ASTEROSEISMOLOGY WITH SMALL TELESCOPES

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ABSTRACT. Study of the solar interior through analysis of solar oscillations, a field now referred to as *helioseismology*, has generated interest in the development of *asteroseismology*, the study of the interior of pulsating stars through the analysis of their oscillations. Some progress has been made in the study of the Rapidly Oscillating Ap stars, cool magnetic Ap stars which pulsate in high overtone, low degree non-radial p-modes with periods between 4 and 15 minutes. Since all of these stars found so far are bright ($V < 10$), their light variations can be studied with small telescopes; most of the work done has been with a 0.5-m telescope. Their light variations are extremely complex, however, which means that they must be intensively observed, something which can only be done with small telescopes. Due to aliasing problems, multisite observing programs of the Rapidly Oscillating Ap stars are often necessary in order to decipher their frequency patterns. A collaborative observing program is suggested.

Daily aliasing is a problem in observing all of the Rapidly Oscillating Ap stars so that collaborative observing projects from more than one observatory are always desirable. For some of them, it is mandatory. HR 1217, for example, oscillates in at least five independent modes which just happen to be separated by about 3 day^{-1} (Kurtz 1982, Kurtz & Seeman 1984, Kurtz, Schneider & Weiss 1985). Each of the frequencies associated with these modes is amplitude modulated with the rotation period of HR 1217, 12.4564 day. According to the oblique pulsator model, each of these pulsation modes will be split into a triplet (for an $\ell = 1$ mode), a quintuplet (for an $\ell = 2$ mode), a septuplet (for an $\ell = 3$ mode), etc. In order to disentangle all of these frequencies in the amplitude spectrum of HR 1217 and determine the spherical harmonic degree of the oscillations, it will be necessary to obtain observations over two consecutive rotation cycles from at least two, and preferably several, observatories well spaced in longitude. HR 1217 is at $\alpha = 4$ hr, $\delta = -12°$ which means that it transits at midnight in late November and can be observed from both northern and southern hemispheres, although southern hemisphere observations will clearly be more easily made.

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I plan to observe this star from Sutherland during the period from 11 November to 8 December 1986 and would like collaboration from as many other observers as possible. In particular, observations from Chile and Australia and/or New Zealand are particularly desirable. Because of the very short southern hemisphere nights (7 hr) at that time of year, and because of the possibility of cloudy weather, observations from all other observatories at all longitudes are desirable. The 60-cm telescope on Mauna Kea is particularly well situated for this project as it is at a longitude of only 20°N and is nearly antipodal to South Africa. Observations from Kitt Peak, McDonald, the Canary Islands, and Israel would also be most useful. All of these observatories have small telescopes for which observing runs of two to four weeks are possible.

All observations of HR 1217 will be made using continuous 20-s integrations through a Johnson B filter with pulse counting photometers. Interruptions for sky observations should be made as often as necessary; I observe the sky background often enough that the change from one sky observation to the next is never more than 0.1 to 0.2% of the count rate on HR 1217. Since HR 1217 has V = 6, this is not much of a problem even during full moon. Observations should always be made with diaphrams of 30 to 40 arcsec. Because of telescope tracking errors, vibrations in the telescope due to wind, seeing, and scintillation, the diffraction spikes and rings (which the observer cannot see in the telescope eyepiece) may spill off the edge of the diaphragm with smaller diaphragms. Photometry of the accuracy shown in the light curves in this paper is difficult or impossible to obtain with the use of small diaphragms. Furthermore, for bright stars like HR 1217 there is no need whatsoever for using a small diaphragm; sky background is not a major problem.

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DISCUSSION

Kumar: Myron Smith at KPNO has looked at line profile variations for B stars. Has anyone done that for this type of project?

Kurtz: Various people have tried but without success. Typically the amplitudes are a few thousands of a magnitude (maybe a factor of ten less). The profile variations are going to be very subtle. That job needs to be done with a big telescope.

Djorgovski: CCDs are, of course, redundant for high-time-resolution photometry. A good way to do it would be with a Runicon or some other microchannel plate imaging detector. Then you can save only the parts of the frame which are of interest: the main target star, and the comparisons. Then you can do relative photometry, PSF fitting, and improve on accuracy.

Kurtz: I agree, that's the way in the future.

Finkenzeller: Could you comment on which filters you used, and how the filter band-width would affect your signal strength and signal contrast?

Kurtz: The observations were taken in the Johnson B filter. I have looked at these objects in U, B and V. The amplitude in U and B is approximately the same but it is substantially down in V. The important thing is that there is a phase shift U to B to V (in the most extreme case it is 60°). You would get better observations with narrow band filters but the universality of Johnson B enables intercomparison of results from different observations. One at least wants a filter bandpass centered near that of B.

Sterken: If you look for monitoring from different sites, would it not be wiser to use a filter with a narrower bandpass (for example Strömgren b or v) than Johnson B?

Kurtz: Some problems with these : 1) b is ~ 300Å redward of B and amplitude is dropping very fast, 2) for fainter stars and small telescopes one will run into photon problems and 3) v is contaminated by the strong (and variable) Sr II 4077Å line which is stronger than Hδ (4101Å).

Sterken: Maybe some specialized narrow-band filter should be produced and distributed to observers (or observatories) in South Africa, Chile, Australia and New Zealand.

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