RADIO LOOPS IN ZONE OF AVOIDING OF OPEN CLUSTERS

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ABSTRACT. New catalogues have confirmed the existence of open clusters avoiding zone in the Sun's vicinity. Originally the zone has been found out by Shatsova & Anisimova in 1990. The zone is filled with the radio loops I - IV, the loops opened later and HI areas. Probably the system of open clusters forms a spatial lattice of the density waves. Internal parts of the loops are inside its cells. Shells are limited by the crests of waves.

Introduction

Distribution of open clusters (OC) is used for studying of Galaxy structure and kinematics for a long time. Areas of the increased density of OC are notable. So Platais et al. (1998) studying distribution of 93 OC according to Hipparcos at $r \leq 0.5$ kpc have noted a layer of ≈ 0.1 kpc thickness inclined to the galactic plane like the Gould Belt. Areas of the lowest density represent not smaller interest. In article of Platais et al. (1998) in a projection (x, y) round the Sun almost empty area of 0.5×0.25 kpc^2 is visible. It is a lot of OC on borders of this area. Authors have not noticed this fact for some reason.

But in 1990 Shatsova & Anisimova have paid attention to this area when there were 52 OC in the same volume at their disposal. Here there would be tens OC at uniform distribution in a layer. It is impossible to explain this emptiness by neither casual fluctuations, nor errors of distances and absorption of light around the Sun, nor any selection. Shatsova & Anisimova (1990a, 1990b) have assumed that anticorrelation of OC with known radio loops $I - IV$ in the same area can clear the situation. The physical and dynamic factors connected with high energy loops could create the avoiding zone of OC.

Several years ago we have checked up and have confirmed the results of works of 1990 with 104 OC from Dias et al. (2002) catalogue. The studied area has been expanded to $r \leq 0.6$ kpc. 80 OC are closer than 0.5 kpc. But there are no clusters in the space of the loops. This result has not been published.

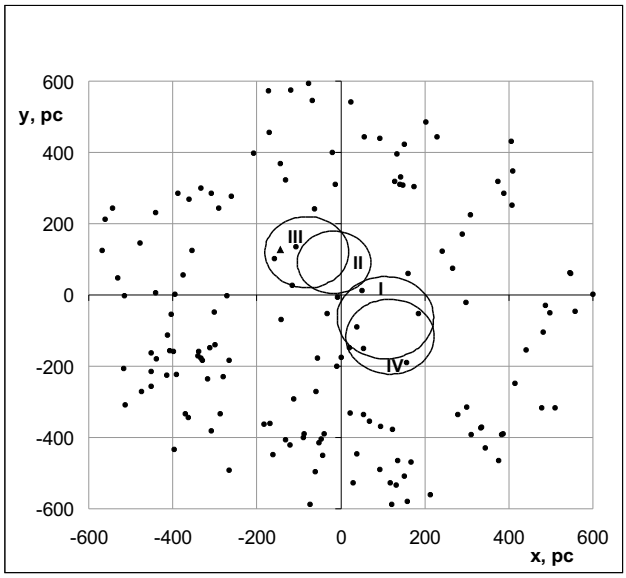

Figure 1: The projections of OC and loops $I - IV$ on the galactic plane

Zone of avoiding of OC

New, more detailed, examination is passed under Kharchenko et al. (2005) catalogues. They contain 148 OC in area with $r \leq 0.6$ kpc. Fig. 1 represents distribution of projections of OC on the galactic plane in coordinates (x, y), where x coordinate is directed towards the galactic centre, y – to galactic rotation. Projections of four radio loops according to Berkhuijsen (1973) are also shown. Similar representations of this system were given by Landecker & Wielebinski (1970) and Spoelstra (1972). 8 OC are only projected on the loops, their z-coordinates are out the loops. Only one of them – Platais 3 ($x = -144$, $y = 127$, $r = 161 - 200$ pc) as possible, but the yet not confirmed cluster, is in the Loop III (a triangle in Fig. 1).

