radius which is comparable to the radius of the visible star, which is known from the brightness, temperature and distance of R 81. The width of the eclipses of the star with respect to the period then allows us to estimate the distance of both stars from each other and thus from Kepler's third law (with the period) the total mass of the system. We find a mass of about 35 $M_\odot$ for R 81. This result is in good agreement with the expectations for a luminous P Cyg star, but note that it is the first direct mass estimate for such a star. We note that this mass estimate is very uncertain so far and clearly more spectroscopy is needed in order to confirm this result.

Interestingly, the scatter around the mean curve of Figure 3 is only of the order of 0.05 mag. This means that also most of the smaller variability which we observed between the eclipses is due to the changing aspects of the observations and not intrinsic to the star. This result leads to the suspicion that also other variations of R 81, e.g. the spectroscopic variations of certain stellar wind lines, are not irregular but phase-dependent. An important point to clarify is also the nature of the secondary. No obvious secondary minimum is present, so the star must be visually faint. New spectroscopic observations of high quality and good phase coverage are badly needed.

The more general question is, of course, whether many P Cyg stars are binaries. Our finding certainly does not prove this. However, the small scatter around the mean light curve shows that R 81 intrinsically is at most slightly variable. If other P Cyg stars (which are observed to be variable with relatively large amplitude) are similar to R 81 in this respect, then the variability observed in these stars requires an explanation.

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Blue Horizontal Branch Field Stars in the Outer Galactic Halo

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1. Introduction

It is a well-known hypothesis that galaxies are surrounded by extended massive envelopes of "dark" matter reaching far beyond the visible edges of the galaxies. For our own Galaxy this hypothesis is supported by kinematical and dynamical studies of globular clusters in the outer Galactic halo.

The usefulness of globular clusters as test objects for probing the mass distribution in the outer part of the Galaxy is limited, however, for the following reason: The sample is small – the number of globular clusters with Galactocentric distances between 15 and 40 kpc, which can be used in a kinematical analysis, is 14. Furthermore, several recent remeasurements of globular cluster radial velocities have shown some of these to be substantially in error.

Lynden-Bell, Cannon and Godwin (1983) studied a sample of dwarf spheroidals situated at very large Galactocentric distances (~100 kpc). They found the objects to have quite low line of sight velocities (relative to the Galactic restframe) – the line of sight velocity dispersion was found to be ~ 60 km/s. Even if one assumes that the velocity distribution of these objects is isotropic, a mass of only $M = (2.6 \pm 0.8) * 10^{11}$ $M_\odot$ is inferred. This does not support the hypothesis that the mass of the Galaxy increases linearly with Galactocentric distance to distances $\geq$ 100 kpc.

In order to clarify further on the properties of distant halo objects we have identified and studied a sample of blue horizontal branch field (bhbf) stars in the outer Galactic halo ($r \leq 40$ kpc). The observations are described in section 2, and the results are discussed in section 3.

2. Observations and Data Analysis

We have carried out a search for bhbf stars at large Galactocentric distances. Part of the observations have been described in Sommer-Larsen and Christensen (1985 and 1986). The basic material was three stellar object catalogues, kindly provided by Drs. G. Gilmore and N. Reid. The catalogues cover three fields located at the SGP (l, b) = (38°, –51°) and (l, b) = (352°, 52°). In total the catalogues cover 54 square degrees of the sky, and they are complete to V = 18.5. By observing spectroscopically faint blue stellar objects drawn from these catalogues, using the selection criterion $0.0 \leq B\text{-}V \leq 0.2$, a sample of 131 bhbf star candidates have been obtained.

The observations were done with the ESO 2.2-m telescope during a number of observing runs in the period 1984–1986. The observational setup and procedure were the same during all observing runs: The detector system consisted of a Boller and Chivens spectrograph together with the dual Reticon Photon Counting System (RPCS) (Christensen et al., 1984). The two decker holes, each projecting down onto its own Reticon-array, corresponded to an area of $4*4$ arcsec^2. With a slit the aperture was reduced to 2 arcsec in the direction of dispersion. A 600 lines/mm grating blazed in the first order at 4200 Å was used yielding a reciprocal dispersion of ~1 Å per channel. The wavelength range covered was

