DISCUSSION

Bok. Is there any information on the concentration of H I in these very dark regions?
Herbig. We have no new information, and hence did not consider the point.

10. LARGER-SCALE PHENOMENA IN DISTRIBUTION AND MOTIONS OF STARS AS COMPARED TO THOSE OF THE GAS

Th. Schmidt-Kaler

The term 'larger scale' serves as a contrast to structures with dimensions of the order of 100 pc, but should remain within the local domain, that is within 2-3 kpc distance from the Sun. Within this domain we know of only one dominating structure, the spiral filaments of our Galaxy. Apparently optical work in the last 2 years leads to a consistent, unified picture of this structure within the local domain.

First, let me give a short review of the methods for determining spiral structure in our Galaxy:

1. *Position and distance*. The most direct method, applied to individual spiral tracers (H II-regions, early-type clusters, associations) and in stellar-statistical investigations (OB-stars, selected fields). In a modified version it can be applied to H I-absorption-lines on thermal sources and to calcium-emission-lines in distant stars by simple *ordering* along the line of sight.

2. *Position and intensity:* looking along a spiral feature we expect to observe intensity (or frequency) maxima. Applied to the surface photometry of the Milky Way, to the thermal radio emission continuum and the frequency distribution of distant objects (M-giants, WR-stars).

3. *Position and direction* (form of dark clouds and details in emission nebulae, interstellar polarization of star-light, measurements of magnetic fields in the Galaxy). The interpretation is not so straightforward as in the first two methods.

4. *Position and velocity* (interstellar calcium-lines, radial velocities of distant OB-stars and supergiants, interferometric velocities for faint emission nebulae, and especially the analysis of the 21 cm-line-profiles). This method implies knowledge of a dynamical model of the Galaxy.

The objects to be discussed should meet two additional conditions: (1) they should represent a statistically homogeneous and complete sample within the local domain covering a full band along the galactic equator, (2) they should be very young since the random velocities tend to smear out objects which originated in the spiral filaments over the plane within *ca.* 10^8 years. So we are finally left with only a few types of objects. It should, however, be emphasized that there is a great number of additional investigations which do not contradict the general picture derived here.

A. Early-type open clusters (with earliest type O5–B2). The distance moduli have been taken from Becker (1963, 1964) and Hoag, Johnson *et al.* (1961), giving double weight to Becker's values. For four clusters with strongly discrepant values the modulus has been determined anew, and four southern clusters have been added on the basis of unpublished work of Graham and H. Schmidt (50 objects).

B. OB-aggregates. From K. H. Schmidt's (1958) list all objects were selected with
(*a*) earliest spectral type O–B0
(*b*) overall diameter between 15 and 180 pc
(*c*) minimum number of 10 members with accurately known MK-classification and photoelectric (U) *BV*-photometry
(*d*) dispersion of distance moduli (determined with the luminosity calibration of Schmidt-Kaler (1963)) $\leqq 0\overset{m}{.}8$.

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I Ara has been added using Whiteoak's (1963) work (altogether 32 objects).

C. H II-regions, taken from the compilation of Becker and Fenkart (1963): there remain 43 objects not belonging to clusters or aggregates already given in A and B.

D. 32 Bpe-stars taken from the list of Schmidt-Kaler (1964).

E. Cepheids of highest luminosity $M_v < -5{\cdot}0$ (14 objects taken from Kraft and Schmidt 1963).

F. Dark cloud complexes derived by Isserstedt and Schmidt-Kaler (1964) from lines of equal reddening in the local domain as fairly extended regions with high gradients (41 objects).

