OBJECTIVE PRISM SURVEY OF THE OUTER GALACTIC HALO

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The aim of this survey is to locate samples of very distant field halo stars, to study the kinematics and metal abundance distribution in the outer regions of the galactic halo. Field halo K giants were chosen for the study, as they are intrinsically bright stars whose evolution is well understood. Halo K giants, near the tip of the giant branch and between 10 and 40 kpc from the sun, will have apparent magnitudes in the range $13 < V < 18$, and colours $(B-V) > 0.9$.

The distant halo K giants in this range of colour and apparent magnitude are greatly outnumbered by the nearby disk K dwarfs. Therefore a very efficient procedure is required to separate the two populations. The Mg b and MgH feature near λ5100 A is a good luminosity discriminant in the colour range $0.9 < (B-V) < 1.4$. It can easily be identified on medium resolution objective prism spectra. Our objective prism plates were therefore taken on hypersensitized IIIa-J emulsion with a Schott GG475 filter, to select the wavelength range from 4700 A (filter cutoff) to 5400 A (emulsion cutoff). This limited spectral range allowed longer sky limited exposures, to reach fainter limiting magnitudes. The short image length also reduces problems of image crowding, which is an important consideration when exposing to faint magnitude limits, even in high latitude fields.

Stars of the required colour range are first selected by photographic photometry, using direct IIIa-J + GG395 and IIIa-F + RG630 Schmidt plates. Locations, magnitudes and colours of all stars in a region are determined by scanning the full Schmidt plate on the Mount Stromlo PDS microdensitometer. Automated software has been developed to locate and estimate magnitudes and colours of all stars from these PDS scans. Although for practical reasons the digitising is done with a 50 micron square aperture, the images are centered to an accuracy of 7 microns and the standard errors of the measured magnitudes and colours are 0.07 and 0.10 magnitudes, respectively.

For automated analysis of the spectra, the individual objective prism spectral images of all stars located in our range of colour and

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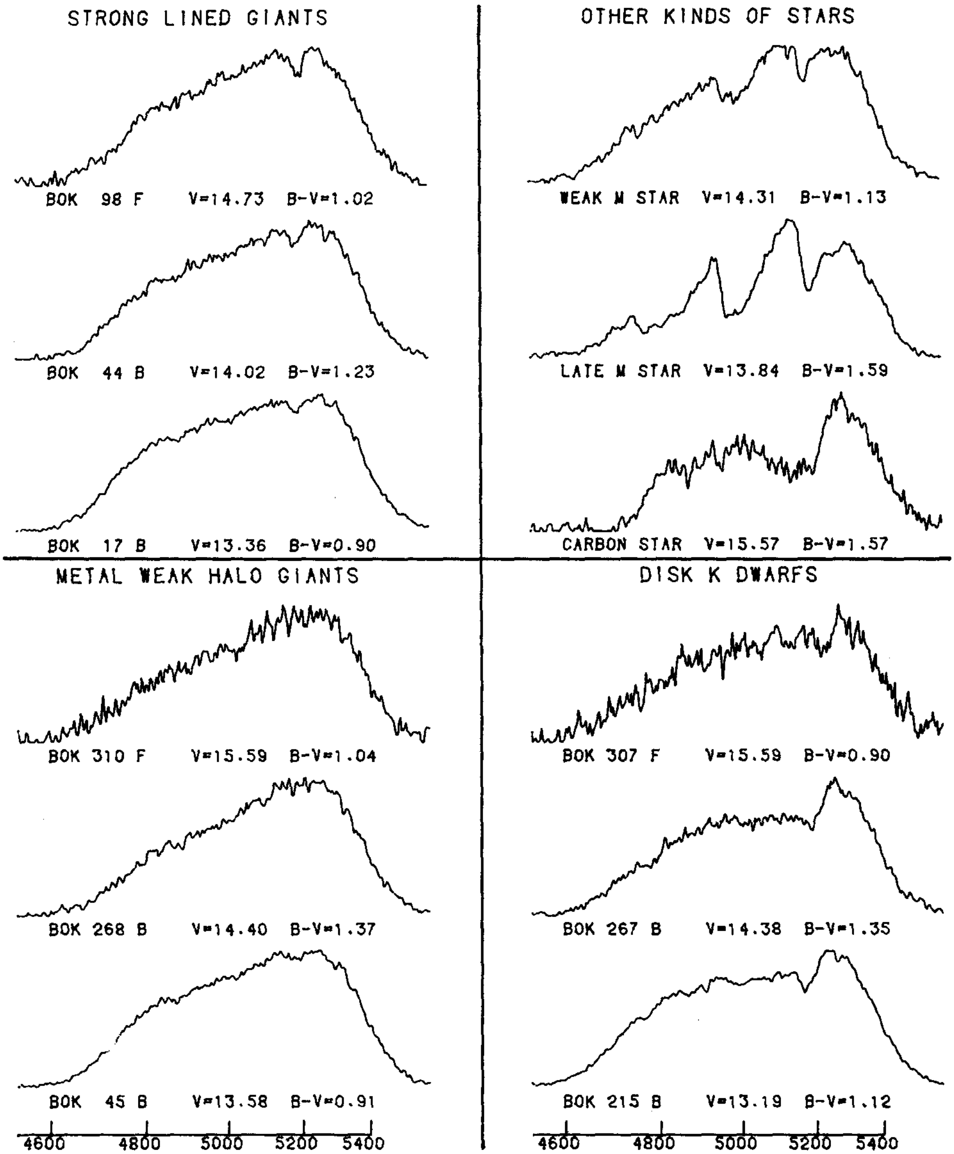

