Blaauw: With reference to the rich A-type population at 800–1000 pc which Professor Bok pointed out: if we photographed the Galaxy from a distance in the blue, would this concentration contribute so much to the light that one would see it in the spiral features, leading to a different picture of the system than that of the OB stars?

Bok: This is quite possible, but *UBV* photometry would make it possible to distinguish between concentrations of A stars and OB stars.

Blaauw: This may well affect our interpretation of other galaxies.

Graham: I would like to emphasize the great amount of work that needs to be done on the faint OB stars in the Vela–Puppis region. Professor Bok has already pointed out the great distances to which we see in this direction because of the comparatively low absorption. Some hundreds of OB stars in these fields have been picked up by the Tonantzintla workers, and we at Stromlo have observed no more than a dozen of these. I feel that more extensive studies in these regions would be very useful.

37. RADIAL VELOCITIES AS A GUIDE TO SPIRAL STRUCTURE

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Four main methods of delineating spiral structure in the Galaxy have been developed in the past 10 years.

(1) Morgan and associates used spectroscopic distances of clusters and associations, particularly those in HII regions, and showed that the further set was strung along what is now known as the Perseus arm.

(2) The Leiden and Sydney workers extended the survey to very great distances through the 21-cm observations. Here of course the distance scale depends intimately on a velocity model for the Galaxy.

(3) Münch's (1957) studies of double and multiple interstellar lines gave strong support to the existence of the Perseus arm, with CaII and NaI concentrated in the arm.

(4) Courtès' interferometric velocities of diffuse nebulae is an optical analogue of the 21-cm approach, with a bias towards the nearer nebulae on account of the absorption at optical wavelengths.

Münch's approach has advantages in the inner portion of the Galaxy since the light-path is limited by a distant star whose distance may be determined, while the 21-cm observations are unlimited in depth, and distance determination can easily be subject to serious ambiguity.

The Radcliffe coudé spectrograph, operating at 6·8 and 15·6 Å/mm, has been used for investigating structure in the H and K lines of distant OB stars. Thackeray (1956) already reported (before the first publication of the Sydney 21-cm results) a few spectacular cases of doubling (particularly in Norma) discovered with the Cassegrain spectrograph operating at 19 Å/mm at K. These results have been expanded and refined with the coudé spectrograph, but progress is necessarily slow on account of the difficulty of detecting strategic stars.

Figure 1 shows eight cases of double CaII between $l^{\mathrm{II}} = 328°$ and $27°$. The low-velocity components correspond of course to gas close to the Sun. The high-velocity components (usually somewhat weaker) lie along the dashed line which

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corresponds approximately to $\Delta\omega = 17 \cdot 7$ km/sec.kpc, *if one attributes the velocities entirely to galactic rotation.* With the standard Leiden model this would correspond to a circular arm lying $3 \cdot 3$ kpc nearer to the galactic centre than the Sun.

The greatest weakness in this argument (which is common to all descriptions of spiral structure from gaseous radial velocities) arises from the expansion of gas about O associations which appeared in Münch's (1957) work. In the two southern

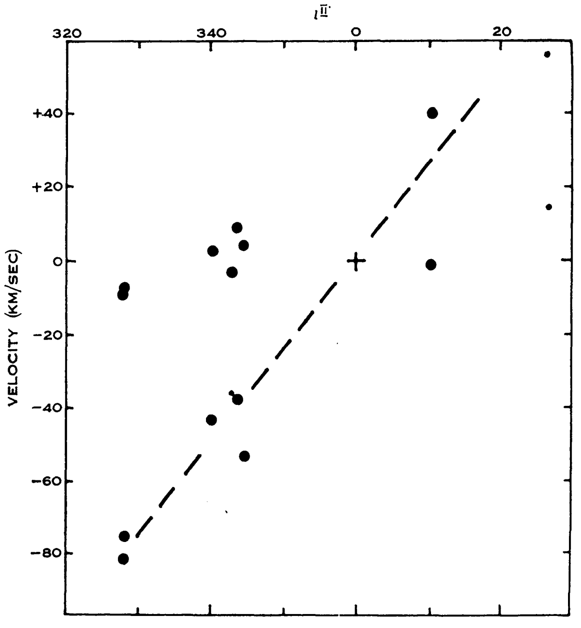

Fig. 1.—Double K velocities, $l^{II} = 320 - 30°$. Each star has two K components whose velocities are plotted in pairs at the same longitude. Small circles carry half weight. The cross at (0, 0) fits the linear interpolation for the high-velocity components.

stars with greatest separation of interstellar lines (142468, 142565) and with very strong V components, the stellar velocities are considerably smaller than those of the V components. Thus expansion of the gas is indicated, but it so happens that around these two stars there is no known O association or HII region. The small (barely resolved) separation in 173987 at 27° would also suggest expansion of gas near the star.

If one accepts these observations as indicating concentration of gas in a spiral arm it is possible that this is identical with the Sagittarius arm containing the OB stars discovered by Morgan and associates. Further, it might be considered that since the linear interpolation passes closely through the origin the gas in this arm has no appreciable radial velocity component, in contradiction of Kerr's (1962) model of expansion (which would predict -10 km/sec relative to the solar neighbourhood at 3 kpc from the Sun). However, one cannot rule out Kerr's model from these few observations without much more data on distant stars towards the galactic centre.

