter 2.

If the photometric variation is due to stellar spots, we might expect an increase in amplitude with increased dynamo efficiency, or with decreasing rotational period. Fig. 4 shows photometric amplitude against photometric period for the main sequence stars in our sample. Note that we expect to find merely an upper envelope than a straight correlation in an amplitude vs. period plot due to the arbitrariness of the inclinations of the stellar rotational axis to the line of sight. Though the sample is limited, a general trend of increasing amplitude with decreasing period is present. Further data may increase the statistical significance.

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References