Fig. 1 confirms a reality of OC avoiding zone near the Sun and specifies its borders: on $|x|$ and $|y|$ to $200 - 300$ pc, on $|z|$ – in tens pc. All large loops, small shells according to Hu (1981) and infrared loops from Könyves et al. (2007) catalogue are in this vol-

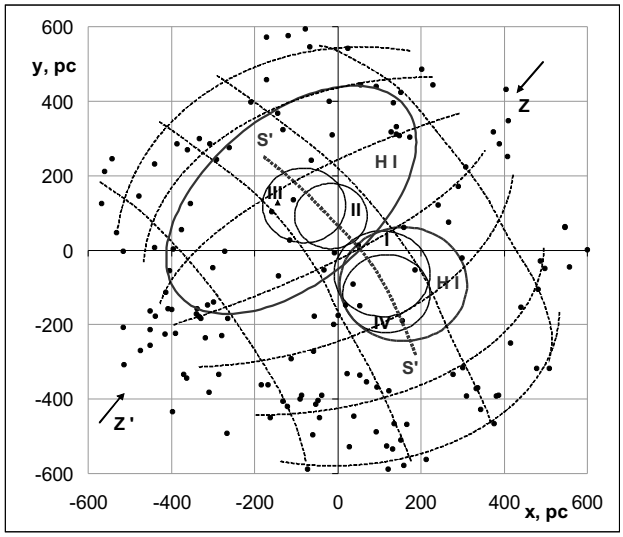

Figure 2: The (x, y)-projections of OC, the loops $I - IV$, H I shells and a variant of the density waves net (dashed lines)

ume. Fig. 1 confirms the anticorrelation OC – radio loops. However the avoiding zone is essentially larger than total volume of the loops. H I shells according to Davelaar et al. (1980) (basically in the fourth quadrant, including the Loops I and IV) and according to Olano (1982) or Lindblad ring (2000) (in the others quadrants, mainly in the second, with the Loops II and III) have the sizes greater than the loops.

Projections (x, z) and (y, z) show that OC fill rather thin layer ($\sim$ 0.1 kpc) inclined to the galactic plane at angle typical for the Gould Belt ($\sim 20°$). But the avoiding zone is not visible on these projections and on a projection to celestial sphere because of forward and far background.

The net of density waves in OC distribution

Long chains of OC in the Gould Belt layer serve as opposite display of non-uniformity of distribution. They also can be link to the system of loops. Shatsova & Anisimova (2002) have shown that the centers of four loops are located on a small circle of sky S' (dotted line in Fig. 2). Circle S' is the middle line of the Spur Belt. S' is perpendicular to one of axes of Local system - ZZ' (longitudes of poles $l = 48°$, $228°$; latitudes $b = \pm 21°$).

Narrow chains of OC are stretched along meridians of axis ZZ'. One of them passes as "corridor" between the Loops I and II. Two other chains touch with these loops outside. One more chain (at $y > 0$) passes on border of large H I area of Lindblad ring. The chain symmetric to it (at $y < 0$), probably, too outlines H I area, but greater than Davelaar et al. (1980) consider. Wide chains (or ridges) of OC are stretched along parallels of axis ZZ'. One pair covers from both sides of the Spur Belt. Another one is more close to poles Z and Z'. But drawing of such chains is less precisely because of ridge width and the greater errors of distances. The greatest OC density near Z' links to Eridanus complex.

The length of the chains is limited by the sizes of area. In total they form the net from two aggregates of the density waves with approximately identical wavelength equal to diameter of the loops ($\sim$ 200 pc). Probably, the density waves of smaller length are available in the third direction – perpendicular to the Gould Belt. Then it will be a spatial wave lattice.

