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DISCUSSION

Davies. Shuter and Verschuur (*Mon. Not. R. astr. Soc.*, **127** 387, 1964) have made a high resolution study with 3 and 5 kc/sec bandwidths of the absorption spectra of the intense radio sources. Such measurements have an angular resolution equal to the angular size of the sources themselves and are less confused than emission spectra. Dispersions were typically 0·5 to 0·8 km/sec and correspond to kinetic temperatures in the range 30 to 100°K.

Grahl. At Bonn Observatory we observed a 21-cm line programme at higher galactic latitude in the vicinity of the north celestial pole. In a region around the position $l^{II} = 125^\circ.5$, $b^{II} = 31^\circ.5$ we found profiles with simple shapes. The main component with standard deviation about $\sigma = 2{\cdot}3$ km/sec predominated. In the isophote map of maximum temperature we find a cloud-structure with a total half-power width of $2^\circ.6$ and high gradients on some edges. With an estimated distance of 100 pc the linear diameter is about 10 pc, and we get a total mass of about 250 solar masses by integration over the solid angle. Some simple model calculations for best fitting of the results will be completed soon.

Fehrenbach. What is the radial velocity of this cloud?

Grahl. Zero.

4. HIGH-LATITUDE, HIGH-VELOCITY CLOUDS

J. H. Oort

The clouds with velocities higher than 70 km/sec with respect to the local standard of rest which were found in a Leiden-Dwingeloo survey for high-velocity features in high galactic latitudes, show a remarkably systematic distribution. They are concentrated between 72° and 167° new longitude and between +15° and +50° latitude. Moreover, their velocities are all negative. They range from −70 to −174 km/sec, with an average of −115 km/sec.

It should be emphasized that the survey is still quite incomplete; it is to be expected in particular that further observations at somewhat lower latitudes will yield many more features of this sort. It should also be pointed out that in the course of W. W. Shane's survey of the galactic structure between 22° and 42° longitude some objects with high *positive* velocity were found. One of these, with a velocity of +90 km/sec, is situated at −15° latitude; the others are closer to the galactic equator. We do not yet know whether these objects are of a different nature.

For most of the high-velocity clouds the structure has not yet been determined. From the few cases studied so far it may be inferred that they are irregular and of widely different angular extent. The velocity dispersion within any one feature is always rather large; the average is $\pm$ 12 km/sec. The object of highest velocity ($v = -175$ km/sec) has a diameter between half-intensity points of about 2°; another cloud appears to extend over a surface of at least 10° diameter. The masses depend on the distances, which are still unknown; they are of the order of 1000 r^2 solar masses, where r is the distance in kpc.

That the concentration in the longitude interval between 72° and 167° is real is strongly supported by the distribution of velocities between -84 and -21 km/sec found in the latitude range 10° to 25° by Blaauw and Tolbert in Groningen. These show a strong concentration between 100° and 140° new longitude.

In their discussion of observations at *high* latitudes Blaauw and Tolbert found a remarkable dependence of the velocity on the longitude, which is most pronounced in the zones at +65° and +75° latitude. While at new longitudes between 230° and 50° the velocities are small, more or less as expected in the normal galactic layer, this low-velocity gas is almost entirely missing between 50° and 230°. There is, instead, gas of about the same surface density moving with rather high velocities; between 120° and 210° these range from -40 and -60 km/sec. As an explanation of this phenomenon they suggest that the local interstellar medium is being disturbed by a fast-moving incoming cloud.

The galactic polar caps within 10° of the poles have been investigated by Mrs Dieter (*Astr. J.*, **69**, 288, 1964). In the north polar cap she found two sets of velocities, one between 0 and -10 km/sec, the other between -20 and -55 km/sec. These observations indicate clearly that gas is streaming towards the galactic plane, and about four tenths of this at a relatively high velocity. Mrs Dieter has recently also found *some* negative-velocity gas near the south galactic pole, though very much less than at the north pole.

How should these phenomena be interpreted?

We may consider the following possibilities:

(*a*) The high-velocity clouds are part of a near-by supernova shell.
(*b*) They form the normal population of the 'galactic corona'.
(*c*) They are part of a 'local current' in the galactic corona, which originated in the galactic system.
(*d*) They are stellar systems at distances comparable to those of near-by galaxies.
(*e*) They come from intergalactic gas which is being swept up by the Galaxy.

