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Search for White Dwarf Companions of Cool Stars  
with Peculiar Element Abundances

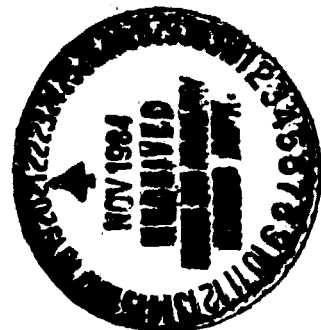
NSG 5398

Report for Period Autumn 1982-Autumn 1984

(NASA-CR-174030) SEARCH FOR WHITE DWARF COMPANIONS OF COOL STARS WITH PECULIAR ELEMENT ABUNDANCES Report, period Autumn 1982 - Autumn 1984 (Washington Univ.) 9 p  
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REPORT FOR NASA GRANT NSG 5398

Period Autumn 1982 - Autumn 1984

A. Search for White Dwarf Companions of Cool Stars with Peculiar Element Abundances.

Ba Stars

We have continued our search for white dwarf companions of cool stars with peculiar element abundances. One additional star ( $\xi$  Cet) was found to have a white dwarf companion. Several others, HR 1016, 56UMa, 16 Ser, were found to have high excitation emission lines indicative of a high temperature object in the system. Since these indications for high temperature companions were seen for all nearby Ba stars we concluded that it is highly probable that all Ba stars have white dwarf companions, and that the peculiar element abundances seen in the Ba stars are due to mass transfer.

Our observations, arguments and conclusions are given in the papers: "The Problem of the Ba Stars" (together with J. Nemec and Ch. Proffitt) in Ap.J. 278, 726, 1984 and in "On the Origin of the Ba Stars", IAU Synp. 105 in press.

Weak G Band Stars.

For the weak G band stars we did not see white dwarf companions. Together with C. Sneden and M. Parthasarathy we studied the Li and Be abundances and the chromospheric emission line spectra in these stars. The results are published in the paper "IUE Observations of Weak G band Stars" (with C. Sneden and M. Parthasarathy), Ap.J.

CH Stars.

No white dwarf companions were seen for subgiant CH stars.

## B. Stellar Chromospheres and Coronae.

The chromospheric Ly  $\alpha$  emission was studied in F stars with different metal abundances. It was found to increase with decreasing metal abundance in such a way that the total chromospheric emission appears to be independent of the metal abundances. The results were published in "An Attempt to Determine Stellar Ly  $\alpha$  Emission Line Fluxes for F Stars with Different Metal Abundances" (with J. Woods), Ap.J. 265, 331, (1983).

We have finished the observations and reductions of the chromospheric transition layer emission lines of binary early F stars in order to see whether rotation or binary nature has a strong influence on the emission of these early F stars. We are still trying to understand the observations, which unfortunately are all very noisy because of the high background radiation. Our general ideas and conclusions concerning stellar chromospheres, coronae and winds were summarized in a review article in Science: "Chromospheres, Transition Regions and Coronae", Science, 223, 777, 1984.

## C. Blue Companions of Cepheids.

Twenty-three cepheids were observed in order to see whether they have blue companions. For 13 of these blue companions were seen. For none of the Population II cepheids suspected to have companions were companions actually seen.

For the cepheids with main sequence companions the masses can be inferred from their effective temperatures, which can be determined from their relative energy distributions in the u.v. For the main sequence companions the masses are given by their effective temperatures. The companions either have masses not very different from that of the cepheid, or about 1/2 to 1/3 of the cepheid masses. The distribution seems to be quite similar to the one found for other binaries. Our results are summarized in a paper submitted to Ap.J.: "Blue Companions of Cepheids" (together with Ch. Proffitt).

For cepheids with giant companions (RW Cam, SV Per, AW Per, AX Cir) we know that they must have almost the same mass as the cepheid, because of the short evolution times for the giants. They should then fit on the same evolutionary track as the cepheid. We find that the cepheid is too bright even for the most favorable chemical composition. These results are also described in the above mentioned paper and in "Cepheid Companions and the Masses of Cepheids" (with S. Borutzki and H. Harris) IAU Symposium 105, 1983 in press.

For the low mass zero age main sequence companions distances can be determined from their absolute uv fluxes. These distances are as uncertain as the position of the ZAMS. A paper on this subject is in preparation.

For cepheids with known orbits and orbital velocities we can determine the ratio of the orbital velocities for Cepheid and companion. This ratio will determine the mass ratio of the stars. With the known mass for the main sequence companion we can determine the mass of the cepheid. These studies are still in progress.

