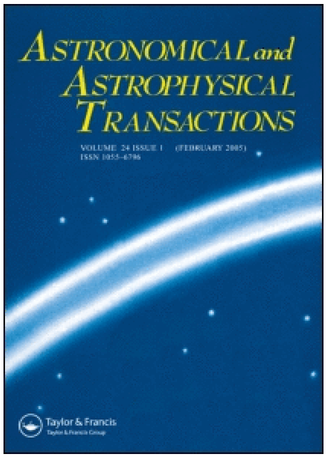

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Nikolai G. Bochkarev [a]
[a] Sternberg Astronomical Institute, Moscow, Russia

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LOCAL INTERSTELLAR MATTER AND INTERSTELLAR BUBBLES

NIKOLAI G. BOCHKAREV

Sternberg Astronomical Institute, Moscow 119899, Russia

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Giant bubbles in nearby galaxies and our Galaxy are observed in optics, radio, and X-rays and have different sizes and origins. The largest ones inside the region occupied by the spiral structure have diameters less than 300–400 pc. The Cygnus Superbubble is not an entity, but represent a result of projection of many sources onto the sky.

X-ray emission from bubbles blown by stellar winds has been predicted in the 1960s. The first Einstein data did not indicate any X-ray flux from Sh308 and RCW58. The most promising stellar wind nebula for X-ray observations is NGC 6888 and processing Einstein archival data reveals a soft X-ray emission whose flux is about 1/10 of the predicted one. A more careful modelling reduces the discrepancy down to a factor of 2 or 3.

The local stellar matter is an old giant bubble around the Sco-Cen stellar association. There are many cold and warm gas clouds inside the bubble. The Sun is probably isolated from the bubble by the Local Cloud. Loop I is an old SNR inside the bubble. Traces of several older bubbles are found near the Local bubble. The ROSAT soft X-ray survey is important for understanding the origin of the galactic soft X-ray background.

KEY WORDS Local interstellar matter, large scale structure of the ISM, giant interstellar bubbles, soft X-ray background.

1. INTRODUCTION

The local interstellar medium (LISM) is a region of the Galaxy with radius $R = 150$–200 pc near the Sun, connected with a giant bubble (the Local cavity). The center of the bubble is located inside the old B-stellar association Sco-Cen (Weaver, 1979). It is but one among many bubbles of the interstellar matter (ISM) in our Galaxy and outer galaxies, but it is a unique bubble which can be studied in many details. These details can be important for understanding bubble evolution, and the latter can be important for studying evolution of galaxies.

2. GIANT BUBBLES IN OTHER GALAXIES

Bubbles, hundreds of parsecs in diameter, prove to be a very common type of structure both in our Galaxy and in other spiral and irregular galaxies. External galaxies are most suitable objects for the identification of the objects of this type. Numerous HII shells about 100 pc in size have been found in the Magellanic Clouds (Goudis and Meaburn, 1978; Meaburn, 1980). Some spiral galaxies have been found to contain HII bubble regions up to about 300 pc in diameter inside the spiral structure (see summary of Sharov's 1982 data on M31 and M33). An example of a "foaming" galaxy is given by Brand and Zealey (1975).

Along with this type of bubbles, one can observe the so-called supergiant ring structures in irregular galaxies and peripheral parts of the spiral galaxies. Ten such objects, 600–1200 pc in diameter, were discovered in the Magellanic Clouds (Goudis and Meaburn, 1978; Meaburn, 1980), and a 3-kpc diameter ring was detected in the peripheral part of the galaxy NGC 157 (Zasov and Demin, 1979). Appleton *et al.* (1987) show one more example of a superring in the outer part of a galaxy. The largest structures in the Magellanic Clouds have blurred edges, in which one sometimes can notice a few shells, about 100 pc in diameter. The origin of objects with diameters $d < 300$–400 pc and with larger d's is probably different (see discussion in Bochkarev 1987b, 1990a).

3. GIANT BUBBLES IN OUR GALAXY

Interstellar absorption prevents optical study of giant bubbles in the Galaxy. Therefore they are searched for by various methods. Nevertheless, many HII bubbles were found on deep photographs of the Milky Way made, using an Hα filter, by Sivan (1974). Brand and Zealey (1975) give several examples of ring emission or absorption structures in the Galaxy. Georgelin *et al.* (1979) observed 13 giant HII shells optically. The giant envelope in the constellations Orion and Eridanus, associated with the star formation complex in Orion, was studied in detail by Reynolds and Ogden (1980), Goudis (1982), and Shestakova *et al.* (1988).