The composite picture clearly shows the local filaments, their average width being about 0·55 kpc. Two questions arise: what does the gap of the Perseus-arm near 150° mean, and what is the course of the local arm between Puppis and Carina? From the colour-excess maps it is apparent that the gap of the Perseus-arm is mainly due to very high local absorption whereas the local arm really thins out in the Orion-Puppis region. The local arm continues to about 270°. This is borne out by the fact that the only two directions of maximal transparency common to all latitudes $-8°5 \ldots +8°5$ lie at 48° and 280°, representing the directions between the local and the inner arm. The same conclusion can be drawn from a number of spiral objects not shown here, from the behaviour of interstellar polarization of the stars, and from Milky Way

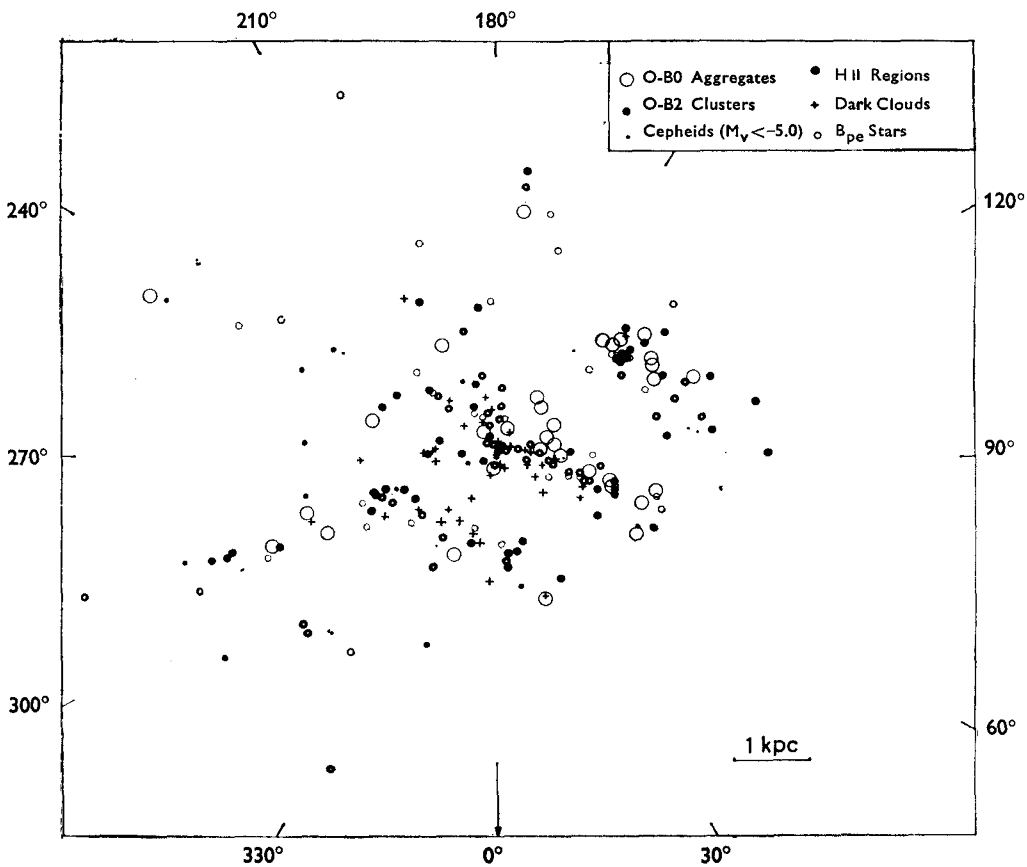

Fig. 1. Distribution of selected types of object in the galactic plane.

surface photometry; it is confirmed by unpublished results of Velghe (see Report of Commission 33).

There is yet one important optical investigation (Elsässer and Haug, 1960) which does, at first sight, not fit into the general picture. In Milky Way photometry we should expect maxima when looking tangentially to spiral features although these may be due also to absorption effects. In fact, a number of maxima lie in regions of comparatively good transparency. Five maxima, however, are situated in regions of comparatively strong absorption and cannot be interpreted in this way. They fit remarkably well into the general picture (Isserstedt and Schmidt-Kaler, 1964) which thus seems to present a consistent picture of all optical evidence of spiral structure in the local domain. In further work one should bear in mind the dangerous effects of observational selection and of interstellar absorption causing spurious features, the regional variations of R, and quite generally the inherent irregularity of normal spiral structure as shown by other galaxies.