As has been stressed before, the inner arm seems to stop abruptly at 328°; distant stars at somewhat smaller longitudes have failed to reveal double lines although conditions are very favourable for resolution. There seems to be other good evidence that at this longitude we begin to see an inner arm tangentially; the Sydney observations show an arm here (admittedly further away than the optical observations suggest), Mills' observations of the continuum show the biggest step of all at this longitude, and Elsässer's photometry of the Milky Way also supports the idea.

Finally, to revert to stellar radial velocities, Figure 2 shows a histogram of residual radial velocities in the restricted longitude range 324 to 336°, compared with the Sydney 21-cm profiles for this region.

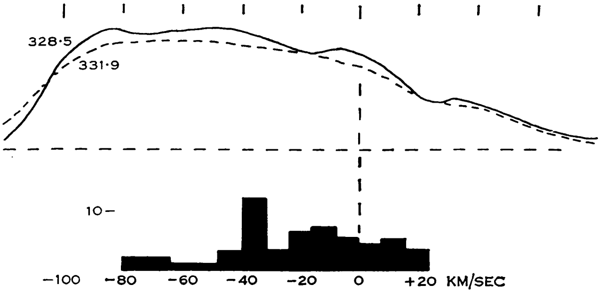

Fig. 2.—Comparison of distribution of 21-cm velocities (above) and stellar velocities (below) near $l^{II} = 330°$. The stellar histogram is based on 54 stars ($l^{II} = 324 - 336°$) divided in groups of 8 km/sec range.

There is a strong concentration of stellar velocities near −40 km/sec, perhaps corresponding to the middle of the three shallow radio peaks, and a very vague suggestion of another stellar peak at −64 to −80 km/sec (where observational selection must be serious).

Radial velocities are available for a considerable number of stars towards the galactic centre with computed distances between 4 and 8 kpc, and these define a galactic rotation curve very similar to that already displayed by the high-velocity CaII components in Figure 1. It seems probable that these stellar distances are overestimated. The stars may in fact lie on a spiral arm about 3 kpc from the Sun, but they are faint and it has not yet been possible to study the interstellar lines in them at high dispersion.

The need for observations of more stellar radial velocities in the range 60 to 100 km/sec is clear, and I would like to appeal to Dr. Fehrenbach's group to discover them in this part of the sky by the objective prism method.

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Discussion

Graham: In the immediate region of the star HD 142468, where Dr. Thackeray finds the very high interstellar line velocities, Professor and Mrs. Bok and I have studied about 20 O and B type stars. As Professor Bok has already stated, we find two concentrations, one at 870 pc and another at 2000 pc. The former group has a relatively small average colour excess of 0·2 magnitudes in $B-V$ whereas in the latter an average excess of 0·8 magnitudes is found. Since this latter group contains the star HD 142468, I would like to ask Dr. Thackeray whether he thinks this strong interstellar absorption in this region is significant.

Thackeray: We have found in the distant stars here that there is well-marked λ4430 interstellar absorption. However, none of these stars show strong double interstellar calcium. This is rather remarkable.

Buscombe: The radial velocities of the early-type supergiants HD 148937 ($l^{\mathrm{II}}=337°$) and HD 150898 ($l^{\mathrm{II}}=331°$) are both -53 km/sec. Photometric distances of 1300 pc seem indicated.

38. ON THE COMPARISON OF SPIRAL STRUCTURE AS DELINEATED BY GAS AND BY STARS

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In an earlier article* it was pointed out that the galactic radial motions $\Delta E\ (R, l)$ of the very young stars did not show the uniformity of motion to be expected from a smooth regular expansion of the Galaxy. Instead, the very young stars were found to show large-scale regional peculiar motions; these regional peculiar motions are displayed in Figure 1. In addition to regional peculiar motions and the space distribution of stars, Figure 1 also shows the spiral structure delineated by neutral hydrogen gas. As is customary in such diagrams, the space distribution of gas and the space distribution of the stars are not in good agreement. As various investigators have mentioned, stars and gas appear to define different spiral arms. However, such a conclusion is not warranted by data such as those employed in construction of Figure 1. In Figure 1 (as is invariably the case in earlier published diagrams of the same sort) two distance scales have been employed in the construction of the diagram. The distances of the stars have been derived from photometric data; the distances of concentrations of neutral hydrogen gas have been derived from measured hydrogen gas radial velocities and a galactic rotation curve. It should therefore come as no surprise if there are disagreements between hydrogen spiral arms and star spiral arms. Any regional peculiar motion of a gas concentration directly becomes an error in the inferred distance of the gas concentration.

Ideally, one would wish to retain the photometric distance scale of the stars, which should be reasonably accurate, and improve the kinematic distance scale of the gas, which is subject to the uncertainties caused by regional peculiar motions. Unfortunately, this is not possible. We have no way to estimate the specific peculiar motion of any particular concentration of hydrogen and thus to determine the error in its kinematically assigned distance. However, we can estimate the peculiar motion

* This volume, paper 23.