

Determination of rotation periods of M stars with photometric techniques.



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Abstract. This work is part of the project CARMENES (Calar Alto search for high-Resolution M dwarfs With Exoearths With Near-infrared and optical Échelle spectrographs) (<http://carmenes.caha.es/>) searching for Earthlike exoplanets in M dwarf stars (Quirrenbach et al. 2014SPIE.9147E..1FQ). Our goal is to characterize the rotation periods of the M-type dwarf stars of CARMENES input catalog in order to distinguish variations in radial velocity produced by magnetic activity of those produced by possible exoplanets. These data will also allow us to study in detail the dependence of chromospheric activity with rotation in this type of stars. We are analyzing photometric series of our input stars obtained by surveys as *MEarth*, *ASAS* or *K2* and making observations at various telescopes in collaboration with amateur observatories. We are also developing and testing new photometric techniques based on intelligent modeling of atmospheric turbulence to improve rotation curves.

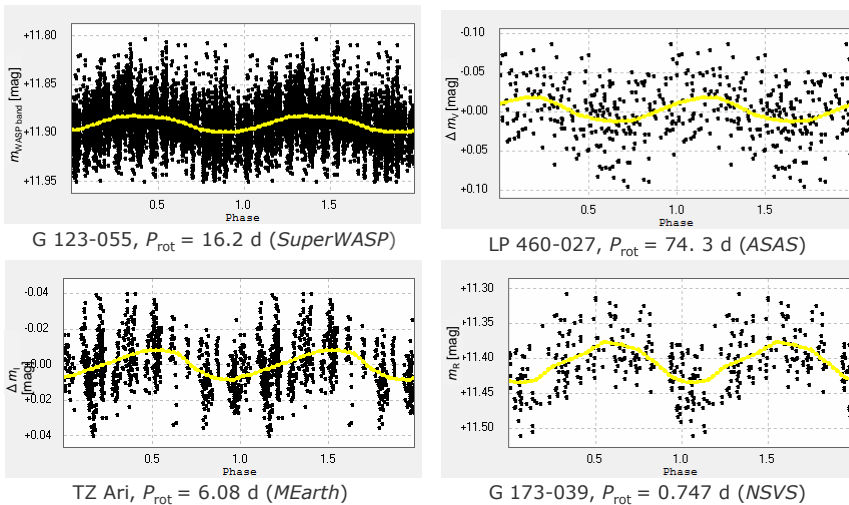


Fig. 1: Examples of determining P_{rot} in four of the surveys analysed (*SuperWASP*, *ASAS*, *MEarth* and *NSVS*). Light curve phased with P_{rot} and average value of the data (yellow curve).

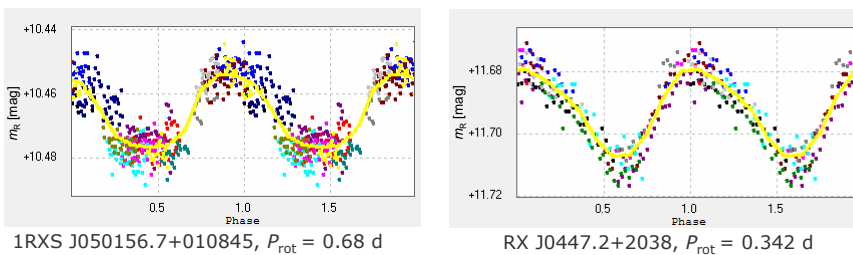


Fig. 2: P_{rot} determination for two stars observed with data obtained at Obs. *Montcabrer*. Light curve phased with P_{rot} (each colour indicates a time of observation) and average value of the data (yellow curve).

We have selected **264 M stars** of our catalogue (Carmencita, see poster Caballero et al., this meeting) with unknown rotation period (P_{rot}) and performed a search of photometric data in the following surveys: *MEarth* (Irwin et al. 2011ApJ...727...56I), *K2* (Howell et al. 2014PASP..126..398H), *ASAS* (Pojmanski et al. 2002AcA...52..397P), *SuperWASP* (Pollacco et al. 2006PASP..118.1407P), *NSVS* (Wozniak et al. 2004AJ....127.2436W) and *Catalina* Real-Time Transient Survey (CRTS, Drake et al. 2009ApJ...696..870D). In addition, we are observing at various telescopes in collaboration with amateur observatories (*Montcabrer*, *La Vara*, and *Carda*, ten stars observed to date). To determine the P_{rot} we analyse periodograms (see Fig. 3) using Lomb-Scargle method (L-S, Scargle, 1982ApJ...263..835S) we also obtain the probability of false alarm and an estimate of confidence of the frequencies found (Horne & Baliunas, 1986ApJ...302..757H).

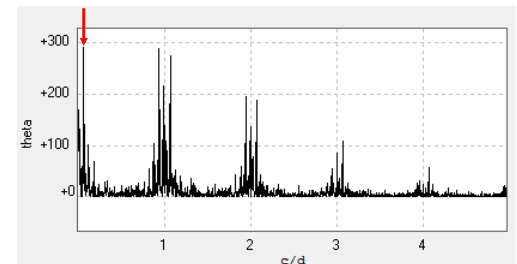


Fig. 3: L-S periodogram of G 123-055. The rotation frequency corresponding to the peak of 0.0617 d^{-1} ($P_{rot} = 16.2 \text{ d}$, red arrow, see Fig. 1). The other prominent peaks are aliases.

To date we determined P_{rot} for **156 M dwarfs** (see examples in Figs. 1 and 2). In cases where photometric data are not available from surveys, we are making observations. Suspected stars of being slow rotators (v_{sini} & $pEW(H\alpha)$) have an observation program in Joan Oró Telescope (*Observatorio Astronómico del Montsec*, 75 hours with Meia 2 instrument since 10/05/16). Suspected stars of being fast rotators are observed in collaboration with amateur observatories *Montcabrer*, *La Vara* and *Carda*.



Fig. 4: Assembly installed in *Carda* observatory.

In collaboration with the *Advanced Mathematical Modelling Group* at the University of Oviedo, we are developing new photometric techniques based on intelligent modelling of atmospheric turbulence. This new technique will be tested in slight photometric modulations induced by rotation in our stars, as well as in the photometric tracking of stars with exoplanets. In this first phase tests are being developed on an assembly with two identical telescopes and CCD cameras, taking science and reconstruction images (see Fig. 4).