GROUPINGS OF POPULATION I OBJECTS IN THE GALAXY

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ABSTRACT. The distribution of Cepheids in the Galaxy is studied using a new catalogue of Cepheid distances in conjunction with the method of hierarchical clustering. The resulting delineation of Cepheid complexes is compared with those for other Population I objects: open clusters and OB-associations. Parameters derived for complexes of Cepheids are very similar to those for open clusters and OB-associations: the typical dimension of first level groups is ∼0.2 kpc, while the size of complexes is ∼0.9 kpc. Mostly the complexes of different objects are spatially coincident, but not always.

Key words: Stars: Cepheids; open clusters; OB-associations; stars: complexes

1. Introduction

The distribution of Cepheids (Berdnikov 1987a) and Cepheid groupings (Berdnikov & Efremov 1989) in the Galaxy were studied previously using an earlier version of a Catalogue of distances for Galactic Cepheids (Berdnikov 1987b), containing data for 363 objects. We have since collected extensive new photoelectric data (available on-line at http://www.sai.msu.su/groups/cluster/CEP/PHE/cepheids-16-03-2006.zip) that, in combination with published photometry, increases the number of stars with reliable distances by ∼42% (Berdnikov 2006). Additional refinements were to the distances of open clusters observed photoelectrically (Glushkova, in preparation). As a result, it is possible to conduct a new study of groupings of Cepheids in our Galaxy and to compare Cepheid complexes with complexes of open clusters and OB-associations (Melnik & Efremov 1995), whose distances are on the same scale as those for Cepheids and open clusters.
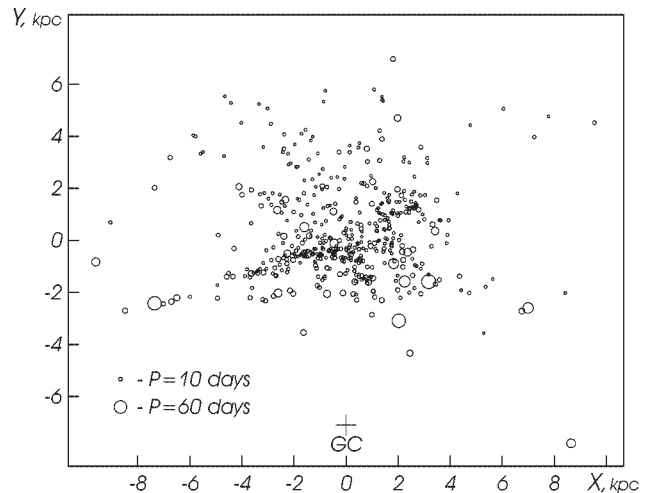

Figure 1: Distribution of Cepheids in the Galaxy.

2. The Distribution of Cepheid Complexes

The resulting distribution of 515 Cepheids in the Galactic plane, shown in Fig. 1, was analyzed by the method of hierarchical clustering described in the previous analysis of Cepheid spatial distributions (Berdnikov & Efremov 1989). Clustering results are depicted for two maximal distances, D_{max}, between Cepheid subgroups united in the same complex: 600 pc (Fig. 2) and 800 pc (Fig.3).

The resulting distribution of Cepheid clusterings in the Galactic plane is about the same in both cases, apart from a bit different separation between the Car-Sgr arm and the Local arm. It is important to note that within ∼2 kpc of the Sun the density of Cepheids (and open clusters) seems higher because of the reduced effects of observational selection.

Figs. 2a and 3a both illustrate the chain of Cepheid complexes lying along the Car-Sgr arm separated in distance by about 1 kpc. First level groups have roughly the same size, about 200 pc (Figs. 2b and
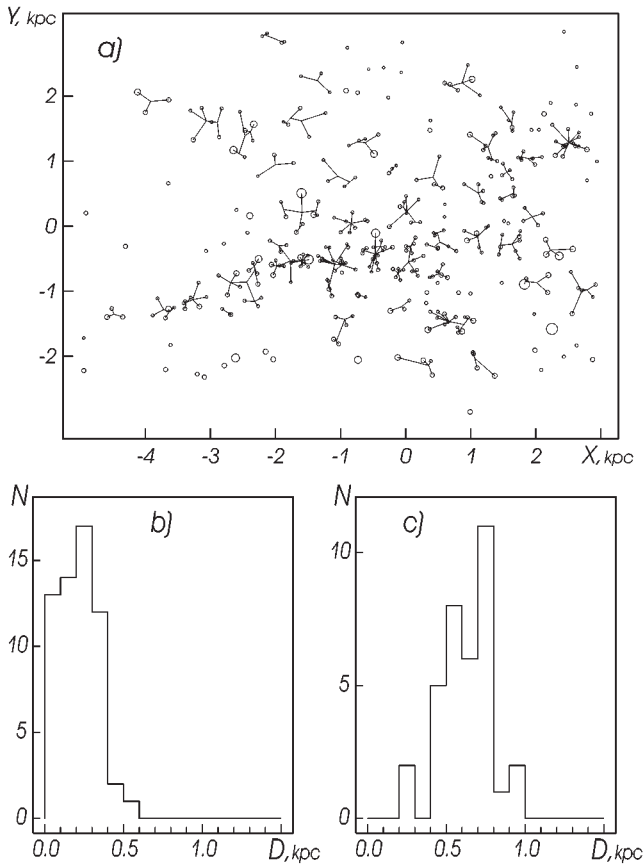
Figure 2: Results for D_{max} = 600 pc. a) Complexes of Cepheids in the galactic plane. b) Distribution in size of first level groupings. c) Distribution in size of Cepheid complexes.