The supernova shell of hypothesis (*a*) would evidently have to be very close-by; but even then the mass required appears unacceptably high. It would, moreover, be difficult to fit the related phenomena at moderate and low velocities into this picture, and to explain why the positive-velocity side of the shell is not observed, (*b*) can be excluded because the observed velocity distribution is incompatible with it, (*d*) seems highly improbable because of the peculiar, and similar, distribution of the objects in the various ranges of velocity. The systematic streams observed at quite low velocity which were discussed by van Woerden, certainly cannot be explained by (*d*). Moreover, the phenomena observed by Blaauw and Tolbert at $b = +65°$ and +75° indicate clearly that at least in this case we are dealing with high-velocity gas within the Galactic System.

The only mechanisms which appear to be capable of explaining all the observed phenomena are (*c*) and (*e*). Case (*c*), which has been considered in some detail by Blaauw, requires a 'coronal' current of vast dimensions and of high initial velocity. The origin of this current would have to be sought in a superexplosion somewhere in the galactic plane. The mass involved should have been of the order of 10^5 or 10^6 solar masses, and, considering the direction of the stream, the explosion should have occurred in one of the outermost spiral arms. Again, it is difficult to explain all the observed phenomena with this hypothesis; moreover, there is no evidence in other galaxies for the occurrence of superexplosions outside the central regions.

For these reasons hypothesis (*e*), i.e. an inflow of matter from extra-galactic space, may seem preferable, though also this mechanism meets with serious difficulties. The clouds falling in would originally have acquired velocities of the order of 600 km/sec relative to the local standard of rest; they must have been decelerated in the galactic layer. The intergalactic density required is at least an order of magnitude higher than the presumable overall density in the Universe. However, this is not impossible, in view of the general inhomogeneity of the Universe, and in particular because of the situation of the galactic system in a local group of galaxies.

DISCUSSION

Zwicky. A sixth possibility of accounting for these clouds is as follows. Supernovae of type III are thought to eject clouds of total mass M_0 greater than 1000 $M_\odot$, and with velocities v_0 greater than 10 000 km/sec. These clouds coming from a supernova on the south side of the galactic plane (near the Sun) will push the interstellar gases of mass M_i north, leaving the imbedded stars of mass M_s behind. The interstellar gas clouds of mass M_i trap the electrons of the impinging supernova clouds C, while the protons and nuclei of C get stopped only much later by the negative clouds and the stars left behind. Because of this intricate build-up of electric and of gravitational fields between the various clouds of stars and gases, the conversion of the initially available kinetic energy $\alpha M_0 v_0^2/2$ (where $\alpha \sim 0{\cdot}1$), is appreciably elastic, and clouds of mass $M = \alpha\beta\left(\frac{v_0}{v_i}\right)^2 M_0$ can be launched away from the galactic plane, returning later with velocities v_i as a consequence of the collapse of the electric and gravitational fields. If $v_i \cong 100$ km/sec, then $M \sim 10^5 M_\odot$, if $\beta \sim 0{\cdot}1$. It should be added that groups of stars moving in noncircular paths as well as interstellar magnetic fields also find their explanation on the sketched theory.

Oort. There is probably not enough matter in the few supernovae that occur.

Bolton. What are the velocity limits of the survey?

Oort. From -250 to $+250$ km/sec. There might be higher velocities, especially if the objects are extragalactic.

Sciama. A variety of considerations suggests that the density of gas in the local group of galaxies may be as high as 5×10^{-28} gm/cc (Sciama, *Quart. J. R. astr. Soc.* Sept. 1964). By parison, Prof. Oort's requirements are quite modest.

Westerhout. I wonder if these clouds might be related to a gas link between the Galaxy and M31.

Kerr. It is also interesting that the main group is located diagonally opposite to the Magellanic Clouds, in the region where a Magellanic 'countertide' might occur.

5. REGIONAL VARIATIONS OF THE INTERSTELLAR REDDENING LAW

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Introduction

The possible existence of variations of the interstellar reddening law has been investigated since the reddening has been recognized as a dangerous phenomenon for the study of galactic structure, as well as an interesting feature connected with the physical state of the interstellar dust. Almost all studies have been made with conventional photographic or blue-sensitive photoelectric techniques, confining the wavelength coverage to the region 6000Å–3100Å. In

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