HYDRODYNAMICAL DESCRIPTION OF STELLAR MOTIONS

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1. Introduction

In the study of the structure of our galaxy and of the stars contained in it one encounters the problem of the space and velocity distributions of stars belonging to various sets. Of greatest theoretical interest are those investigations which deal with sets whose members are selected on the basis of such intrinsic attributes as luminosity or spectral characteristics. The general concern is with the properties of a function

$$\psi\,(x, y, z; \dot{x}, \dot{y}, \dot{z}; t)$$

giving the number of stars, at time t, in the neighborhood of point x, y, z and velocity $\dot{x}, \dot{y}, \dot{z}$, reckoned per unit volume and per unit range of velocities, which belong to a particular set. The function ψ can and does depend on the set criteria.

Here we are not directly concerned with the methods that have been used to determine the nature of such distributions from statistical treatments of observed characteristics. It is sufficient to point out that our present knowledge is largely confined to the neighborhood of the sun and has been derived only after involved discussions of the effects of observational and sampling errors. Moreover the time interval over which observations have been made is so brief as to be hopelessly inadequate for revealing any significant changes.

In this paper we shall be concerned with the dynamical theory used in the study of the function ψ and, particularly, with the specific methods that this theory may employ. We consider first a brief summary of the main kinematical features that observations reveal, secondly a statement of the basic theoretical formulation of the problems to be considered, thirdly an account of methods that have been utilized, and finally a proposed modification in the mode of attack on the basic problem. This final section uses a representation of the statistics of stellar motions in what is substantially a hydrodynamical scheme.

Before proceeding with these points we must note that the problems encountered in the study of our galaxy are paralleled by similar problems for other galaxies. While the observational techniques are different, the theoretical problems are similar. Moreover, facts discovered for these objects bear directly on the study and interpretation of our own system.

2. Summary of kinematical characteristics

The general form of the function $\psi(x, y, z; \dot{x}, \dot{y}, \dot{z}; t)$ implies the possibility of defining, for each point in space and time, an average velocity. Let

$$n = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\psi\,(x, y, z; \dot{x}, \dot{y}, \dot{z}; t)\,d\dot{x}d\dot{y}d\dot{z} \tag{1}$$