The Monogem ring structure in Monocerotis and Gemini was found on soft X-ray maps by Nousek *et al.* (1981). Heiles (1979, 1984) discovered about 50 supershells of neutral hydrogen in the Galaxy. Descriptions of a number of ring objects can be found in the monograph by Lozinskaya (1986). More than one reference also can be found in publications by Bochkarev (1984a, b). Superbubbles are also studied using Faraday rotation of the linear polarization plane of radiowaves (e.g. Vallee *et al.*, 1988 and references therein). Some average characteristics of giant bubbles in the Galaxy are given by Broten *et al.* (1985).

Note that no cavities exceeding about 350 pc in size and confined by matter are observed inside the spiral arms of the Galaxy or other galaxies (Bochkarev, 1984a, b). In connection with the data, special attention was paid to a giant ($13° \times 18°$) horseshoe-shaped source emitting soft X-rays. This is the Cygnus Superbubble discovered by Cash *et al.* (1980). They suggested that it represents a ring of optical filaments ($15° \times 13°$) noted by Ikhsanov (1960), Dickel *et al.* (1969) and Brand and Zealey (1975) and the Cyg OB2 association, located at the distance of 2 kpc from the Sun. In this case, its size is equal to 450×600 pc, that is, it could be the largest shell inside the spiral structure of our Galaxy.

Simultaneous explosion of 100 SNs (Cash *et al.*, 1980), superstrong steller winds from stars of Cyg OB2 association (Abbott *et al.*, 1981), or explosion of a single star with the mass of about 2000 $M_\odot$ (Blinnikov *et al.*, 1982) were suggested for interpretation of the Cyg Superbubble. Nevertheless, after a detailed analysis of numerous observational data in radio, IR, optics, and X-rays, Bochkarev and Sitnik (1983, 1985) showed that the Cyg Superbubble is not an entity, but a result of projection of many sources onto the sky, located at different distances from the Sun within the Local spiral arm, along which we are looking in the Cygnus direction. About 2/3 of the Superbubble X-ray emission can be ascribed to discrete sources, the rest being probably due to regions of coronal gas about 100 pc in diameter, created by stellar winds and, possibly, supernova explosions in individual associations Cyg OB1, 2, 3, 4, 7, 8 and 9. Interstellar absorption of the central part of the superbubble image by molecular clouds constituting the Great Rift produces its horseshoe shape. The objects that produce the X-ray and optical radiation of the apparent superbubble are located at distances from 0.5 to 2.5 kpc from the Sun.

4. X-RAYS FROM BUBBLES BLOWN BY STELLAR WINDS

Large-scale HII rings usually contain OB stellar association. Interaction of stellar winds with interstellar gas is assumed to be an important source of momentum and energy for these envelopes. A two-layered shock wave is formed in this case (Pikel'ner, 1968). Each layer evolves through energy-conserving and momentum-conserving phases, similar to SNRs. For the majority of nebulae blown by stellar winds, the decelerated layer of the stellar wind is observed in the adiabatic phase and the layer of compressed interstellar matter is observed in the radiative phase (Lozinskaya, 1986). The decelerated wind layer must be a source of soft X-rays (Pikel'ner, 1968). The structure of such a layer has been studied in the case of a nebula expanding into a homogeneous interstellar medium (Castor *et al.* 1975, Weaver *et al.* 1977).

The results of the first attempts to detect X-rays from the ring nebulae of this type were negative. The Einstein data did not indicate any X-ray flux from Sh308 and RCW 58 (Moffat *et al.* 1982). EXOSAT results on NGC 6888 have proved to be negative (Kahler *et al.* 1987). As a result, a suggestion that the stellar wind should rather effectively leak through the gaps of the regular shell structure was discussed (e.g. Lozinskaya, 1983, 1986).

Calculating X-ray fluxes from ring nebulae using the stellar wind-interstellar medium interaction model (Bochkarev, 1985) has shown that for two nebulae (NGC 6888 and S119) the flux is at the IPC (imaging proportional counter) detectability level of the Einstein observatory (Bochkarev and Lozinskaya, 1985). As a result of processing Einstein archival observation data, Bochkarev (1988a) found soft X-ray emission from NGC 6888, removing faint background sources in the vicinity of the nebula (Bochkarev, 1988b). A new class of X-ray sources, predicted some 20 years ago, has thus been discovered.

