DYNAMIC INSTABILITY OF THE χ AND h Per ASSOCIATION

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In a recent paper [1], we proposed a method for the investigation of the stellar velocity distribution in spherically symmetric systems, using the residual radial velocities of these stars and their observed distribution projected onto the celestial sphere. The use of this method in connection with a synthetic association of O-B stars indicates that there is a regular increase in the mean density with distance from the center of the system [1, 2]. It is precisely this type of result that one would expect [3] for an expanding system in which the expansion velocity exhibits appreciable dispersion. We have discussed this fact as evidence for the expansion of stellar associations and, consequently, their dynamic instability.

The relation between the mean expansion velocity and the corresponding distance from the center of the system, established in [1, 2] and by a less accurate method in the earlier papers [3, 4], refers to the synthetic association of O-B stars, i.e., a set of known O-associations as a whole. Therefore, the conclusion about the expansion and the dynamic instability of these systems drawn in these papers is valid only on the average. This does not mean, however, that some of the components of the synthetic association may turn out to be stable.

In view of the foregoing, there is definite interest in the conclusion reported recently by Kholopov [5] that, in many cases, O-associations are ordinary, dynamically stable, young stellar clusters. In the present paper we shall investigate the dynamic stability of such systems, including in particular χ and h Per system.

Unfortunately, the application of our method [1] to individual associations with a view to establishing the dynamic stability is complicated by the absence of radial velocities for a sufficient number of members. However, the χ and h Per system is an exception and will be discussed below.

We have used the radial velocities and the distribution in projection onto the celestial sphere of 38 O-B stars in the χ and h Per association, using the data given in [6]. The midpoint of the segment joining the two nuclei of the system in projection onto the celestial sphere was taken as the center of the distribution, and the radial velocity of the center of the system was taken to be the mean radial velocity of all the 38 stars (−40.7 km/sec). The distance of the association was assumed to be 2.1 kpc [6]. Using these data and the formulas given by Eqs. (19)-(21) in [1] for different plane-parallel sections through the χ and h Per system, we calculated the following quantities: $\bar{v}$, – the mean space velocity of the stars within a given plane-parallel section, and $\bar{r}$, the mean distance of these stars from the center of the association [1]. The results are shown graphically in Fig. 1. The straight line in this figure was obtained by the method of least squares. It is clear from Fig. 1 that $\bar{v}(\bar{r})$ is an increasing linear function. It was shown in [1] that an increasing $\bar{v}(\bar{r})$ implies that $v(r)$ is also an increasing function (it represents the mean space velocity v as a function of distance r from the center of the system). If the function $\bar{v}(\bar{r})$ is linear, then $v(r)$ should also be linear. It is important to note that, according to [1], the linearity of $\bar{v}(\bar{r})$ or $v(r)$ continues up to the neighborhood of the center of the system.

We note that, in accordance with the function $\bar{v}(\bar{r})$ which we have obtained (Fig. 1), $\bar{v}$ tends to zero at a finite distance from the adopted center of the system. This may be due to the fact that the system has two nuclei, which was not taken into account in our calculations. However, for our purpose, it is quite sufficient to determine the overall behavior of $\bar{v}(\bar{r})$, namely, the fact that it increases with increasing mean distance.

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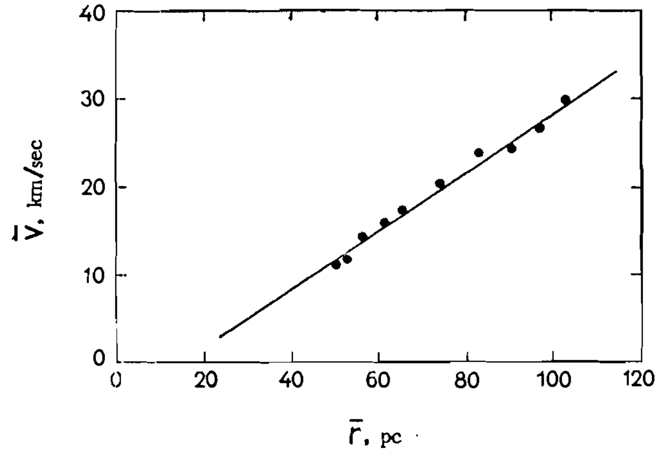

Fig. 1

Thus, the analysis based on the data on 38 O - B stars in the χ and h Per association shows that their mean space velocity increases with increasing distance from the center. As already noted in [3], it is precisely this type of relationship between $\overline{v}$ and ($\overline{r}$) which characterizes expanding systems with substantial dispersion of the expansion velocity.

Hence, the function $\overline{v}(\overline{r})$ shown in Fig. 1 can be looked upon as evidence in favor of the dynamic instability of the χ and h Per association.

All that remains is to add that the dynamic estimates of the age of the association based on the above ideas yield a figure of the order of 10^7 years [6-8]. It is clear that the dynamic age of an association is always greater than the ratio $\overline{r}/\overline{v}$ because of the substantial dispersion in the expansion velocities for each value of $\overline{r}$. The figure of 10^7 years is higher by an order of magnitude than the result given by Kholopov in [5]. When this is taken into account we can explain (without introducing very high expansion velocities) the distribution of the O - B stars around the nuclei of the association, using the theory that the stars which occupy the volume of the "corona" originate in these nuclei. This explanation is in complete agreement with the Ambartsumyan theory [9] of the origin and development of stars in stellar associations.

For the sake of completeness, we must note that the increase in $\overline{v}$ with increasing $\overline{r}$ can also, at least in principle, be explained in other ways, but these alternative interpretations have a very low probability. They are, in fact, unconnected with the hypothesis of expansions of stellar associations [1, 3]. One of these alternative interpretations involves the assumption that there is a galactic background of O - B stars which is projected onto the given association in such a way that stars belonging to this background have velocities relative to the center of gravity of the association which are considerably greater than the velocities of the members of the association. The observed function $\overline{v}(\overline{r})$ can then be interpreted as a consequence of different percentage concentration of O - B stars of the above two types at different distances from the center. In other words, one has to assume that large values of $\overline{v}$, as one departs from the center of the system, are due to the reduction in the number of O–B stars in the system, but there is an increase in the number of background O - B stars in the overall galactic field. This interpretation seems to us to be artificial and, moreover, if it is valid there is no need for the existence of an O - B corona around the χ and h Per cluster.

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