The Bulge-Halo Transition Region

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Abstract.

The Baade's Window bulge is a metal-rich, rotationally supported entity, whereas the solar neighbourhood halo is metal-poor and non-rotating; what is the connection between these two spheroid components?

We present results of a spectroscopic survey of 847 K-giants from 3 low absorption windows at (5,-12), (-5,-12) and (-25,-12). This is a seven times larger sample than has been previously studied in this region.

Key words: Galaxy - Structure - Bulge - Halo

The bulge is in several ways very different from the halo: it is predominantly rotationally supported, it is metal enriched, non-axisymmetric and exhibits a steep density distribution; in contrast the halo is pressure supported, metal poor, axisymmetric and has a shallower density distribution (Gilmore 1989).

We wish to determine whether these two components are indeed separate entities or just different regions of a spheroid whose attributes vary in some smooth way from the centre of the galaxy to beyond the solar neighbourhood. This, apart from letting us discover the Galaxy's appearance, may well shed light on the nature of its formation, and the physical processes involved in the formation of spiral galaxies in general.

There have been many studies investigating the inner bulge of the Galaxy (mostly Baade's Window), the minor axis (Blanco et al) and the halo. However, surprisingly few data have been published on the intermediate region between the bulge and the halo. It is interesting to point out that it is this spheroid region that is easiest to observe in external galaxies (Kormendy et al 1982), where halos are too dim and inner bulges too heavily obscured.

Three low absorption regions of approximately half a degree in diameter at (5,-12), (-5,-12) and (-25,-12) were selected for observation. UK Schmidt-Telescope plates of these regions were scanned using the APM facility at Cambridge, giving a complete sample for $14 \leq m_V \leq 16$, $1.1 < (B-V) < 2.0$. This selction window was chosen so as to find K-giants in the galactic bulge region.

Spectra of 847 candidate K-giants were observed with the AUTOFIB + IPCS configuration at the AAT. Radial velocities were calculated by crosscorrelation with standard radial velocity star spectra. Figure 1 shows the resulting radial velocity distributions.

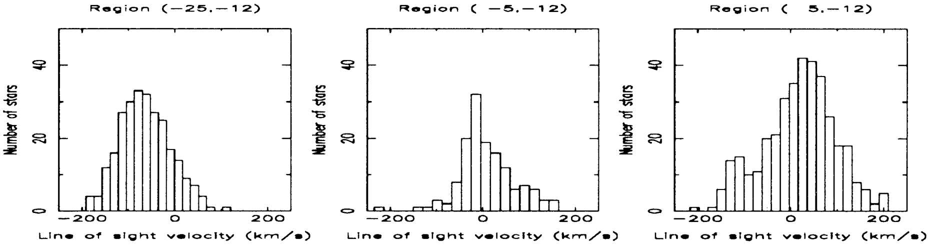

Fig 1 Observed line of sight velocity distributions.

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To investigate the contribution of the disk, halo and thick disk and the effect of our selection criteria on the velocity distribution, we constructed a galaxy model which calculates the expected number of stars down a line of sight and the velocity distribution associated with these.

For the bulge we assume a gaussian velocity distribution along each of the familiar (u,v,w) axes. The total line of sight velocity distribution is calculated by summing the velocity distributions projected onto the line of sight of the stars found in each distance bin:

$$K(v) = \omega \int_0^\infty \sum_{\substack{spectral\\classes}} \left(\sum_{m=m_1}^{m_2} \Phi[M,S] D_S(r) r^2 \frac{e^{-\frac{(v-\bar{v}P_L)^2}{2\sigma_L}}}{\sqrt{2\pi}\sigma_L} \right) dr$$

where v is velocity, Φ is the luminosity function, $D_S(r)$ is the relative density of spectral class S, ω is the solid angle viewed, r is the distance along the line of sight, P_L is a projection of v onto the line of sight, C is stellar colour and $R(r)$ is intestellar reddening.

The integrand is put to zero at those values of r where the apparent colour lies outside the observational colour bounds: $(B-V)_1 \leq C - R(r) \leq (B-V)_2$.

The course we take is to insert into the model all the necessary relations and parameters pertaining to the disk, thick disk and halo. For the bulge we assume a luminosity function and colour-magnitude relation, and guess functional forms for the bulge geometry and velocity distribution.

Assuming the model to be correct, we compute the most likely set of bulge geometry and velocity distribution parameters using the maximum likelihood method given our observational data. We minimise the model's likelihood function using an amoeba-simplex routine (Press et al 1989). The robustness of any resultant parameter set is then tested by 'bootstrapping'.

We are in the process of examining our model parameter space, and as yet have no firm preference for a particular set of bulge parameters. However, it is clear that the data is inconsistent with a galaxy model being either axisymmetric or having a single bulge component with a density distribution of scale length 200-400 kpc.

1. Conclusions

We have reduced a large sample of K-giant stars away from the minor axis in the region 1.8-3.7 kpc from the galactic centre. We hope this data set will offer a significant contribution to the understanding of the halo-bulge connection. A star-count and kinematic model has been written to understand our results. Work is currently in progress to find which sets of bulge parameters are most likely to be consistent with the data.

References

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