Prof. V A. Ambartsumian sent the following supplementary data on recent work in the U.S.S.R.:

(1) The Byurakan Observatory has published a study by V A. Ambartsumian on the fluctuations in the apparent distribution of the stars. The theory developed takes account of the irregular structure of the absorbing layer as well as of the natural fluctuations in the space density of the stars. The author considers the correlation between the numbers of nebulae in regions near to each other, and similarly the correlation in surface brightness of neighbouring regions in the Milky Way.*

(2) Y. Y Ikauniczs has investigated the space distribution of the carbon stars, as well as the kinematics of the subsystem formed by these stars.†

(3) A. G. Masevich and P. P. Parenago investigated the empirical relations between mass, radius and luminosity. One of the principal conclusions is the striking division in the main sequence into two parts, O–G and G–M.‡

Meeting with Commission 32

The Commission met in combination with Commission 32. The Report of the meeting is to be found under Commission 32.

Report of the combined meeting of Commissions 33, 34 and 40

PRESIDENT: Prof. O. STRUVE.

SECRETARY: Prof. A. VAN HOOF.

The meeting was held on Friday, 12 September, at 9.30.

The President called the meeting to order and asked Prof. Oort to read his paper on radio emission in the Galaxy.

Prof. Oort gave an account of the work by Messrs C. A. Muller, van de Hulst and himself on the 21 cm. radiation emitted by the cool interstellar clouds. Line contours were measured for points in the galactic plane, in various longitudes. The contours found in the directions of the centre and of the anti-centre are practically symmetrical and fairly narrow, their widths being no greater than would be expected as a consequence of the random motions of the clouds (which average about 8 km./sec. in one co-ordinate). The mean frequencies found in the two directions agree accurately. These facts may be interpreted as evidence that the systematic motions in the Galactic System are mainly along circles around the galactic centre.

The much greater widths of the line contours in all other longitudes must be due to differential galactic rotation. These line contours enable us, then, to derive the density distribution of the gas in the direction in which the measures were made. Comparison of various longitudes shows clearly the spiral-like arrangement of the gas clouds in the outer parts of the Galactic System. The Sun is located near the inner side of an arm coinciding with that already indicated by W. W Morgan. Another powerful arm lies about 2 kparsecs further out. The clusters *h* and χ Persei are situated in this arm. The radio measures show that this is the outermost spiral arm of the system. A long arm at about the same distance from the centre can be traced over a long stretch, down to the opposite side of the centre, at a distance of nearly 20 kparsecs from the Sun. Analysis of the inner parts of the Galactic System is more difficult and has not yet seriously been

* *Commun. Byurakan Obs.* no. 6, 1951. It should be noted that the same general problems have recently been extensively investigated by Chandrasekhar and Münch (cf. *Ap. J* **112**, 380, 393, 1950; **114**, 110, 1951; **115**, 94, 103, 1952).

† *Variable Stars*, Vol. **8**, 1952.

‡ *Publ. Sternberg Inst.* **20**, 81, 1951.

tackled, except for a provisional determination of the rotational velocity as function of the distance from the centre.

The speaker gave also a brief account of estimates of average density of hydrogen, and the absorption coefficient in the line. The density is estimated to average about one hydrogen atom per cm.^{3} near the galactic plane.

Van de Hulst added some more detailed explanations of the observations.

The President expressed his admiration for this communication of exceptional interest and declared the discussion open.

ÖHMAN: What is the accuracy in the determination of the distances?

OORT: The probable error of the distances must be about 100–150 parsec, as may be inferred from the p.e. of the Doppler-shifts.

BAADE: What is the best estimate of the density between the arms?

OORT: Some 50% of the density in the arms, but it varies much from place to place.

STRUVE: What is the evidence of there being gas between the arms?

BAADE: There are no exciting stars, so we do not know, but the dust is concentrated in the arms.

The second speaker was Prof. van de Hulst who presented the principal conclusions from a paper on the continuous radiation of the Galaxy, sent in for discussion in Commission 40 by I. S. Shklovsky.* The conclusions were compared with those drawn by G. Westerhout and J. H. Oort† in one of the earlier attempts at separating the various sources of radio emission with a continuous spectrum.

The main differences in interpretation are shown in the following scheme:

Model: Shklovsky	Observed radiation	Model: Westerhout and Oort
Fairly strong	Gas (narrow strip)	Weak
Spheroidal distribution of radio stars	Even background	Extragalactic (or spurious)
	Broad galactic belt Weak observed point sources	Sources with same space distribution as dwarf stars
×	Strong point sources	×

The component due to free-free emission in the ionized regions of the interstellar gas must by all estimates be confined to a narrow strip of a few degrees around the galactic equator. Shklovsky concludes that at 100 Mc./s. the gas-component is not a small fraction but about half of the total radiation. He ascribes the secondary maxima, e.g. in Cygnus, to gas emission in a spiral arm. A consequence of this interpretation is that there should be much gas in the galactic nucleus.

A further difference is that Shklovsky does not accept the idea of a general, possible extra-galactic background, that should be subtracted before an analysis of the galactic distribution can be made. His arguments briefly are (*a*) that such an intense background cannot be explained in terms of radiation from other galaxies (this is indeed an acute problem, but it is not quite sure whether even the observations are correct); (*b*) that the intensity decreases from the poles to the anti-centre (too uncertain observationally); and (*c*) that the radio isophotes of the Andromeda nebula seem circular.