Figure 3: The same as Fig. 2 for D_{max} = 800 pc.

3b), whereas the average size of the entire complexes are ∼640 pc for D_{max} = 600 pc and ∼900 pc for D_{max} = 800 pc (Figs. 2c and 3c).

3. Comparing the Distributions of Cepheids, Open Clusters, and OB-associations

Concentrations of open clusters and field stars mostly coincide, but notable differences sometimes occur. Examples of such disparities are recognized in the Milky Way galaxy, and more dramatically, in the LMC (Efremov 1989, p.204; Efremov 2002). In Fig. 4 complexes of Cepheids are depicted along with the location of open cluster complexes. Three clumps of clusters located well outside Cepheid complexes are found at (X = 0.2, Y = 1, 4), (X = −0.3, Y = −1.1) and (X = −2.0, Y = −1.0).

The distribution of young Cepheids, those with periods longer than 10 days, is shown in Fig. 5. The delineation of the Car-Sgr arm is evident from long-period Cepheids, while the existence of another inner arm (Cru-Scu) is strongly suspected. The Car-Sgr
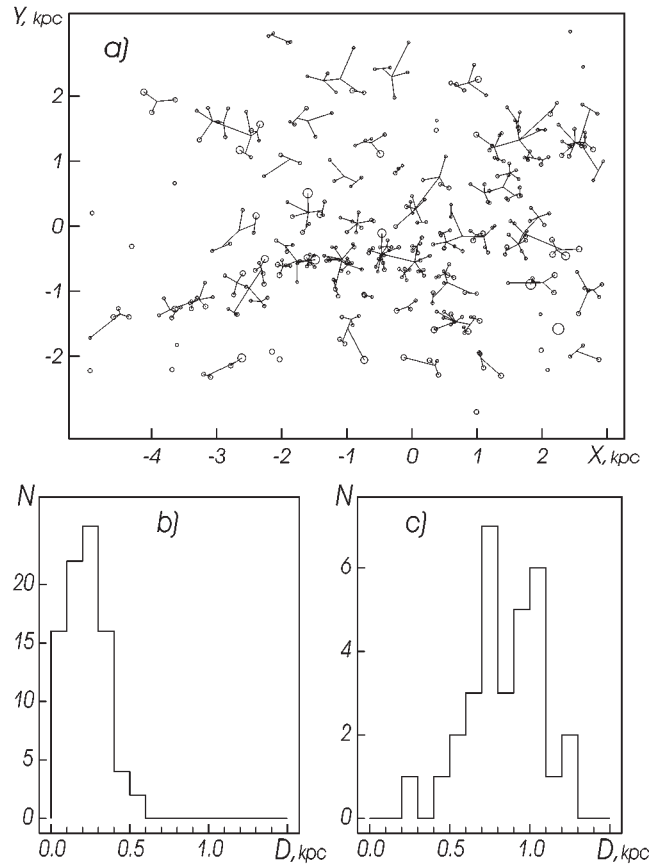
arm is also seen distinctly in the distribution of OB-associations (Fig. 6a), using data from the catalogue by Melnik & Efremov (1995). The size of first level groups is again ∼0.200 pc (Fig. 6b), while that of complexes is ∼1.0 kpc (Fig. 6c). We note the similarity of these dimensions to those obtained for Cepheids, which are on average ten times older than OB-stars.