If we attempt a direct comparison of optical and H I-structure we first must bring both maps to the same scale. The optical structure is in all cases based on a photometric scale eventually going back to the Hyades, and corresponding to a galactic rotation constant $A = 15$ km/sec kpc. The H I-map of Kerr and Westerhout has been scaled accordingly. There appears, however, no correlation with the optical features of the local domain. The arms appear as a series of longish clumps rather than a smooth distribution, the connections between them being often doubtful. In order to bring them on the optical features deviations from circular motion of about 15 km/sec are needed. It has been recently pointed out by McGee and Milton (1964) that the gas forms large cloud aggregates with average deviations of just that order of magnitude. The OB-stars likewise show a clumpy velocity distribution which, moreover, is correlated to that of the gas. A fine example is the Perseus-region where OB-stars and gas deviate from the circular motion by very nearly the same amount. Evidently, the spiral arms are not only geometrically, but also kinematically, complex structures.

So it seems wise not to compare directly structures located by two basically different methods. Model-independent comparison is possible in two ways:

1. By direct comparison of the frequency function of the radial velocities of the stars and the 21 cm-profile.

2. By comparison of the results of the surface intensity distribution of the Milky Way with the number of H I-atoms summed up along the Milky Way, as a function of longitude.

Rubin *et al.* (1962) have compared the distribution of the radial velocities of O-B5 stars in strips of 5° along the Milky Way with the corresponding 21 cm-line profiles, and found good qualitative agreement in most directions. This is confirmed by new observations of Feast and Thackeray, and Rubin, presented at this meeting. An intuitive representation of this result is obtained by locating the stars according to their radial velocity and galactic longitude in exactly the same way as the neutral hydrogen, plotting them on the Leiden-Sydney map (Fletcher, 1964). Related star groups and gas patches have highly correlated velocities.

The strong correlation in velocity space would be compatible with weak correlation in space only if there is a systematic difference between the circular velocity (stars) and that of the gas. This can be tested completely independent of kinematical assumptions by the second method. Work on these lines is in progress (Schmidt-Kaler and Schwartz, 1964); provisional results point to complete coincidence of stellar and interstellar features, deviations of the order of 100 pc may occur. On the other hand, observational and theoretical evidence strongly suggests that around groups of O-stars there is a void of neutral hydrogen with diameters somewhere between 10 and 200 pc. Therefore we can conclude that within the local domain the spiral filaments formed by young stars, gas and dust seem to coincide spatially and kinematically except for regions with dimensions of the order of 100 pc.

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II. THE MOTIONS, DISTRIBUTION AND RATES OF EVOLUTION OF O-B1 STARS IN STELLAR ASSOCIATIONS

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The most typical members of the O-associations, the O-B1 stars, are young objects (**1, 2**). Due to their high luminosities they are observable in a fairly large volume around the Sun.

These two circumstances arouse great interest in O-B1 stars, in connection with problems on the origin and evolution of stars and stellar systems in our Galaxy as well as from the point of view of studying the local motions of stars in the vicinity of the Sun.

In this report we shall try to present a summary of some results of the study of O-B1 stars relating to the programme of the present Joint Discussion. They have been obtained in recent years at the Byurakan Astrophysical Observatory of the Academy of Sciences of the Armenian SSR.

Motions of O-B1 Stars

It has been shown in paper (**3**) that the *K*-term for the subsystem of O-B1 stars decreases nearly regularly with the mean distance from the Sun and becomes negative at considerable distances. A similar dependence has been found between the *K*-term and the mean absolute magnitude of O-B1 stars. It is clear that these two dependences are correlated, since the proportion of high luminosity stars of a given visible magnitude increases with the distance from the Sun. Therefore, to reveal the nature of the *K*-effect it is necessary to elucidate which of those dependences is the basic one.

An investigation based on an analysis of residual (corrected for galactic rotation) radial velocities of O-B0·5 stars (stellar and interstellar) and classical cepheids has led to the conclusion that such correlation between the *K*-term and the mean distance from the Sun is observed in all three cases (**4**). This fact may be considered as evidence in favour of the dynamic nature of the *K*-effect.