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Naini Tal - Cape survey for pulsating chemically peculiar stars – A status report

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Abstract. The "Naini Tal-Cape survey for rapidly oscillating Ap stars", to search the northern hemi-sphere sky for pulsating stars was initiated in 1997. This is a collaboration between India and South Africa. So far about 70 stars have been observed and 4 variables have been discovered. The variables are HD 13079, HD 13038, HD 12098 and HD 98851. Of these HD 12098 is a likely rapidly oscillating Ap star. This paper gives a status report on the survey. The methodology of this survey and an evaluation of observing time vis-a-vis the chance of discovering a new variable are discussed.

1. Introduction

Several A type main sequence stars exhibit overabundance of rare earth metals like Sr, Cr, Eu, etc. coupled with abnormally large magnetic fields of the order of kGauss. These stars are termed as A peculiar or 'Ap' stars. All the Ap stars exhibit regular variabilities in photometric brightness, line intensity, magnetic field strength and radial velocity. These stars have rotation periods of the order of few days to few tens of days. A subset of the Ap stars also exhibit rapid oscillations with periods of 4-16 minutes and amplitudes in the range of few millimagnitude. The oscillations can be detected by optical photometry. These are interpreted to be non-radial p modes with low degree ($l \approx 2$) and high overtone ($n \approx 20$). This subclass of rapidly oscillating Ap stars is termed as 'roAp' stars.

2. Why study roAp stars

The rapidly oscillating Ap stars are in all other ways similar to other Ap stars which do not exhibit pulsations. It is necessary to determine what distinguishes roAp stars from non-oscillating Ap stars. Since roAp stars exhibit oscillations with large overtone numbers, many of the

multiperiodic roAp stars may be used for 'asteroseismology' of these stars. The outstanding questions on roAp stars are :

- Do all Ap Stars exhibit rapid oscillations if the searches are sensitive enough ?
- How does the presence of magnetic field affect the chemical peculiarity and pulsations ?
- Is there any connection between the Ap stars exhibiting δ *Scuti* oscillations in low overtone mode and the Ap stars exhibiting rapid oscillations in high overtone mode ?
- How similar are roAp stars to our Sun ?
- Are there subclasses in roAp stars ?

3. The Naini Tal-Cape Survey

Several surveys have been conducted (see references in Martinez 1993) to locate potential roAp stars. 31 have been discovered of which 28 have southern declinations, primarily due to the location of the SAAO from where they were observed. An organised survey in the northern hemisphere was therefore necessary in order to detect new roAp stars in this part of the sky. This led to the collaborative initiative "The Naini Tal-Cape survey for rapidly oscillating Ap stars" between India and South Africa, which was formalised in 1999.

The requirements for the survey are - a minimum of 1m class telescope placed at a photometric observing site to detect 1 millimag variations. A single channel photometer extendable to three channels with 30″ diaphragm, Johnson B-filter and 10-s integration time is normally used.

3.1 Selection Criteria of candidates for survey

The peculiarity of the Ap stars is estimated based on spectroscopy or Stromgren photometric indices. The criteria used for selecting targets are adapted from the Cape survey (Martinez 1993) of roAp stars and are as follows :

2.69	≤	β	≤	2.88
0.08	≤	(b-y)	≤	0.31
0.19	≤	m_1	≤	0.33
-0.12	≤	δm_1	≤	0.02
0.46	≤	c_1	≤	0.88
-0.31	≤	δc_1	≤	0.04

4. Observations and data analysis

The 104 cm Sampurnand Telescope at UPSO is used with a single channel photometer. A week long observation every month near full moon time is alotted for this program. Typically 1-2 hour observing run per night on an object is done and 3-4 such runs are conducted. Light curve is produced after correcting for dead time, sky background and extinction trends. Fourier transform of the light curve is performed to check for any periodicities exhibited by the object. Follow up observations are done with three channel photometer (Ashoka et al 2001).

