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ELEMENTAL ABUNDANCES OF MERCURY-MANGANESE STARS AND THE POPULATION II A TYPE STAR HD 109995

National Aeronautics and Space Administration Grant

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Dr. David S. Leckrone, Laboratory for Astronomy and Solar Physics (Code 681), NASA Goddard Space Flight Center, is the co-investigator for this project. The purpose of our study is to combine ultraviolet and optical data for the HgMn stars ι Coronae Borealis and κ Cancri and the field horizontal branch Population II star HD 109995 and derive in a thorough self-consistent analysis the abundances of the elements in their photospheres. This work is a continuation of our earlier initiated project on the normal late B and early A stars, π Cet, 21 Aql, 134 Tau, ν Cap, o Peg, and θ Leo, which is still in progress and will provide a standard of comparison for these stars.

The IUE data for ι CrB and κ Cnc was obtained at the beginning of January 1985. The high dispersion images are being coadded and line identification studies will begin soon. Reduction of the optical region spectrograms should be completed during a visit to the Dominion Astrophysical Observatory in March 1985 with the completion of the optical region analyses a few months thereafter.

Much of the IUE data for HD 109995 was obtained in early summer 1984. The high dispersion images have been coadded and a line identification study was completed. The last IUE shift for this star will be on February 5. As soon as that data is available, a new coaddition will be performed and the line identifications, especially in those regions where the new images substantially improve the signal-to-noise, will be checked and revised as appropriate. Then Leckrone and I will submit for publication our manuscript "The Ultraviolet IUE Spectrum of the Population II Horizontal Branch A Star HD 109995".

Low noise optical region spectroscopic data of HD 109995 will be obtained in March and April 1985 if the weather cooperates. During my forthcoming visit to the Dominion Astrophysical Observatory, I have eight nights on their 48" telescope. My primary goal is obtain several 6.7 Å/mm IIaO spectrograms of HD 109995 and then coadd the resulting spectra to increase the signal-to-noise ratio. At Kitt Peak National Observatory in cooperation with Drs. Donald S. Hayes and A. G. Davis Philip, I will observe red and infrared C I, N I, and O I lines of several stars including HD 109995 with CCDs in the coude spectrograph of the 2.1-m telescope.

In the last few months, Leckrone and I have investigated several factors which affect the accuracy of abundances derived from IUE spectra including noise, gf- and line damping values, and the choice of model atmospheres. We studied noise in IUE high dispersion images by comparing individual images and our coadditions of normal stars. In well-exposed orders the amplitude relative to the total signal was 6% for fixed pattern and 4% for random noise. Further our coaddition procedure increased the signal-to-noise ratio by a factor of 2 compared with individual images. At the Tucson American Astronomical Society Meeting in January 1985, we presented a poster paper "Investigation of Random and Fixed Pattern Noise in High Dispersion IUE Spectra" (1984, Bulletin of the American

Astronomical Society 16, 903). We will shortly submit the results of our study to a refereed journal.

The choice of gf-values and for strong lines line damping constants affects the derived abundances. A standard assumption for optical region analyses that the line damping is ten times classical can lead to incorrect results. R. L. Kurucz in his current version of WIDTH, a computer program which determines the abundances given the model atmosphere, the equivalent width, and the atomic parameters, employs semi-classical approximations to calculate line damping constants. Only for a few species such as Fe II (Kurucz, 1981, SAO Special Report 390) have calculations been performed which permit one to use better approximations to the true damping constants.

Fe I and Fe II are key species in optical region abundance analyses as they have many lines. Often the deduced abundances are calculated for a range of possible microturbulent velocities. The value of the microturbulent velocity is chosen so that the derived abundances are not a function of equivalent width.

Last fall, Dr. J. R. Fuhr, National Bureau of Standards, completed a new critical compilation of Fe II values. I used these new values and damping constants derived from Kurucz (1981) to reevaluate optical region abundances from a dozen sharp-lined B and A stars. Whenever possible, I compared these values to those derived from Fe I lines, where the gf values came from a previous critical compilation by Fuhr, and are on the whole of slightly better quality than those for Fe II, and the damping constants were calculated using semi-classical approximations. The results from Fe I and Fe II lines are in slightly better agreement than as originally published with a slightly different set of gf-values for Fe II and ten times classical damping for both atomic species. Abundance analyses for all other atomic species were performed for all stars with the new microturbulent velocities and semi-classical approximations to the damping constants. The results will be contained in a forthcoming paper.

There are still some minor systematic trends in the optical abundances of the normal stars. Nevertheless, the results of optical region studies are useful as initial input parameters for ultraviolet region analyses. Analyses of ultraviolet lines in the same stars may help to illuminate the origin of the systematics. An abundance analysis of θ Leo based on optical region data and consistent with the reevaluated optical region studies just described has also been completed.

When the effective temperature and surface gravity are determined for optical region abundance studies, one often compares the predictions of model atmospheres of the appropriate metallicity with the optical energy distribution, often found by spectrophotometry, and a measure of a Balmer line, often the profile of Hγ. IUE low dispersion scans can be used to extend the range over which the energy distributions are known. By comparing this data with model predictions, the model parameters selected from optical data alone can be verified or perhaps refined. This was done for the six normal B and A stars of our earlier initiated project. Except for o Peg, the previously selected models were verified.

The first results for the normal stars for FeII λ2607 were presented at the Tucson AAS meeting in January 1985 (D. S. Leckrone and S. J. Adelman, "Elemental Abundances in Early Type Stars", 1984, B. A. A. S. 16, 973). The agreement with optical results was good. Some systematics are present, but more lines need to be studied to confirm them.

In the process of synthesizing the line profiles, the necessity for drawing the continuum in the same manner for all stars in our program became apparent. Thus Leckrone and I are planning to analyze the normal, HgMn, and the HB stars at the same time. We have selected preliminary models for ι CrB, κ Cnc, and HD 109995. As soon as we coadd the high dispersion exposures of these stars, we will include them in our abundance analysis program. Their abundances will be refined as soon as the optical abundances are completed. We will first complete the study of approximately 25 Fe II lines and then proceed to other important atomic species such as C I, N I, O I, and Zn II.