OB-associations are located mostly along the inner part of the Car-Sgr arm relative to Cepheids (compare Fig. 3a and Fig. 6a). They form four complexes along the Car-Sgr arm that may be united into two super-complexes (similar to ones outlined by Efremov, 1995, fig. 4), between which lies a complex of older objects at (X = −1.0, Y = −1.0), as first noted by Avedisova (1989). The essential difference in age between adjacent complexes located along a spiral arm is also observed in other galaxies, such as M31 and M51; it is also seen in many color images of galaxies where pink complexes, bright in H_α, are adjacent to blue ones. The connection of the phenomenon to theories for the formation of gas/star complexes along a spiral arm should be studied.
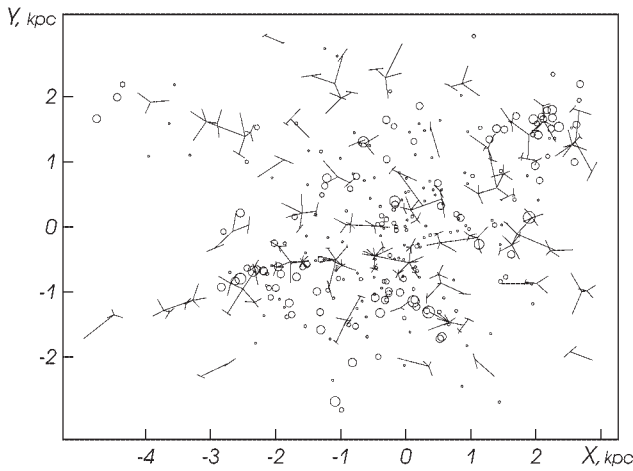
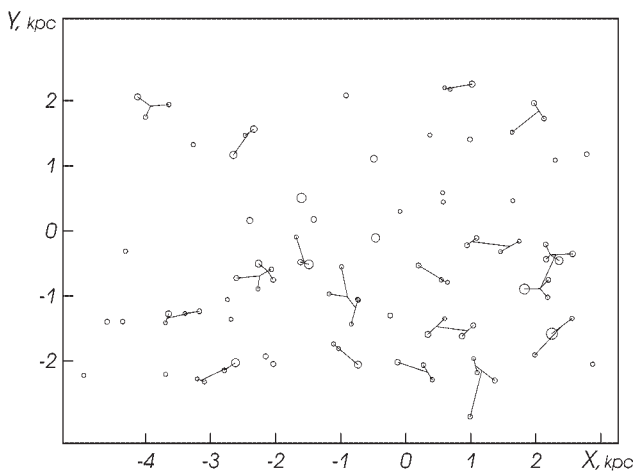Figure 4: Complexes of Cepheids and open clusters (circles) in the Galactic plane.

Figure 5: Distribution of Cepheids with periods longer than 10 days in the Galactic plane.

4. Conclusion

The parameters found for complexes of Cepheids, open clusters, and OB-associations are very similar. The size of the first level groups is always ~0.2 kpc, while the average size of the associated complexes is between ~0.6 kpc and ~1.0 kpc. The different types of complexes are mostly spatially coincident, but not always.

So far our conclusions are based upon a small number of complexes. It is necessary to initiate further searches for Cepheids and open clusters in order to increase the statistical confidence level of the results.

A complete study is to be published elsewhere. The catalogues of distances to Cepheids and open clusters are available upon request.
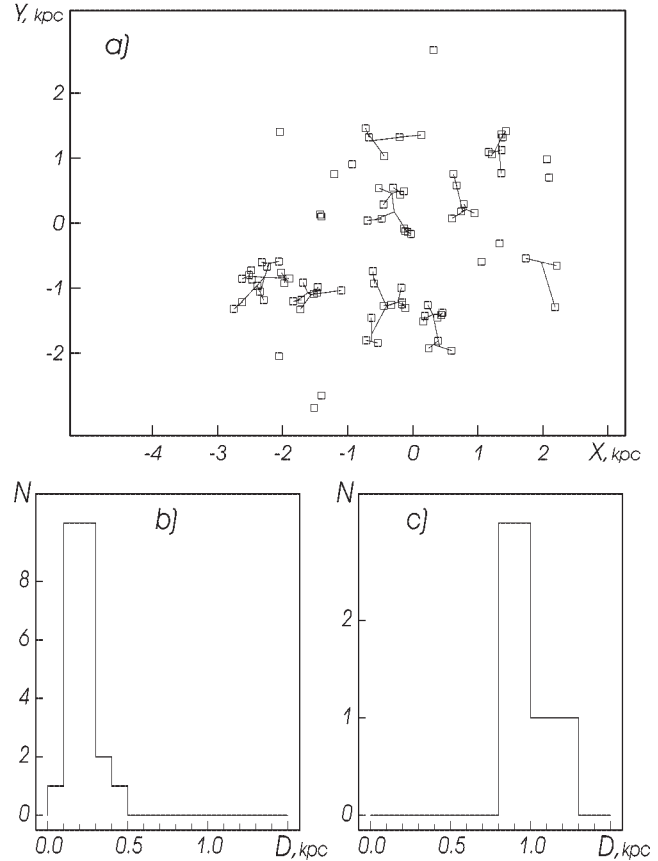

Figure 6: The same as Fig. 2 for OB-associations and $D_{max} = 800$ pc.

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