So the crests of waves coincide with contours of some structures in the Sun vicinities: with loops, H I clouds, areas around poles. The troughs of cells coincide with their internal parts. Anticorrelation OC – loops is represented as a combination of the crests and the troughs of the net (lattice) of the density waves.

The geometrical picture of Fig. 2 is clearer than the physical one. But other interpretations of the loops (supernovae, stellar wind and collisions of clouds) are not clearer.

Table 1: Approximate parameters of the elements of the density waves net and the examples of projections of peculiar velocity of OC belonging to these elements. Units: x_i, y_i in pc; v_x, v_y in km s^{-1}.

i	x_i	y_i	N	OC Name	v_x	v_y
Meridians						
1	-460	430	10-15	NGC 752	-2.0	-5.3
				Stock 2	-13.6	-11.6
2	-330	240	10-15	Platais 2	2.2	3.5
3	30	-30	10-15	NGC 1977	-8.5	-2.6
				IC 4665	8.7	0.9
4	330	-240	5-10	Platais 10	-22.3	-1.6
				Alessi 21	-25.1	-4.0
5	460	-430	10-15	Alessi 5	-12.1	-5.4
				Vel OB 2	-12.4	2.5
Parallels						
1	-70	-170	10-15	Melotte 22	3.8	-11.6
				NGC 1901	-0.6	-19.1
2	170	220	10-15	Platais 12	-11.7	12.7
3	430	530	10-15	Roslund 5	4.4	-3.8
				NGC 6281	-7.2	7.4

Parameters of the elements of the density waves net and the examples of projections of peculiar velocity of OC belonging to these elements are given in Table 1. Here x_i, y_i are coordinates of intersections of the meridians and the parallels with coordinate axes, N – number of OC in the net element. There is an uncertainty in calculation of OC for which there is no data for v_r in areas near to intersection of the meridians and the parallels. Examples of projections v_x and v_y of peculiar velocity of OC belonging to the corresponding elements of the net are given in two last columns. Names of these OC are shown in the fifth

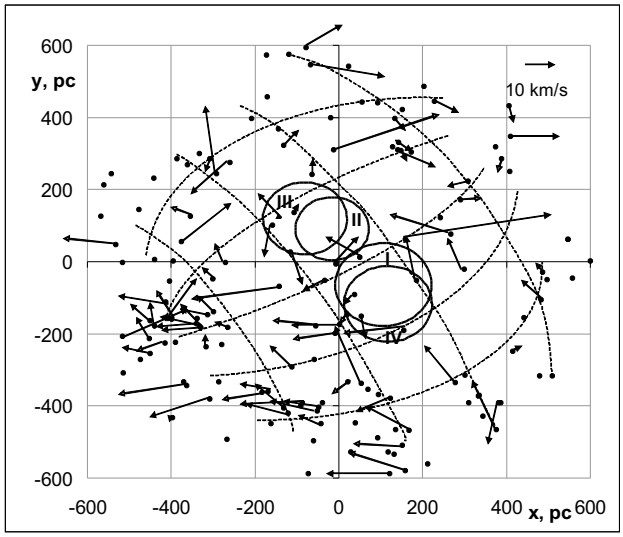

Figure 3: The (x, y)-projections of spatial peculiar velocity vectors of OC

column.

Kinematics of OC

The density waves net would be short-lived if peculiar motions of OC are chaotic. Therefore it is important to know their real motions. Platais et al. (1998) have offered motions relative to the Sun, basically reflecting motion of the Sun towards the apex. Shatsova & Anisimova (2002) have shown that the solar apex coincides with the Local system pole Z.

The Fig. 3 gives picture of peculiar motions in the (x, y)-plane for 2/3 of OC with known Vr. Primary motions along narrow meridian chains have greater values than in wide chains along parallels, where the disorder of velocity directions is more. It is difficult to separate the general expansion suspected in a number of articles from these features.

So the kinematics is compatible to wave structure of OC system. They should be considered together at the decision of all problems connected both with radio loops and with star clusters.

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