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NEW LIMITS ON THE INSTABILITY STRIP OF THE HRD: OBSERVATIONS FROM A NORTHERN SKY SURVEY OF Ap STARS FOR RAPID VARIABILITY

Matthew J. Nelson
Dept. of Astronomy, University of Wisconsin, Madison, Wisconsin.

Tobias J. Kreidl
Lowell Observatory, Flagstaff, Arizona.

ABSTRACT The search for pulsational variables that occupy the hotter realms of the instability strip in the Hertzsprung-Russel diagram (HRD) have been traditionally restricted to the regions where models indicated that pulsation is tractable. Recent surveys of stars have revealed, however, that stars that were thought not to lie in the instability strip do indeed pulsate. This raises questions about the extent of the instability strip.

While this has implications for all hot pulsating stars, we use here primarily our survey results of Ap stars to compare with the models. We report results here from a high-speed photometric survey of 120 Ap stars that was conducted between 1985 and 1991 to search for rapid variability. The absence of pulsations in the hotter Ap stars (roughly B8-A3) is noted and deemed significant on the basis of the number of stars observed in this temperature range, as well as the overall quality of the data. This, however, does not preclude their existence, especially since HD 218495 was recently discovered to be a rapidly oscillating Ap (roAp) star (Martinez, Kurtz and Kaufmann 1991), and has a spectral type of about A3.

Color-magnitude diagrams of the survey stars are presented, with the known roAp stars included for reference. The diagrams are presented in the Strömgren and Geneva systems. The color-magnitude diagrams demonstrate the completeness of the survey in covering Ap stars at a wide range of temperatures. We find no obvious means of using color indices to differentiate roAp stars from non-pulsating Ap stars.

SURVEY RESULTS

The Geneva Color System

The Geneva [g] index seemed the most promising for selecting roAp stars from stable Ap stars. Figure 1 is the Geneva [g],Δ diagram. The [g] index is a temperature and luminosity indicator, while the Δ parameter provides a measure of the Balmer discontinuity. This diagram separates quite well the hotter SiCr stars from the cooler SrCrEu stars, which in turn overlap to some

extent the Am group. Although many roAp stars have unusually high [g] indices (around 0.2) one must point out that at least one survey star (β CrB) with a high [g] index was observed very intensively, and is apparently non-variable. In addition, for [g]$\leq$0.16, the roAp stars no longer stand out from the non-variable stars of our survey. Hence, we feel the Geneva [g],Δ diagram, while more encouraging than the others, still has its limitations.

The Strömgren Color System

Figure 2 shows the Strömgren [c1],[m1] diagram, and is included to provide a comparison of our results in the Geneva color system with another photometric system. In the Strömgren system the [m1] parameter is a metallicity/peculiarity indicator, and the [c1] parameter is a luminosity indicator. The roAp stars populate the lower right portion of the diagram. In this survey the [c1],[m1] color system does not show any distinction between the roAp stars and stable Ap stars. Many survey stars which show no variability overlap the region occupied by the roAp stars, tending to disagree with the color distinctions found by Matthews (1990) for this color diagram.

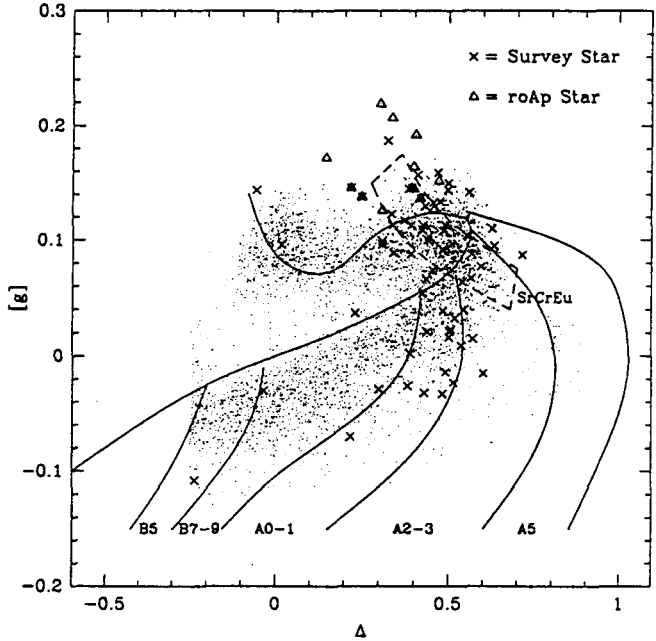

Figure 1. The Geneva [g],Δ diagram. Temperature ranges B5 through A5 are indicated on the diagram as adjacent bands. The part of the diagram populated by SrCrEu peculiarity stars is indicated as a dashed box. The Open symbols indicate stars from this survey, the closed symbols indicate known roAp stars, and the small dots are the stars in the Geneva system with colors in the same range as the survey stars.

CONCLUSIONS

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The primary result of this study is that various combinations of photometric indices, while pointing towards the roAp stars having the characteristic signatures of cool, SrCrEu stars, still fail to isolate the roAp stars from nonvariable Ap stars. Differentiating roAp stars from non-variable stars may be possible with spectroscopic studies, and a study of roAp and stable-to-oscillation stars via high-resolution spectroscopy should be undertaken to look for subtle signature differences. Matthews (1990) came to the same conclusion. About one week of observing time on a 2 meter class telescope should be sufficient for significant headway. Future photometric surveys should concentrate on cooler Ap stars, in particular the SrCrEu types.

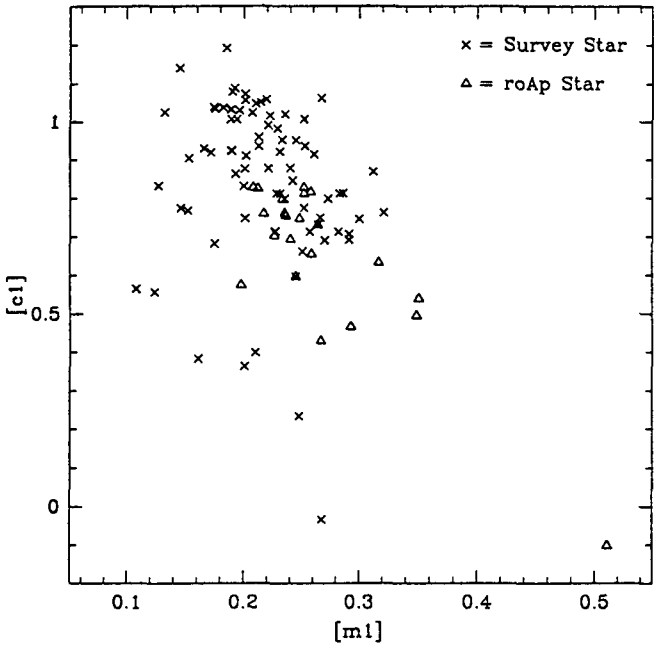

Figure 2. The Strömgren [c1],[m1] diagram. The symbols have the same meaning as in Figure 1.

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