If Shklovsky's interpretation is accepted, the space distribution of the weak radio stars is unlike the distribution of any other known type of galactic objects; it is a nearly spherical distribution extending far beyond the Sun's orbit and with a moderate concentration toward the centre. The ratio of the axes in the internal regions is 2:1 and the density at the centre is 2·7 times the density near the Sun. The total number of radio stars must be of an order greater than the number of optical stars. Shklovsky leaves the possibility open that these sources are not 'radio stars' but peculiar regions of the interstellar gas. He agrees with other authors that the giant radio stars like the one in Cygnus are unique objects, that have little to do with the preceding discussion.

No discussion developed at the end of this communication.

Prof. M. Ryle, as the last speaker, presented the results of an 'Investigation of the H II-regions by their continuous radio emission'

* Based on *A.J. U.S.S.R.* **25**, 237, 1948 and **29**, no. 4, 1952. † *B.A.N* no. 426; **11**, 323, 1951.

Previous surveys of galactic radio emission have shown that the general distribution of intensity may be consistent with an origin in bodies distributed like common stars, together with a smaller isotropic component, which may be due to the integrated radiation from extra-galactic sources (1). At a given galactic longitude the variation of intensity with latitude therefore falls to half at galactic latitudes of about $\pm 7°$

Since the regions of ionized interstellar hydrogen are associated with early-type stars, they will be strongly concentrated towards the galactic plane, and will therefore only produce an appreciable effect within 1–2° of the galactic equator. The H II regions might affect the observed intensity of radio emission in two ways:

(*a*) Their emission might produce a 'bright' strip along the galactic equator.

(*b*) The absorption of the general galactic radiation and the extra-galactic component by the H II regions might result in a 'dark' strip along the galactic equator.

The resultant effect of these two mechanisms will depend on the effective electron density (N_e), the average temperature (T_e) within the regions, and the wave-length. For a value of $T_e = 10.000°$ and $\int N_e^2\, ds = 1{\cdot}9 . 10^{22}$ cm.$^{-5}$, it can be shown that the strip should be detected in emission at wave-lengths shorter than 5 m. and in absorption at longer wave-lengths.

Detailed measurements of the distribution of intensity with galactic latitude at two or more wave-lengths should therefore enable deductions to be made concerning the density and temperature in the H II regions. Observations at different galactic longitudes should also allow information to be derived on the distribution of the H II regions within the galaxy.

Previous surveys of galactic radiation have been made with aerials of insufficient resolving power ($\sim 15°$) to detect the presence of such a narrow strip. A series of observations has therefore been made at Cambridge (2), using a system of much greater resolving power, to determine the intensity distribution near the galactic equator, at galactic longitudes between 338° and 16°

In this system an interferometer of variable aperture is set up on an axis pointing to the galactic poles, and the system is used in conjunction with the phase-switching method of recording (3). The deflection of the record is then proportional to one term of the Fourier transform of the latitude distribution of intensity; the angular periodicity of the term is determined by the aperture. By making observations with a number of different apertures, it is thus possible to derive the complete Fourier amplitude curve, and hence the distribution of intensity.

Observations have been made on two wave-lengths, 1·4 m. and 3·7 m., using apertures of up to 60 wave-lengths. In each case the observed distribution exhibits a narrow bright belt about $1\frac{1}{2}°$ wide along the galactic equator. Observations at different galactic longitudes suggest that the distribution of the H II regions within the Galaxy has a greater nuclear concentration than either of the models suggested by Westerhout and Oort (1).

By comparing the relative intensities of the bright belt at the two wave-lengths it is possible to derive figures for the quantity $\int N_e^2\, ds$ and the average kinetic temperature T_e. The temperature derived in this way must be at least 18.000°, a figure considerably greater than the normally accepted value.

It is possible that the observed bright belt is not due entirely to the H II regions, but to the emission from a different population of radio stars, showing strong galactic concentration, if this were the explanation it would also be necessary to postulate that these radio stars had a radio spectrum quite different from that of other radio stars or the general radiation, and corresponding more to that of an optically thin gas.

Definite proof that the observed effects are due to the H II regions might be provided if measurements at a long wave-length allowed the observation of the belt in absorption.

REFERENCES

(1) G. Westerhout and J. H. Oort: *B.A.N.* **11**, 323, 1951.
(2) P. A. G. Scheuer and M. Ryle (in the Press).
(3) M. Ryle: *Proc. Roy. Soc.* A, **211**, 351, 1952.

UNSÖLD: It would be desirable to observe bright gas nebulosities, like the one in Orion, in the range 30–60 cm.

RYLE: Some approximate calculations we made some time ago suggested that even at wave-lengths of several metres, the optical depth of the Orion nebula would only be appreciable over an angular width of about $\frac{1}{2}°$ The detection of such a small source at metre wave-lengths would present very serious practical difficulties owing to the large brightness temperature of the surrounding background radiation, and the difficulty of obtaining a large resolving power.

If Dr Unsöld's figures are right and the optical depth is appreciable over such an angular width even at 50 cm. wave-length, the detection of the Orion nebula should be possible with a large aerial system, and such an investigation would be most important.

VAN DE HULST: Is it correct that your measurements seem to indicate a much weaker gas component than postulated by Shklovsky?

RYLE: Indeed so.

The President returned the thanks of the audience to the speakers and closed the session.