5. Results and discussion

During Nov 1999 to May 2000, 52 objects were observed. Of these 6 had been observed in earlier runs; 28 objects were observed only once. There are multiple runs on remaining objects of varying data lengths. Two objects are confirmed to be variables. HD12098 is a new roAp star and HD 98851 is most likely a new δ *Scuti* star (Martinez et al. 2000; Joshi et al 2000). Three objects appear to be non-variables. For the others either the data length coverage is not sufficient to rule out variability, or the data has superposed sky variations which could not be totally removed (single channel observations). Figure 1 shows a distribution of the number of sources having a specific observation length (hours). This clearly shows that most objects have been observed for 1-2 hours. Only the likely variables have been observed for more than 15 hours. Figure 2 shows the distribution of the number of sources with respect to the length of the first run on the object. This again peaks at 1-2 hour, indicating this is sufficient time to judge if the source is interesting for further observations. From November 1999 to May 2000, 236 hours of data are available. (March & April 2000 were not very favourable for photometry). Of these 23 hours have been spent on observing HD12098, and 56 hours on HD 98851, the two identified variables. Taking together all the data collected from 1997, 74 stars have been observed, of which 4 are variables including the two discovered in 1999 (see also Ashoka et al, 2000. Martinez et al, 1999).

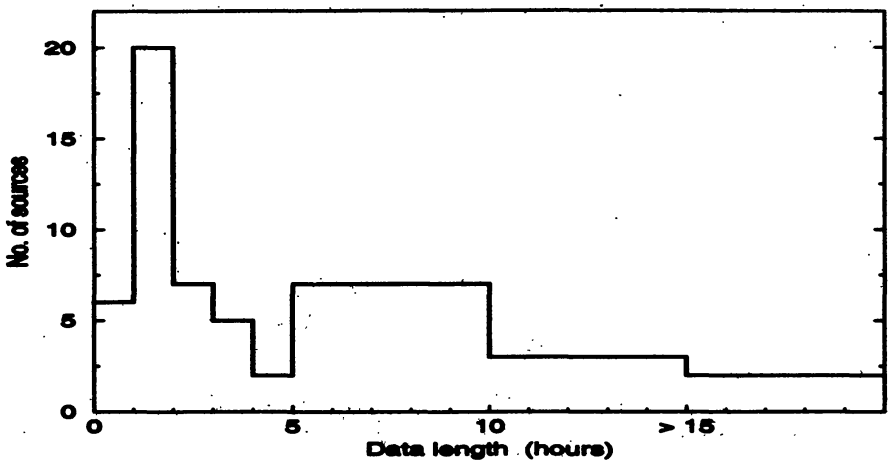

Figure 1. No. of sources vs. data length. A few suspected variables are observed for > 5 hours. The confirmed variables are observed for more than 15 hours

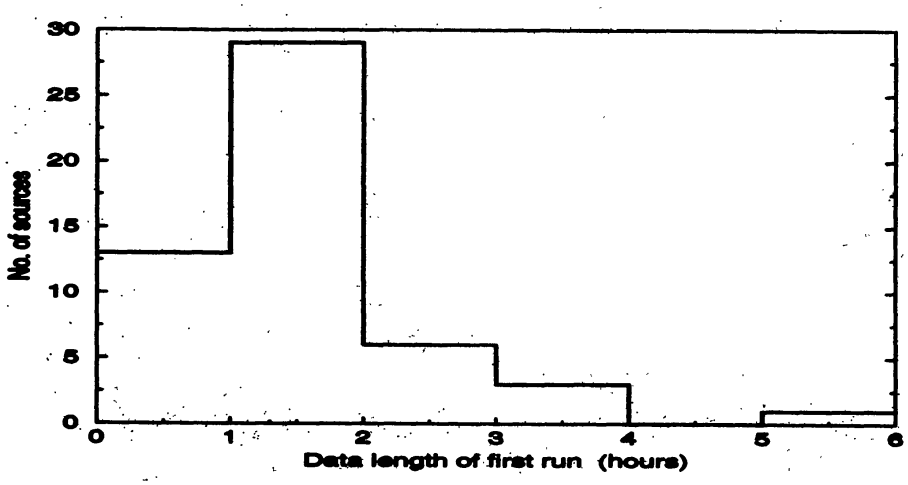

Figure 2. The data length of first run for various sources. This indicates that for most sources first run is < 2 hrs

6. Optimisation methods for future and conclusions

A two channel photometer is to be used so that the sky variations can be continuously monitored. Runs are to be conducted around magnetic maxima wherever available, so that chances of discovering pulsations are improved. The gaps between runs are to be varied in order to identify null results. If 500 stars are to be surveyed with atleast 5 hours of observation on each object, and taking into account the current rate of telescope time allotment, the complete survey will take about 5 years to be completed.

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