B (1). LOCAL STRUCTURE: DISTRIBUTION OF DIFFERENT TYPES OF STARS IN THE PLANE

Numerous extensive studies of the space distribution of stars of different spectral types, based on star counts and colour measures, have in the past been published for different sections of the Milky Way.[1] These studies have given information on the nearby obscuring clouds, and they have revealed marked differences between the distribution of different kinds of stars. They have not, however, given us the much desired insight into the large-scale features of the density distribution.

With the new developments in our knowledge of spiral structure of the interstellar gas, and the increased information to be expected from the planned observations of super-giants described in section A (2), the fundamental question with regard to the normal giants and main sequence stars can be formulated as follows. We have theoretical reasons for believing that as we go down the main sequence from the OB super-giants to the stars of lower luminosities, the main sequence B stars, the A stars and F stars, we are considering stars in the order of their ages. Until we come to the G main sequence stars, we very probably are dealing with stars which are younger than 3×10^9 years. The later type giants may also be included among these. Can we, going up these steps in age, trace differences in the large-scale structure in their distributions which might give information on the distributions at the times of formation?

The lower luminosity of these stars with respect to the super-giants limits the investigation to a much smaller region around the Sun. When we consider stars like main sequence A stars or ordinary K giants, that is of absolute magnitude around zero, and if we assume 2·5 magnitudes absorption, the distance up to which we may hope to get reasonably accurate information is about 1500 parsecs, corresponding to a limiting apparent magnitude about 13·5. This, however, reaches far enough to allow comparison with the section of the spiral arm of gas and OB super-giants in which the Sun is located. One of the first things to be done will be to determine the density distribution of, for instance, the A stars, in directions along and across the direction of the spiral arm. As the shortest distance to the next arm is 2000 parsecs, an investigation up to 1500 parsecs would penetrate far enough into the inter-arm population.

From the observations in the Andromeda nebula we know that the major constituent among the inter-arm giant stars is the population II stars which are resolved simultaneously with the same kind of objects in globular clusters. This probably is also the case in the Galaxy, the population II giants forming a continuous medium in which the population I stars are imbedded. It is, therefore, of primary importance that in the investigation indicated above there should be no confusion between the giants of the two population types. We should select only those objects for which reliable criteria to discriminate are available.

SELECTION OF TYPES OF STARS FOR STUDY

The stars to be picked out from surveys for further investigation should meet the following requirements.

(1) They must represent a narrow region of the HR diagram, that is, they must be defined by narrow limits of absolute magnitude and intrinsic colour.

(2) It should be possible to pick them out up to distances of the order of 1500 parsecs.

(3) It should be possible to distinguish between population I and II objects.

(4) It must be possible to pick out identical groups of stars among the very faintest objects (about $m=13$ or 14) and among the bright ones ($m<8$), in order to make the comparison of nearer and distant regions possible.

From the discussions at the conference it became clear that there are only few groups which meet all these requirements, but these offer an interesting choice.

(*a*) The most promising group is that of the main sequence A0 stars. From Morgan's description of the natural groups in spectral classification,[1] as well as from the experience of W. Becker, it appears that these stars can be picked out on objective prism plates of very low dispersion (1000–2000 A./mm.), being recognized by the maximum strength of the H lines. It was stressed by different participants, that it will be necessary to limit the group to the A0 stars only and not to take the B9–A3 stars, in order that the four requirements just mentioned will be best satisfied. The main sequence A0 stars can even be found up to $m=14$ without real difficulty. The best procedure might be to search for all the objects with maximum and near maximum intensity of the Balmer lines, and next to narrow down the selection of those with strongest lines by photometric tracing of the spectra. Tracing might also help to guarantee the uniformity of the selection of bright and faint surveys. Some widening of the spectra is recommended to facilitate the first visual step.

As was pointed out by Bok during the conference, earlier and current investigations of the A stars reveal a density distribution which does not seem to resemble that of the OB stars. For instance, an increase of the density in the direction to Carina at distances of 500–1000 parsecs is found, although this region is located between the spiral arms of the OB stars. In the directions of Sagittarius, Cygnus, and Monoceros, a drop in the A star density is indicated, according to Bok. The deviations in the motions of the A-type stars with respect to the later types (solar motion, distribution of peculiar motions) also reflect irregularities in the space distribution of these stars. These facts, combined with the presumption that these stars are older than the OB super-giants but younger than the majority of the common stars, make them very interesting objects for the proposed survey.

(*b*) Next in importance in the study of local structure seem to be the F2–F8 weak-line and strong-line stars. From Miss Roman's studies[1] of the differences in the kinematical properties of these stars it is very probable that they represent different stages of stellar evolution, the strong-line stars possibly being close to the A stars in kinematical and distributional properties, whereas the weak-line stars rather have to be considered as an intermediate stage between populations I and II.

The differences between these two categories and the problem of their relation with other types of stars make them interesting objects for the present studies. The two groups can be distinguished up to $m = 11{\cdot}5$ on objective prism plates (dispersion 230 A./mm. between H_γ and H_δ) of a good quality, and perhaps even fainter if special effort is made. The objective prism survey must be followed by slit spectra for a more refined classification.[2]

(*c*) A third group which may be well suited for this investigation is the natural group of K-giants. The main problem is here, the segregation of population I and II objects. The best way to deal with these stars might be, to pick them out from objective prism surveys without the segregation of the various types and have this latter done by individual spectroscopic observation afterwards. The survey of the objective prism spectra could probably be based on the CN break at λ 3863. The observation of some hundreds of stars up to $m = 14$ for slit spectra with a dispersion of 150 A./mm. will require a powerful instrument, but the importance of the studies would justify the effort. It is not impossible that one of the largest telescopes may become available for this work. According to Baade, six-colour photometry as was employed by Stebbins and Whitford might also be able to distinguish between the two types of population. This would require some more experimental work.