Figure 1. Plots of objective prism spectra, after image analysis. The vertical axis is intensity, on the instrumental system (arbitrary units). The nonlinear wavelength scale (A) is shown. The panels give three examples each of strong-lined giants, metal-weak halo giants, disk K dwarfs, and late-type stars, over the range of magnitude and colour as given. The differences between these stellar types are clearly visible, and form the basis for the classification procedure used in this survey. The spectra are from an ESO objective prism plate, 450 A/mm at Hγ, using IIIa-J emulsion and a GG475 filter.

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apparent magnitude are scanned on the PDS as 2D arrays. The image profiles perpendicular to the dispersion, for a few photoelectric standards in the field, are used to bootstrap a wavelength-dependent intensity calibration. The mean cross-sectional profile of these standards is also used as a template in the analysis, for integrating the intensity at each wavelength. This procedure is able to resolve any partly merged spectra, and also corrects for saturation in the brighter images. The software uses the maximum amount of useful information in the image, and therefore gives spectra with the best possible resolution. Spectral features which are not visible in the faint images, even at high magnification, are seen on the digital spectra after image analysis. Since the analysis of the PDS scan of the image is automated, it may be done online, and only the evaluated spectrum need be recorded for classification.

Figure 1 shows examples of spectra determined by this procedure. Qualitative classification from the digital plots turned out to be very efficient in identifying sufficiently large samples of halo K giants, so quantitative methods with automated spectral classification have not yet been fully developed.

Most of the objective prism plates used for this survey were taken with the ESO 1-m Schmidt in Chile (4-degree prism, dispersion 450 A/mm at Hγ). All the direct plates were taken with the UKSTU 1.2-m Schmidt in Australia, and also some objective prism plates (3-degree prism, dispersion 830 A/mm at Hγ). Plates of the northern fields have been taken for us with the 1-m Schmidt of the Tokyo Observatory at Kiso, Japan (2-degree prism, dispersion 800 A/mm at Hγ). The success of this survey is entirely dependent on the very kind cooperation of these Schmidt observatories, and we wish to take this opportunity to thank them.

We have completed surveys of about 20 square degrees in each of three fields (SA141, 189, 127) which can be easily observed from the southern hemisphere. Locations, magnitudes and colours of about 80,000 stars have been determined, complete to a limiting magnitude of V = 18. Objective prism spectra of about 6000 stars, with colours (B-V) > 0.9 and magnitudes in the range $13 < V < 16$, have been measured and classified. Two hundred metal-weak halo giants, between 10 and 40 kpc from the sun, have been positively identified in this survey, and are now being studied with slit spectroscopy, to measure their radial velocities and chemical abundances. About 400 giants with metal abundances similar to 47 Tuc have also been discovered. Two faint carbon stars with V = 15.5 were also found.

These automated survey procedures have been developed and used successfully to locate large samples of distant field halo K giants. The same procedures could be applied to make any other similar objective prism survey to faint magnitudes a practical and quick process.