Photometric observations of
Grid Giant Star Survey candidates

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We compare variability of radial velocity (RV) and brightness for a sample of red giants which were selected as candidates for the Grid Giant Star Survey (GGSS). The purpose of the survey is to select astrometrically stable stars as a reference frame for the future Space Interferometry Mission. We incorporate photometric data taken by ROTSE-I and being taken by ROTSE-III robotic telescopes. Typically 2/3 of all GGSS stars to the north of DEC=-35 were observed 76 and 8 times by ROTSE-I and III respectively in white-light filters. It is shown that photometric stability at the 0.02 mag level cannot be used for a pre-selection of RV-stable stars, and the most important tool remains high-resolution spectroscopy. We deeply thank the ROTSE collaboration providing us observing time at the ROTSE-IIIb telescope. We gratefully acknowledge NASA grant NRA-99-04-OSS-058.

OBSERVATIONS

We present results from the spectroscopic and photometric followup survey of GGSS candidates. The main goal of the survey is to select astrometrically stable stars in support of the future Space Interferometry Mission. The GGSS sample consists of mostly distant red giants (see [1]). Followup spectroscopic observations of this sample were conducted in 2001-2004 and reveal radial velocity stable and unstable stars at the level of 50-100 m/s. In support of the spectroscopic observations, we carry out a photometric monitoring of the candidates brightness with the help of ROTSE-IIIb robotic telescope (operated at McDonald observatory, Texas). The ROTSE-IIIb is a fully robotic telescope ([2]) dedicated to observe GRB afterglows and well suited for sky surveys.

Of the all-sky GGSS sample (4739 stars) we were able to observe 3233 in the white-light filter. The expected accuracy was about 0.02 mag for our V=11-13.5 mag stars. Since August 2003 when the survey started, we took 28401 individual magnitudes for 3233 stars. We here examine any correlation between RV and photometric stability of our candidates.
In addition to the ROTSE-IIIb observations, we incorporate results of the Northern Sky Variability Survey (NSVS, [3]), a white-light photometric followup survey of all northern (DEC > -35 degrees) sky sources carried out with the help of ROTSE-I robotic telescope (Robotic Optical Transient Search Experiment). Approximately 2/3 our GGSS northern and southern candidates were observed during this survey. A fraction of these objects were rejected because of nearby companions, since the ROTSE-I pixel size is 14 arcsec. The expected accuracy in brightness for our sample of NSVS for our candidates is about 0.02 magnitudes. During this survey our candidates were observed 76 times on average during one year.

RESULTS

We estimate the accuracy in brightness taking the same source 3 times per night. The mean value of the brightness accuracy is about 0.02 mag. The long-term brightness variability was estimated as standard deviation of all magnitude values available for the source (sigma hereafter). Fig.1 shows the histogram with distribution of sigma and averaged internal accuracy for 3132 stars. Dashed line shows the same values for the stars which were taken more than two and 5 times. There is no difference in shape of these two distributions. It is seen that the variability of brightness is statistically significant for most of the investigated stars relative to the internal accuracy. However, long-term night-to-night errors coming from calibration procedure and sky conditions were not taken into account in this error estimation. This introduces an additional error and moves the maximum of distribution on Fig.1 along x-axis toward the higher values. It is a reasonable assumption that most of our stars are photometrically stable. Then the position of the maximum in Fig.1 at about 0.025 mag reveals the real mean level of long-term photometric accuracy. From this point of view, only a small fraction of observed GGSS candidates are photometrically unstable.

We are enabled to compare the photometric variability with stability level of radial velocity for two subsample of stars ([4]) observed at the McDonald observatory (northern subsample hereafter) with 2.1m telescope and Sandiford Echelle Spectrograph (R=55000), and at the ESO (Chile) with CORALIE velocimeter at the Swiss 1.2 telescope (southern subsample). The photometric and RV sigmas for 124 GGSS stars are compared in Fig.2 (upper left panel). A lack of correlation between the photometric variability and the main stellar parameters (Teff, log G, [Fe/H]) is seen in the rest of the panels in Fig.2.

The ROTSE-I photometric variability estimated as the standard deviation of brightness measured on different nights (sigma hereafter) is also available to compare with two samples of RV sigmas, northern and southern. Fig.3 represents the relations between photometric and RV sigmas. Left pannels show the northern subsample, and the right ones are for the southern stars. In addition to the photometric sigma (shown in the bottom panels), we calculate also chi square and compare them in the top panels. Open symbols mark the
Figure 1:
Figure 2:
RV sigmas based on two estimates, and the filled ones are for 3 and more RV values utilized to obtain the RV sigma.

There is a lack of correlation between the basic stellar parameters and chi square photometric values, as well as for the photometric sigma, obtained for the ROTSE-I data. Finally, we kept an eye on individual objects and found some examples of stars with highly variable radial velocity but stable photometrically, as well as vice versa, good and stable radial velocity can coexist with suspicious photometric instability.

CONCLUSION

We investigate whether the all-sky photometric variability surveys can help us to pre-select K-giants which would indicate stable radial velocity. We show that, most probably, it can not be done via a photometric survey, at least with accuracy of order 0.025 mag. The most important tool remains high-resolution spectroscopy.

ACKNOWLEDGMENTS

We deeply thank the ROTSE collaboration, and personally Carl Akerlof, Tim McKey, Eli Rykoff and Don Smith for providing us observing time at the ROTSE-IIIb telescope and for discussions. We thank Michel Mayor for generous allotment of telescope time. This project utilizes data obtained by the Robotic Optical Transient Search Experiment. ROTSE is a collaboration of Lawrence Livermore National Lab, Los Alamos National Lab, and the University of Michigan. The GGSS followup survey is supported by NASA/JPL via grant NRA-99-04-OSS-058.

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Figure 3: