WHAT HAPPENED TO STELLAR DRIFTS?

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The concepts of a local standard of rest and a standard solar motion and the nature of the data giving rise to these concepts are so much part of the given knowledge of galactic astronomy that it hardly seems possible that anything new might be learnt from continued study of this subject. But the examination of local stellar kinematics is by no means a tidy subject, and the history of its development does conceal one or two peculiarities which bear reconsideration.

At the turn of the century, it was generally accepted that nearby stellar motions possessed random properties which could be described by a velocity sphere. The centre of this sphere represented a vector in velocity space relative to the sun of very nearly 20 kms^{-1} the reflex of the standard solar motion. In modern coordinates the components of this motion in the galactic plane may be given by

$u = -10 \qquad v = -15$

It had long been clear however that the concept of a velocity sphere was not a satisfactory one, and it was Kapteyn (eg 1905) who first showed that a better representation of the data could be achieved by <u>two</u> velocity spheres. His hypothesis led to the identification of two streams amongst the motion of bright stars with <u>approximate</u> galactic components (in the plane) given by

Drift I	$u = -22$	$v = -15$
Drift II	$u = +8$	$v = -15$
	$(\bar{u} = -10$	$\bar{v} = -15)$

The relative concentrations of the two drifts appeared to vary with spectral type and apparent magnitude but at the brightest levels were around I : II = 3 : 2. Very soon afterwards Schwarzchild (1907) suggested that the data could equally well be represented by a velocity ellipsoid whose centre corresponds closely to that of the standard solar motion and whose longest axis was oriented along the line of motions between Drift I and Drift II. At this time, no explanation for the greater "mobility" along this axis was ventured, but there were many attractions in the conceptual simplicity of Schwarzchild's scheme.

A useful landmark in the discussion of these two "theories" is Eddington's book "Stellar Movements and the Structure of the Universe" (1914), which was written before the development of the theory of galactic rotation. In this book, the physically different nature of the two "theories" is made clear and Eddington evidently takes a neutral stance in relation to which is preferable. As is well known, the ellipsoidal theory eventually gained ascendancy because physical reasons (related to rotation in the galactic gravity field) were found for the ratio of the σ_u and σ_v axes of the velocity ellipsoid, and the orientation of the major axis towards the galactic centre. What is not so well known is that a great deal of effort was devoted to the search for a physical characteristic which would enable one to distinguish Drift I from Drift II by some criterion other than kinematics. Indeed, by 1930, it was reasonably clear that the Drifts had different luminosity functions in the sense that Drift II lacked O, B and A stars (eg see Eddington, loc. cit.). But the theory of stellar evolution was not sufficiently advanced at this time for the effect to be seen as the result of difference in age of the two Drifts. Had such an effect been established, there can be little doubt that the ellipsoidal theory in its simplest form would have been untenable. It is interesting to reflect on possible reasons for the ultimate failure to realise that the Drifts may have separate identities which could not be submerged in a single velocity ellipsoid. It seems very likely that the rise of the theory of galactic rotation and the fact that it drew attention to the behaviour of very distant O, B stars, led interest away from the properties of nearby stars out of which the concept of two streams had originated.

During more recent years, there has been a continued improvement in the data describing the properties of nearby stars, but the fact that a significant population of stars exists moving in the general direction of the fourth quadrant of galactic longitude is not widely known. This is perhaps well illustrated by Eggen's careful work on nearby A-stars (1963) which belong to Drift I. Eggen has shown that the distribution of A-stars in velocity space has structure and divides into four main groups, namely

Pleiades	$u = -10$,	$v = -30$
Hyades	$u = -40$,	$v = -10$
Coma	$u = -10$,	$v = -10$
Sirius	$u = +17$,	$v = +5$

Taken together, these groups and other outlying stars may be considered to describe a deviated velocity ellipsoid, but their distribution is chiefly significant for the total lack of stars going towards the fourth quadrant (ie $u>0$, $v<0$).

Let us now consider some modern observations by Upgren (1976). He has examined objective prism sampled M-dwarfs in the solar neighbourhood possessing trigonometric parallaxes and K-line emission indices which are usually interpreted as a measure of age (eg Wilson, 1963). With a sample of 140 stars, it is found (eg Clube, 1977) that they divide on the basis of their K-line indices into two groups such that

	CaII	Age		
Group A	>0	$<5.10^8$	$u = -9$	$v = -16$
Group B	≤0	$\tilde{}5.10^9$	$u = +20$	$v = -17$
			$\bar{u} = 0$	$\bar{v} = -16$

the relative concentrations of the two groups being about A : B = 2 : 1. The exact association between Drifts I and II and the Groups A and B derived from Upgren's results is not fully established and must await publication of Upgren's complete data, but there is sufficient similarity to justify the conclusion that

$$\mathrm{I} \simeq \mathrm{A} \qquad \text{and} \qquad \mathrm{II} \simeq \mathrm{B}$$

thereby bringing the K-line ages of A, B in line with the evolutionary age differences suggested by I and II's luminosity functions. It seems that Kapteyn's hypothesis of two star streams provides a rather more accurate description of local stellar kinematics than is generally supposed, even though Drift I is by no means a population of uniform age.

The question now arises as to where the local standard of rest should be placed. Dynamical theory would suggest that Drift II, being composed of stars with relatively well mixed orbits ($\tau \sim 5.10^9$ years), is to be preferred to either Drift I, which is largely composed of younger stars ($\tau \lesssim 5.10^8$ years), or any combination of Drifts I and II. This interpretation of stellar kinematics requires us to recognise that the conventional local standard of rest (which approximates to that of Drift I) is moving outwards in the galaxy at ~ 30 kms^{-1}.

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