FURTHER WORK ON THE INDIVIDUAL STARS FOUND IN THE SURVEY

The determination of the colours and absolute magnitudes of the selected stars must be based on accurate photometry at different wave-lengths. The multi-colour method now being developed by B. Strömgren may provide accurate luminosity and spectral classifications for the types of stars considered, except perhaps for Ao.

This method is based on photo-electric measurements of the intensity in narrow wave-length regions. For the B, A and F stars one uses the intensity of H_β and the Balmer discontinuity. For the K stars the strength of the K line, the CN band and the G band. Preliminary results indicate a very high accuracy for the absolute magnitudes and colours measured in this way for the F stars, and a somewhat lower accuracy, but still better than that found by other methods now available, for the B and K stars. The separation of population types I and II among the K stars remains a difficult problem. For the early A stars the method is less accurate.

A most important aspect of the multi-colour method is that it allows measurements of fainter stars than spectroscopy can reach with an equal observing time; an accuracy of 0·2 magnitudes in the absolute magnitude, and of 0·03 in the spectral class can be reached for F stars which are about two magnitudes fainter in the multi-colour method than in the direct spectroscopic observations. The method does allow detection of some peculiar stars like metallic line stars, for which the predicted luminosities are somewhat lower than for normal stars of the same Balmer discontinuity.[1]

In the case of the A-type stars it is possible that the selection by the method of the last section is narrow enough to ensure a small range in colour and luminosity. This, however, would have to be tested by means of samples. It will hardly be possible to investigate all the stars found in the surveys. The solution might be to observe representative samples of stars of different apparent magnitudes, large enough to allow conclusions with regard to the distance distribution.

It was the general opinion of the participants at the conference that the above-mentioned programmes require preliminary work to find out if the approach outlined above is feasible. It is, therefore, recommended that one should start with a very limited programme containing two or three test areas in the Milky Way and chosen so that they will give information on the density distribution along and across the spiral arm. The following areas were recommended:

(*a*) An area at $l=45°$ (Cygnus Cloud), i.e. in the low latitude field number 3 studied by Nassau and MacRae; this field lies in the direction of the spiral arm passing through the Sun.[1]

(*b*) An area at $l=92°$, centred on Kapteyn S.A. 8. In this area we would have proper motions available which may prove to be an important aid in analysing the photometric and spectroscopic data. The absorption seems to be low. The distance to the next spiral arm in this direction is about 2500 parsecs. An alternative choice suggested at the conference was an area at $l=70°$, $b=-2°$, which seems to be unusually transparent and has already been investigated by several authors. It would, however, be a disadvantage that here the inclination to our spiral arm is only 40° and hence the survey might not reach sufficiently far outside the arm. Another choice would be $l=97°$, an area for which spectral plates are already available at the Warner and Swasey Observatory and which also seems rather transparent. Here, however, there are no data yet available on the proper motions.

(*c*) Possibly an area at $l=175°$ or at $l=205°$. In the direction $l=175°$ our spiral arm shows branching and one probably would not reach outside the arm within the first 1500 parsecs. The investigation might show to what extent the somewhat irregular distribution of the OB stars is also present among the other types. According to Bok, the obscuration is low around $l=175°$, near NGC 2244. At $l=205°$, radio measurements (21 cm.) indicate low interstellar gas density up to 1 kiloparsec, next, a high maximum at 1·4 kiloparsecs, and again very low density between 2·0 and 3·0 kiloparsecs. The density distribution of the gas is less complicated than at $l=175°$.

The final choice between these fields will be a matter for the continuation committee to decide.

Dr Nassau thought it might be quite possible for the Warner and Swasey Observatory to take the objective prism plates which are required for the first steps in the surveys mentioned above.

SURVEY OF AO-TYPE STARS

In the case of the Ao-type stars it would be interesting to add to the above programme a survey of all main sequence Ao-type stars occurring on the plates taken for the survey of the super-giants ($m < 12$). From this, one might obtain a complete picture of the distribution of these objects within 1000 parsecs from the Sun.

SURVEY OF WEAK-LINE AND STRONG-LINE STARS

Different participants at the conference were of the opinion that an extension of Miss Roman's survey of weak-line and strong-line stars beyond $m = 5{\cdot}5$ would be very important. This would allow a more detailed study of the kinematical properties of the two groups. It would be especially interesting to know, for instance, what the distribution of the peculiar motions is for the group of the strong-line stars, and how closely it resembles the distribution found for the A-type stars. In this way it might be possible to indicate to which age-group these stars must be assigned.

Such work might also throw more light on the question of the continuity or discontinuity of the physical and kinematical properties of the main sequence stars. As reported by Parenago (see the translation of his speech in the *Astronomical Newsletter*), Einesto has found evidence of the composite nature of the main sequence F5–G9 stars from the velocity distribution of these objects, supporting Parenago's and Masevich's results on the existence of two overlapping main sequence series.