Solar Motion with Respect to the High-velocity HI Clouds and to the Local Group

WE have derived[1] the solar motion with respect to galaxies at different distances and have shown how the solar apex varies systematically with the distance of the reference objects.

The intriguing suggestion of Kerr[2] that the high-velocity HI clouds may be satellites of the galaxy has been recently examined by Verschuur[3], who goes further and considers them as possibly extragalactic and purely gaseous members of the local group. We have re-examined the problem in terms of the solar apex and velocity which by comparison with corresponding values for the local group may give some indication of the relationships between the galaxy, the local group and the system of the low-velocity HI clouds.

Revised solutions for the local group, including two possible new members, IC10 (ref. 4) and IC342 (ref. 5), are shown in Table 1. Solutions with and without a K term are shown for equations of the form

$$V = V_{\odot} \cos A \quad (1)$$

$$V = C + V_{\odot} \cos A \quad (2)$$

$$V = K\Delta + V_{\odot} \cos A \quad (3)$$

where $V_{\odot}$ is the solar velocity in km s^{-1}, A is the angular distance from object to solar apex, C is the assumed zero point error in red-shift data, $K\Delta$ is the expansion velocity if the law of red-shifts operates within the local group (K is the expansion parameter, Δ the distance in Mpc). Galactic coordinates l, b of apex are in system II; all errors are mean errors; σ is r.m.s. residual of solutions.

All solutions point to $l \simeq 95° \pm 10°$, $b = -15° \pm 7°$, $V_{\odot} = 325 \pm 30$. Note in particular that, although the longitude does not depart significantly from 90°, the apex is consistently south of the galactic plane, and the velocity is higher than the current value (250) for galactic rotation. This may or may not be significant depending on the unknown contribution of the motion of the galactic centre in the local group (ref. 1 contains solutions corrected for solar motion toward classical apex and galactic rotation).

Solutions for solar motion with respect to the high-velocity HI clouds were based on the seventeen cloud complexes listed by Verschuur[3]. The observed velocities used were values with respect to the local standard of rest. Solutions for equations of the forms 1 and 2 are listed in Table 2. No solution for the form 3 is possible as long as Δ is unknown. Cloud complexes are numbered C1 to C17 as in Table 1 of ref. 3.

Solutions of type 1 have a certain similarity with corresponding solutions in Table 1; the apex is still south of the galactic plane. Its longitude is, however, shifted 50° from that of galactic rotation and the velocity is over 100 km s^{-1} less, resembling that of solar motion solutions with respect to the system of globular clusters[6], $l = 91°{\cdot}0 \pm 7°{\cdot}5$, $b = -4°{\cdot}1 \pm 7°{\cdot}6$, $V_{\odot}(\oplus) = 168 \pm 27$ ($n = 70$). If, as seems plausible, the correct interpretation for the low value of $V_{\odot}(\oplus)$ is that the system of globular clusters as a whole has a net angular momentum with respect to galactocentric inertial axes, the same interpretation could be placed on the low value of $V_{\odot}$ with respect to the HI cloud complexes. The high-velocity HI clouds would then clearly be close satellites of the galaxy or loosely bound wisps of turbulent gas in the galactic corona.

Note, however, that solutions of the form 2 give widely different values for l, b and $V_{\odot}$ and a much better fit as judged by the r.m.s. residual σ. This instability of the solution for the solar apex with respect to the HI clouds is not observed in the case of local group members. A possible cause is incompleteness of the data, especially in the southern hemisphere, giving an artificial asymmetry. We have observed that this effect is quite pronounced and leads to spurious solutions, especially in the presence of a K term, as for galaxies; it seems unlikely, however, that a large K term would be present in the case of the HI clouds, even if they should prove to be distant members of the local group rather than close fragments of the galactic hydrogen layer.

After this study was completed we learned that Kerr and Sullivan[7] are studying the problem of the high-velocity clouds by several methods, including the solar motion approach, so that we do not propose to follow up the subject unless these clouds do eventually turn out to be truly extragalactic. On present evidence this hypothesis does not seem particularly probable to us.

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Primordial Helium Production in "Magnetic" Cosmologies

O'Connell and Matese[1] and L. Fassio-Canuto (private communication) have shown that in the presence of a very intense magnetic field ($B \gtrsim 10^{13}$ G) the neutron should decay more rapidly than in the field-free case. If such fields had existed during the very early stages of a big-bang cosmology, they would clearly have altered the primordial helium abundance to be expected. O'Connell and Matese[1] pointed out that the decrease in the neutron half-life would tend to reduce this abundance. We give here an analysis of the other effects such a field would have, and conclude that for 10^{12} G $\lesssim B \lesssim 10^{17}$ G at the epoch of nucleosynthesis either too much helium or too much deuterium and helium-3 would have been produced. This is good evidence that such fields could

Table 1. SOLAR MOTION WITH RESPECT TO LOCAL GROUP

Solution	l	b	V	C	K	σ	n	Largest residuals	Rejected
1*a*	85 ± 11	−12 ± 9	311 ± 48	—	—	91	14	IC10 (−93), IC342 (+217)	
1*b*	95 ± 8	−8 ± 5	315 ± 26	—	—	57	13	IC1613 (−70), A1009 (+91)	IC342 (+268)
2*a*	95 ± 12	−25 ± 9	241 ± 40	72 ± 34	—	79	14	IC10 (−129), IC342 (+174)	
2*b*	100 ± 7	−17 ± 6	333 ± 23	46 ± 22	—	49	13	IC10 (−87), NGC221 (+53)	IC342 (+234)
3*a*	97 ± 11	−15 ± 7	342 ± 37	—	85 ± 37	77	14	IC10 (−143), IC342 (+153)	

Table 2. SOLAR MOTION WITH RESPECT TO HI CLOUD COMPLEXES

Solution	l	b	V	C	σ	n	Largest residuals	Rejected
1*a*	139 ± 16	−13 ± 13	184 ± 66	—	107	17	C12 (−331), C16 (+85)	
1*b*	148 ± 7	−12 ± 5	234 ± 29	—	50	16	C5 (−75), C16 (+75)	C12 (−389)
2*a*	334 ± 96	+66 ± 34	37 ± 24	127 ± 13	45	17	C1 (−50), C12 (+97)	
2*b*	332 ± 21	+32 ± 14	58 ± 21	110 ± 11	32	16	C6 (−50), C4 (+44)	C12 (+143)