Letter to the Editor

Note on Verschuur’s Article on High-Velocity Clouds and “Normal” Galactic Structure

A. N. M. Hulsbosch and J. H. Oort
Leiden Observatory

Received August 14, 1972

Summary. Verschuur’s model which explains most of the high-velocity clouds as being parts of distant spiral arms is discussed. It is argued that, at least for the lower latitudes, this model deserves attention but that at the high latitudes, which to us seem the crucial places for a study of the nature of these clouds, it encounters great difficulties, as noted also by Verschuur. For explaining the high-velocity clouds at high latitudes the model in which an intergalactic wind is supposed to supply momentum to neutral hydrogen complexes in the outlying parts of spiral arms, provides a more satisfactory interpretation.

Key words: 21-cm line — high-velocity clouds — galactic spiral structure

In an earlier article in this issue (p. 139) Verschuur defends the theory that practically all high-velocity clouds belong to distant spiral arms, and that they show no evidence for gas falling in from outside. A similar view was recently put forward by Davies (1972). We agree that this may be true for the lower latitudes, \( \leq 25^\circ \), but for the high-galactic-latitude clouds this is less clear, and for some high-velocity clouds the hypothesis seems to us to meet with insurmountable difficulties.

Verschuur bases his interpretation on the observation that much of the higher-velocity hydrogen in intermediate and lower latitudes is arranged in ridge-like structures. It is evident, however, that if the Galaxy would be accreting intergalactic gas this could be observed only in the spiral arms, and would thus necessarily lie in ridges. For the presumably very hot intergalactic gas could only become visible after it has cooled through interaction with galactic gas. This will generally take place in the extensions of the spiral arms to high \( z \) discovered by Margaret Kepner (1970) and now observed in much greater detail by Verschuur. It is in these ridges that the ordinary galactic gas as well as gas accelerated by a hypothetical intergalactic wind would be concentrated. In general it would be difficult to distinguish between the two. This could only be done in directions where the infall velocity would differ from the effects of differential rotation. The regions where this distinction can most definitely be made are the galactic polar caps. It was therefore from observations in high galactic latitudes that the peculiar character of the high-velocity complexes was first discovered. In our opinion the problem of the existence of an infalling wind can still be studied best at the higher galactic latitudes. This region provides also the best opportunity for a detailed investigation of the structure and dynamics of individual high-velocity features and for estimates of their distances by means of interstellar absorption lines. The evidence provided by the high-latitude zones, which in our opinion is the most crucial for the interpretation of the high-velocity gas, is, however, largely disqualified by Verschuur as being due to accidental local phenomena (Verschuur, 1971).

The gas below \( b = 25^\circ \) is clearly distinct from the high-latitude gas, as can be seen from Verschuur’s Fig. 1. The high-latitude high-velocity gas appears in two or three large complexes. One of these complexes is a string between \( l = 132^\circ, b = +23^\circ \) and \( l = 161^\circ, b = +46^\circ \) consisting of several components with velocities between \( -137 \) km/s and \( -204 \) km/s, varying in an irregular way (Hulsbosch, 1968 and unpublished material). On phenomenologic grounds these components seem to belong together so that their distances would be about equal. It is hard to believe that they would form part of a distant “spiral arm” drawn far out of the plane. The second large complex, around \( l \approx 120^\circ, b \approx +50^\circ \), shows two distinct velocity groups, \( V \approx -140 \) km/s and \( V \approx -115 \) km/s. Attributing them to two different spiral arms, as Verschuur suggests, would give a picture in which two high latitude spiral arms show their highest intensities at the same place. Furthermore, identifying these arms with Verschuur’s \( \gamma \) and \( \delta \)
feature, ignoring a \( \cos b \) effect is premature. His Fig. 4 shows that the radial velocity is hardly dependent on \( z \), so a feature, extending over 50° in latitude must show a \( \cos b \) effect and this makes identification impossible, unless the feature can be continuously followed over all latitudes, which is clearly not the case according to Verschuur's Fig. 1.

The arms in the plane show many bifurcations and terminations and it should be a bit surprising if the five arms which Verschuur delineates outside the Perseus arm should keep their identity over almost 180° over the sky. It also seems possible that in the \( l-V \) diagrams the ridges cross over giving at some places a lower negative velocity for a more distant arm than for its neighbouring arm. We feel that it is impossible to use radial velocities as distance indicators for the higher latitude objects (cf. the foregoing description of the two high-velocity complexes).

Another complex of clouds which poses difficulties are the objects in the anticentre, exhibiting velocities of \(-100\) and \(-200\) km/s. While these objects are probably physically related Verschuur's model predicts totally different distances. The explanation of two other interesting objects, the complex extending from the galactic south pole to about \( l \approx 90°, b \approx -30° \), described by Wannier and Wrixon (1972), and the intermediate-velocity material near both galactic poles, are already supposed to be different from his model by Verschuur himself.

Beside in the galactic polar caps the effects of possible infalling matter might also be observed in low-latitude regions around the anticentre. Margaret Kepner (1970) as well as Nan Dieter (1971) had already shown the existence of hydrogen with high negative velocities over a large interval of \( l \) as well as \( b \) in this general direction. The large radial motions towards the galactic centre might be ascribed to just anomalous motions of the outer spiral arms, as suggested by Verschuur and by Davies, but it is perhaps simpler to ascribe them — as in the case of the high-latitude clouds — to the action of matter falling in from outside.

In conclusion we wish to point out a misunderstanding that has arisen about the hypothesis of infalling extragalactic gas. In several publications this has been wrongly interpreted as meaning that high-velocity clouds would be intergalactic clouds raining into the Galaxy. The actual hypothesis (cf. Oort, 1966, 1969 and 1970) was that these clouds consist largely of normal galactic gas situated in the outskirts of the Galaxy or in a transition region between halo and galactic layer. It is only their high velocities which would be due to extra-galactic pressure. Therefore their location in the Galaxy is normal and presumably associated with spiral arms, only their velocities are anomalous, and cannot give any information on distances.

The instability and life-time problems of high-velocity complexes are solved quite naturally on the hypothesis of interaction of intergalactic wind with halo gas.

References


A. N. M. Hulsbosch
J. H. Oort
Leiden Observatory
Leiden, The Netherlands