#### D. Studies of the Young Cluster NGC 6530.

Together with P. Hodge we have finished a study of the HR diagram of NGC 6530, the interstellar extinction law in that cluster and the stellar wind properties. We find that the stars in this cluster are all very close to the main sequence. We also find that the interstellar uv extinction law is different for different stars. We are trying to find out what determines the IS extinction, is it the effective temperature or the position in the cluster? The observations are not yet finished. We have also studied the stellar wind properties in this cluster for stars with different effective temperatures. The results of our studies are summarized in a paper, "Ultraviolet studies of the Young Galactic Cluster NGC 6530" (with P.Hodge and D. Roggs), Ap.J., Dec. 1984.

## NGC 2100

For this young populous cluster in the LMC we also studied the position of the stars in the HR diagram. We did not see any indications that the evolutionary tracks are influenced by mass loss. We also did not see any indication of mass loss in the low resolution spectra. Comparing stars with equal  $L$  and  $T_{\text{eff}}$  in the galaxy and in the LMC we confirm a lower mass loss in the LMC. The results are given in the paper "Ultraviolet Studies of the Stars in the Populous Cluster NGC 2100 in the Large Magellanic Clouds" (with P. Hodge and C. Proffitt), submitted to Ap.J. A similar study for NGC 330 in the Small Magellanic Cloud is in progress.

## E. Studies of Population II Cepheids.

### HD 112374

We are studying the ultraviolet energy distributions of population II Cepheids. From the discontinuities at  $1700\text{\AA}$  and at  $2600\text{\AA}$  and the absolute intensities at  $1800\text{\AA}$  and  $650\text{\AA}$  we determine that  $T_{\text{eff}}$ ,  $\log g$ , and metal abundances. An additional metal abundance indicator is given by the broad Fe absorption feature at  $2400\text{\AA}$ . We have finished a study for the variable HD 112374, which was studied in the optical by Luck et al. We find reasonable agreement with their results. Our results are given in the paper "Ultraviolet Analysis of the Peculiar F Supergiant HD 112374" (together with Ch. Proffitt).

### ST Pup and W Vir.

We are applying the same methods of analysis to the Population II Cepheids ST Pup and W Vir. We find consistent results for ST Pup for which we obtain a very low metal abundance,  $\log Z/Z_{\odot} \sim -1.8$ . For W Vir different criteria give slightly discrepant results. These findings were represented at the NASA conference in the paper "Ultraviolet Observations of the Population II Cepheids St Pup and W Vir" in 'The Future of Astronomy Based on Six Years of IUE Research',

NASA Conf. Publ. (with C. Proffitt and G. Wallerstein).

$\kappa$  Pav.

Observations of  $\kappa$  Pav are still in progress.

A Publication List for the year 1982-1984 is enclosed.

- "Suggested U<sup>v</sup> Spectral Classification Criteria for A Stars", in:  
"Ultraviolet Spectral Classification" ESA SP-182, p. 121 (1982).
- "MgII K Emission Lines in Stars with Different Rotational Velocities and  
Metal Abundances", in: Proceedings of Harvard Conference on Cool Stars  
(1981).
- "The Interstellar Absorption Lines Spectrum of  $\mu$  Oph" (with J.  
Cardelli), Ap.J. 262, 213 (1982).
- "The MgII Resonance Line Emission at 2800A in Stars with Different  
Rotational Velocities and Different Metal Abundances", Ap.J. 258, 628  
(1982).
- "The Ultraviolet Continuous and Emission Line Spectra of the Herbig-Haro  
Objects HH2 and HH1", Ap.J. 262, 224 (1982).
- "An Attempt to Determine Stellar Ly Emission Line Fluxes for F Stars  
with Different Metal Abundances" (with J. Woods), Ap.J. 265, 331 (1983).
- "Ultraviolet Spectra of Herbig-Haro Objects and of the Environment of the  
Cohen-Schwartz Star" (with K.H. Böhm and J. Cardelli) in: Advances in  
Ultraviolet Astronomy, NASA Conference Publ. 2238, p. 223 (1982).
- "Chromospheric, Transition Layer and Coronal Emission of Metal Deficient  
Stars" in: Advances in Ultraviolet Astronomy, NASA Conference Publ. 2238,  
p.231 (1982).
- "Chromospheric, Transition Layer and X-Ray Emission for Stars with  
Different Rotational Velocities", in: Advances in Ultraviolet Astronomy,  
NASA Conference Publ. 2238, p.247.
- "Einstein Observations of Three Classical Cepheids" (with S. Parsons),  
Ap.J. 266, 171 (1983).
- "Ultraviolet Radiation from the Environment of the Cohen-Schwartz Star",  
Ap.J. Lett. 263, L35 (1982).
- "Cepheid Mass Determinations from the Companions of the Cepheids SV Per,  
SY Nor, RW Cam and KN Cen" (with S. Borutzki and H. Harris), submitted to  
Ap.J.
- "Chromospheres, Transition Regions and Coronae" (Review Article),  
Science, 223, 777, 1984.
- "IUE Observations of Weak G Band Stars" (with C. Sneden and M.  
Parthasarathy), Ap.J.,
- "The Problem of the Ba Stars" (with J. Nemeč and C. Proffitt), 278, 726  
(1984).
- "On the Origin of the Ba Stars", IAU Symp. 105, in press (1983).
- "Cepheid Companions and the Masses of Cepheids" (with S. Borutzki and H.  
Harris), IAU Symp. 105, in press (1983).