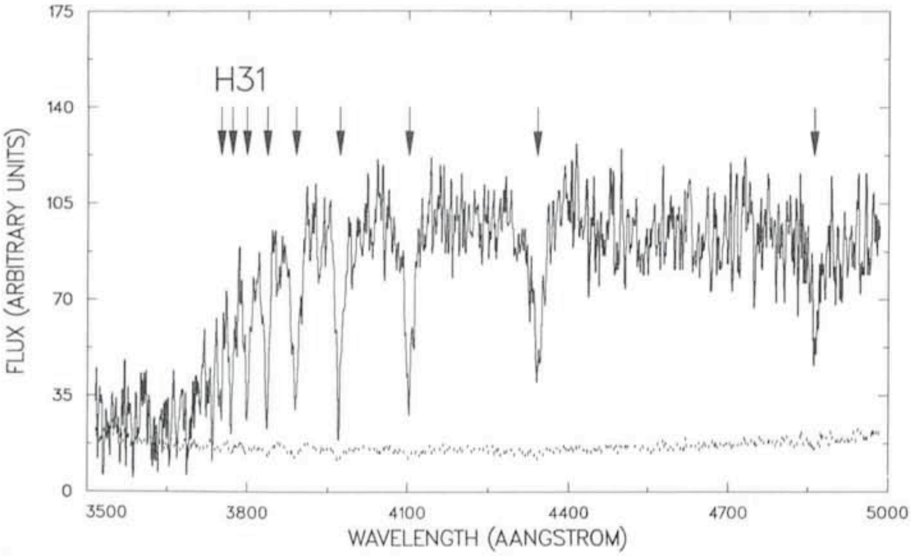

Figure 1: *Part of the spectrum obtained for the bhbf object H31. The full drawn curve is the flux spectrum. The dotted curve shows the 1 σ level due to statistics. The magnitude of the object is V = 18.4, inferring a heliocentric distance of 29.6 kpc. The exposure time was 2,700 sec. The arrows show the positions of the Balmer lines H 10 (3750 Å) to Hβ (4861 Å). The radial velocity of this bhbf star was determined to be 20 ± 20 kms^{-1}.*

3200–5500 Å. The intrinsic resolution of the RPCS detector with this dispersion was ~2.0 Å, but with the 2 arcsec wide slit, the resolution increased to 3.5 Å.

Each object was observed twice, focusing the object in the two decker holes subsequently. He-Ar calibration spectra were obtained after each pair of exposures. Every star which had an A-star type spectrum, and therefore was a potential bhbf star, was exposed until at least 100 (sky-subtracted) counts per channel had accumulated in the continuum in the centre of the array. No (double) exposure lasted more than 3,600 s. We were able to obtain such spectra for bhbf stars as faint as V = 18.7 with this combination of telescope and detector. Such stars are located at Galactocentric distances r ~40 kpc. A spectrum of a V = 18.4 bhbf star is shown in Figure 1.

Radial (line of sight) velocities were obtained using the correlation technique. The rms error was 20 km/s for the brighter stars, increasing to 25 km/s for the faintest stars.

Balmer line widths were used to get a rough estimate of the surface gravities of the bhbf star candidates. 116 of the 131 candidates could unambiguously be identified as bhbf stars. The remaining 15 may have too high surface gravities to be bhbf stars and are tentatively identified as field blue stragglers.

3. Discussion

An analysis of the data obtained gives the following results: The system of bhbf stars in the Galactic halo is quite round with an axial ratio q ~0.8. The density distribution out to the limit of the sample (r ~40 kpc) is well described by a power law with index ν ~−3. The system of bhbf stars does neither expand nor contract as would be expected for an old, well mixed system. It rotates, if at all, very slowly relative to a Galactic rest-frame: v_{ROT} = 10 ± 32 km/s assuming $v_{\odot}$ = 220 km/s. This is consistent with what is found in general for metal poor stellar subsystems in the Galaxy. There are indications that the velocity distribution of bhbf stars is peaked in the radial direction (towards and away from the Galactic centre) everywhere in the inner Galactic halo.

The observed spatial and kinematical properties of the system of bhbf stars in the outer Galactic halo can be modelled without assuming that the Galaxy is embedded in an extended, massive halo characterized by an approximately flat rotation curve to r ≥50 kpc. If the Galaxy is embedded in such a massive halo then the motion of bhbf stars in the outer Galactic halo must be predominantly tangential (low eccentricity orbits). This contrasts with what is found for halo stars in the inner Galactic halo and tells us something about early Galactic history. It certainly does not support a rapid collapse picture for the outer Galactic halo. It may suggest that the bhbf stars in the outer Galactic halo were formed out of turbulent gas rather than out of gas with small macroscopic motions.

Our study of the inner and outer Galactic halo is by no means complete. Observations of bhbf stars in considerably more fields probing other parts of the Galactic halo would be of great interest in the light of the results obtained so far. Such observations are planned.

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And then there were Three . . .

At the end of the article about the recovered minor planet MALLY (*Messenger* **46,** 11), the five remaining 'lost' minor planets were enumerated. Readers of this journal may be interested to learn, once more, that things move fast in astronomy nowadays, not only in front-line areas of high energy astrophysics, but also in the classical backwaters of celestial mechanics.

By early February 1987, two more lost minor planets had been 'shot down'. Persistent efforts by Mr. Syuichi Nakano, who is spending one year at the IAU Minor Planet Centre in Cambridge, Mass., lead to the identification of (1026) INGRID with a minor planet observed in early 1986. He sent the resulting orbit to ESO, where no less than six further images of this planet were found on plates in the plate library.

The remeasurement at ESO of the original 1901 Heidelberg plates of (473) NOLLI, lost since that year, showed that the published positions were somewhat in error (one by more than 30 arcseconds). Based on the improved measurements, Dr. Brian Marsden, who heads the Minor Planet Centre, was able to find identifications with minor planets, observed in 1940, 1981 and 1986. Three additional images were found in the ESO plate library, definitely confirming these identifications.

So, now there are only three left . . . (there are rumours that some of the MP-people are busy).