Prospects for observing pulsating red giants with the MONS Star Trackers

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ABSTRACT

K and M giants show variability on timescales from years down to days and possibly even hours. I discuss the contribution that can be made with high-precision photometry that will be obtained by the MONS Star Trackers. These include observations of flare-like events on Mira variables, and oscillation spectra for K giants and short-period M giants.

1. Introduction

The Star Trackers on the MONS satellite (Bedding & Kjeldsen, these Proceedings) should produce exquisite light curves for many hundreds of red giant stars. These observations, made over about 30 days with high duty cycle, will allow a number of questions to be addressed. Classes of stars are discussed in order of decreasing effective temperature, starting with the Mira variables.

2. Mira variables

Miras have the largest amplitudes and longest periods of all pulsating stars. What can we then hope to learn by studying them at high precision over a month, which is only a small fraction of a pulsation cycle? Schaefer (1991) has collected 14 cases of flares reported on Miras, lasting minutes to hours and having amplitudes up to a magnitude. A systematic study by Maffei & Tosti (1995) found short-term variations in the photographic light curves 18 long-period variables in M 16, with amplitudes ≥ 0.5 magnitudes and durations 1–30 days. Most recently, de Laverny et al. (1998) detected variations from Hipparcos photometry of Miras, with amplitudes 0.2 to 1.1 magnitudes and durations from 2 hours up to 6 days. In some cases, repeat events were observed on the same star (see Fig. 1).

The origin of these short-term variations is not clear, but they are presumably due to rapid and probably localized temperature changes. One possible cause might be the arrival at the surface of an unusually large convection cell. Given the high precision of the MONS Star Trackers, we should expect to see a distribution of events down to much smaller amplitudes. Two-colour information would be especially useful for shedding light on this phenomenon.

3. Short-period M giants

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Koen & Laney (2000) have studied what they describe as rapidly oscillating M giant stars. They present a few dozen M giants that were discovered by Hipparcos to have periods shorter than 10 days and amplitudes up to a few tenths of a magnitude. The only viable explanation seems to be pulsation in very high overtones, and some stars shows signs of multiple periodicities. Koen & Laney list about 35 stars with periods less than 10 days, having $V$ magnitudes from 5.4 to 8.9 and amplitudes mostly below 0.1 mag. Several of these stars will be observed by the MONS Star Trackers, and the light curves should allow a proper frequency analysis for multiple modes.

4. Oscillations in K giants

It has been established from ground-based photometry that variability in red giants decreases in amplitude as one moves down the spectral sequence from M to K (Jorissen et al. 1997, Fekel et al. 2000). With the kappa mechanism no longer functioning, excitation is presumably due to convection. Periods become shorter as stellar density increases, and variability becomes less regular, presumably due to the stochastic nature of the excitation process and/or to the presence of multiple modes.

A few bright K giants show radial-velocity (RV) variations that could be due to oscillations, but it has proved difficult to obtain time series that are long and continuous enough to resolve the frequency spectrum. Matters are complicated by the presence of long-term variations (hundreds of days), which could be due to pulsation, rotational modulation or low-mass companions (e.g., Hatzes & Cochran 1993, 1999).

The best-studied example is Arcturus ($\alpha$ Boo), which has been found to have short-term RV variations with periods of a few days (Smith et al. 1987, Belmonte et al. 1990, Hatzes & Cochran 1994, Merline 1999), as well as long-term variations with a period of a few hundred days (Hatzes & Cochran 1993). This star
will definitely be observed by the MONS Star Trackers, since it lies close to η Boo, a high-priority primary target. It is not clear whether 30-50 d will be long enough to produce a usable oscillation spectrum, but nearly-continuous coverage over this period will produce a time series far better than any RV observations so far obtained.

Figure 2 shows Hipparcos light curves for a sample of the brightest K giants (many of which are also known to be RV variables). Suprisingly, these light curves have not yet been discussed in the literature. We see clear evidence for photometric variability in several stars, and we can confirm that Arcturus is indeed a variable star, with peak-to-peak variations of about 0.04 mag.

Another interesting case is π Her, for which Hatzes & Cochran (1999) obtained RV measurements over two years that showed variability with a period of about 600 d. They pointed out that if rotational modulation of surface structure were the cause, one would expect photometric variations of about 0.1 mag (peak-to-peak). The Hipparcos light curve was obtained at roughly the same time and shows some evidence for slow variability, but at level about ten times smaller than this, allowing us to rule out spots as the cause of the RV variations in π Her.

Photometric variability in K giants has previously been seen in globular clusters. Edmonds & Gilliland (1996) observed 47 Tuc with the Hubble Space Telescope over 38.5 hr and found variables with periods of 2–4 days and semi-amplitudes of 5–15 mmag. Kaluzny et al. (1998) detected 15 red variables in 47 Tuc from the Optical Gravitational Lensing Experiment (OGLE), which had poorer precision but much better temporal coverage. Their K-giant variables have periods of 2–36 d and semi-amplitudes of 40–90 mmag. Interestingly, both these observations are predated by a report by Yao (1990) of a red giant variable in the globular cluster M 15, with a period of 4.3 hr and an amplitude of about 20 mmag.

It seems clear that many K giants are variable on timescales of hours to days, and observations with the MONS Star Trackers should produce excellent light curves.

Finally, we mention the recent exciting results by Buzasi et al. (2000 and these Proceedings), who used the star camera on the failed WIRE satellite to perform high-precision photometry of the bright K giant α UMa. They produced evidence for multi-mode oscillations in this star with periods of 0.3–6 d and amplitudes of 0.1–0.4 mmag. Data of much higher quality are expected from the MONS Star Trackers and should produce rich oscillation spectra for a sample of bright K giants.

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Fig. 2.— *Hipparcos* photometry of 14 bright K giants. Small diamonds with error bars are individual measurements, while larger diamonds (connected by a line) are means in one-day bins. The horizontal axis shows JD minus 2400000, and the vertical axis in each case has a range of 0.1 magnitudes, with the horizontal lines showing the means of the observations.
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