*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 ($l^{II}=337°$) and HD 150898 ($l^{II}=331°$) 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

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of any group or concentration of very young stars. As examples of the size of distance errors to be expected in the kinematic distance scale, we have, in Figure 1, drawn two heavy arrows to indicate the errors that would have been made in the distances of two important stellar concentrations if their distances had been determined from their radial velocities. On the basis of a kinematic distance, each group centred on the tail of an arrow would move to the head of the arrow.

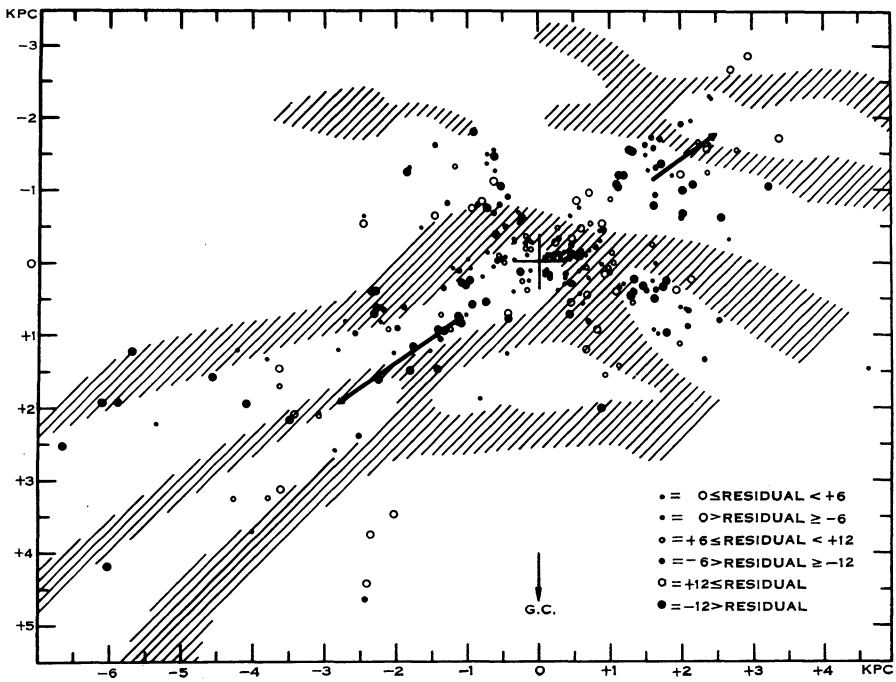


Fig. 1.—The distribution of very young stars in the galactic plane with their large-scale regional peculiar motions indicated. The cross hatching shows spiral structure as indicated by neutral hydrogen on the basis of work by F. J. Kerr.

Various lines of evidence indicate that related star groups and gas concentrations have highly correlated radial velocity values. We may expect the errors in the distances of gas concentrations to be quite similar in size to those illustrated in Figure 1 for the stellar groups. In fact, if we reverse the arrows in Figure 1 and move the gas, in which the heads of the arrows are imbedded, to the tails of the arrows, a procedure which implies equal peculiar motion for gas concentration and star group, we note that the appropriate concentrations of gas would move to positions much closer to the presumed related star groups. With application of such corrections to the picture of gas concentrations in general, gas and stars might appear much more closely related than is indicated in the figure as originally drawn.

The purpose of these remarks is not to suggest complete spatial coincidence of gas and star concentrations; there is no reason to expect such perfect coincidence. The purpose is, rather, to call attention to the dangers in comparing diagrams of gas

spiral structure and star spiral structure when the distance scale of the gas is kinematic and the distance scale of the stars is photometric. When such inhomogeneous distance scales are employed, discrepancies in the derived space distribution of the stars and gas may be expected even if, in reality, they were in perfect agreement.

*Discussion*

*Burke:* Our observations of M31 showed that agreement of bright star arms with hydrogen maxima was close for only about half of the cases. Therefore, all discussion of distance scale apart, if one tries to force agreement between hydrogen arms and bright star arms there is 50% chance that one is trying to make a coincidence where no coincidence exists.

*Weaver:* I quite agree, and I am not suggesting that allowing for differences in the distance scales is a universal panacea. We do not and probably should not expect to find agreement in all cases between stars and gas. My point is that if we use inconsistent distance scales we shall never find agreement between stars and gas even in those cases in which it exists.

*Courtès:* In finding a relation between the two distance scales I use one common point, that is the HII regions. When you obtain the same velocity for the 21-cm line, the H$\alpha$ line, and the K line, it is obvious, or at least very likely, that the exciting star responsible for the HII region emitting H$\alpha$ belongs to the same gas spiral arm.

*Weaver:* Do you find good agreement between the radial velocity of the star and of the HII region?

*Courtès:* This agreement is mainly between the different components of the interstellar matter — HI, HII, and K or Na lines — but often the radial velocity of the star is also in good agreement with these velocities. This is especially true for the Perseus arm.

*Parijsky:* I have two remarks on Dr. Thackeray's and Dr. Weaver's papers.

1. A new possibility for distance scale measurements arises when we compare the brightness of HII regions in H$\alpha$ or H$\beta$ with that in the radio continuum. The main difficulty is to ascertain the distribution of dust along the line of sight (cf. *Izvestia Glavnoi Astron. Obs. Pulkovo, U.S.S.R.* **21**: 54–61 (1961) ).

2. There is some difficulty when we try to apply the 21-cm absorption method to the very bright nebulae, owing to high absorption at the centres of the nebulae. In such cases the method gives the wrong result.

*Bolton:* 21-cm absorption measurements on emission nebulae possibly form the best meeting point between the two methods of determining distance scales in the nearby regions of the Galaxy. Radio telescopes of the size of the 210-foot can possibly detect absorption features in 100 emission nebulae.

*Tifft:* Regarding the correlation between optical and radio structure, one should not neglect to consider the distribution of dark absorbing material with distance. Since dust and gas can be expected to occur together we can expect a reasonable correlation. From three-colour photometry of stars — both OB stars and *general* field stars — we can determine individual absorptions and map the absorption field in depth to some degree of accuracy.

## 39. AN INFRARED SURVEY OF THE SOUTHERN MILKY WAY

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*Introduction*

The determination by optical means of the galactic structure at great distances from the Sun is becoming more and more important. Most optical investigations, using ordinary techniques — objective-prism survey in the blue spectral region $+UBV$ photometry — do not reach very far out owing to the heavy obscura-