"Ultraviolet Studies of O and B Stars in the LMC Cluster NGC 2100, the SMC Cluster NGC 330 and in the Galactic Cluster NGC 6530" (with P. Hodge), in: Structure and Evolution of the Magellanic Clouds, eds. van den Bergh and K. de Boer (Dordrecht:Reidel) p. 59.

"Ultraviolet Studies of the Young Galactic Cluster NGC 6530" (with P. Hodge and D. Boggs), in press, Ap.J., December 1984.

"The Puzzle of the UV Continua of the Hyades Giants", Cambridge Workshop on Cool Stars, (1983), Lecture Notes in Physics 193, 273.

"The Ultraviolet Spectrum of a Strongly Reddened High Excitation Herbig-Haro Object", Ap.J., in press.

"Blue Companions of Cepheids" (with C. Proffitt), in: Future of Ultraviolet Astronomy Based on Six Years of IUE Research (FUAUIE), NASA Conference Publ., in press.

"Stellar Winds in the Young Galactic Cluster NGC 6530" (with P. Hodge), in: FUAUIE, NASA Conference Publ., in press.

"Ultraviolet Observations of the Population II Cepheids ST Pup and W Vir" (with C. Proffitt and G. Wallerstein), in: FUAUIE, NASA Conference Publ., in press.

"An Ultraviolet Study of the Star HD 112374 = HR 4912 (with C. Proffitt), in: FUAUIE, NASA Conference Publ., in press.

"The White Dwarf Companion of the Mild Ba Star  $\xi^1$  Cet (with C. Proffitt and H. Johnson), in: FUAUIE, NASA Conference Publ., in press.

"The Changing Ultraviolet Spectrum of Herbig-Haro Object No. 1" (with K.H. Böhm and E. Brugel), in FUAUIE, NASA Conference Publ., in press.

"Interstellar Absorption in Two Very Young Star Clusters" (with P. Hodge, D. Boggs and C. Proffitt), in: FUAUIE, NASA Conference Publ., in press.

"The HR Diagram for the Populous Cluster NGC 2100 in the LMC" (with P. Hodge and C. Proffitt), in: FUAUIE, NASA Conference Publ., in press.

"Properties of the White Dwarf Companion of  $\xi^1$  Cet" (with C. Proffitt and H. Johnson), ready to be submitted to Ap.J.

"UV Analysis of the Peculiar Supergiant HD 112374" (with C. Proffitt), ready to be submitted to PASP.

"Ultraviolet Studies of the Young Populous Cluster NGC 330 in the SMC" (with P. Hodge and C. Proffitt), in preparation.

"Ultraviolet Studies of the Stars in the Populous Cluster NGC 2100 in the Large Magellanic Clouds" (with P. Hodge and C. Proffitt), submitted to Ap.J.

"Metal Abundances and Effective Temperatures of the Pop. II Cepheids ST Pup, W Vir and Al Vir (with G. Wallerstein and C. Proffitt), in preparation.

\*The Ultraviolet Spectra of the O and B Stars in the Young Galactic Cluster NGC 6530 (with P. Hodge and Ch. Proffitt), Ap.J. 1984, in press.

Detection of a Compact Companion of the Mild Ba Star  $\xi^1$  Cet (with H. Johnson and Ch. Proffitt), submitted to Ap.J.

Blue Companions of Cepheids (with Ch. Proffitt), submitted to Ap.J.