The spectral shape agrees completely with theoretical predictions, but the emitted flux is more than an order of magnitude less than the predictions. Bochkarev and Zhakov (1989, 1990) have made more detailed calculations of soft X-ray spectra and fluxes and show that the discrepancy between observations and the theoretical predictions for a homogeneous interstellar medium is only 2–3 times. Thus, X-ray spectra are a moderately good tool for analysis of bubbles blown by stellar winds.

5. LOCAL INTERSTELLAR MEDIUM (LISM)

5.1. *Methods Suitable for the Study of the LISM*

The LISM is an object which is spread over all sky, therefore it is difficult "to recognize a forest among trees". Moreover, the technique of kinematic distances is unsuitable as applied to distances less than 500 pc. That is why data on distances can be gathered only by studying the ISM against luminous background sources (usually stars) with known distances. This technique involves observations of a large number of objects. As a matter of fact, to employ 1000 stars does not enable one to get an average accuracy better than 10 pc in exploring a region $100 \times 100 \times 100\,pc^3$ in size. Usually ISM spatial structures are smaller than 10 pc while the diameter of the region under investigation (LISM) is substantially larger than 100 pc. None of the observational programs are capable of providing the necessary comprehensive data. Accordingly, one has to be satisfied with small, and usually random samples.

The LISM is characterized by a low mean density. As a whole, interstellar extinction (in the continuum) in this region is negligible (Lucke, 1978; Perry and Johnson, 1982; Perry *et al.*, 1982): the color excess E(B-V) amounts to 0.1^m at distances not less than 100 pc, and at much longer distances in most directions, thus failing to stand as a basis for studying the distribution of matter in the LISM. Extinction in optical spectral lines is also usually very small (Ardeberg *et al.*, 1984; Frisch and York, 1984; Crutcher and Lien, 1984). The more pronounced resonance lines of abundant ions are in the UV range, therefore UV observations have played a significant role in studying the LISM.

The survey of all the sky in soft (100–500 eV) X-rays made by McCammon *et al.* (1983) is very important (see also the review of McCammon and Sanders, 1990). Localization of the source of the X-ray background is a subject of active discussions. Basing on SAS-3 data, Clark (1984) and Morrison and Sanders (1984) argue for a non-local origin of the emission. Burrows (1984) and Nousek *et al.* (1984) use HEAD-1 data to propose that the main part of emission softer than 1 keV is of a local (LISM) nature. The same conclusion has been made by McCammon (1984), Sanders *et al.* (1984), Bochkarev (1987a, b; 1990a). Recent ROSAT observations of soft X-ray shadowing for Draco Cloud (Burrows and Mendenhall, 1991; Snowden *et al.*, 1991) seem to indicate that at least about a half of the emission can be non-local, but complicated structure of the ISM in the direction of the cloud (Lilienthal *et al.*, 1991) results in ambiguous interpretation of the data. Future ROSAT data about shadowing of soft X-ray background by interstellar clouds with known distances will be a very important source of information about the LISM.

Other significant sources of information about the LISM are all-sky surveys of HI (Heiles and Jenkins, 1976; Colomb *et al.*, 1980); very precise observations of interstellar polarization (with accuracy better than 0.01% (Piirola, 1977; Tinbergen, 1982) and interstellar extinction (Knude, 1979); interstellar absorption lines (many contributors); very faint emission in spectral lines Hα, Hβ (Reynolds, 1984a, b, 1988), and Lα, Lβ, and HeI 584 Å backgrounds which supply us with information about the nearest parts of the LISM.

The LISM is a very difficult object for investigations, but to the middle of 1980s so much information was obtained that collecting and summarizing this information became an important problem. This was done during two special meetings

(Kondo *et al.*, 1984, Gry and Wamsteker, 1986), in several reviews (Cox and Reynolds, 1987, Bochkarev, 1987b), and recently in a monograph by Bochkarev (1990a).

5.2. *The Local Interstellar Cloud*

Physical conditions prevailing in the immediate vicinity of the Sun are determined using the distribution of Lα, Lβ and HeI 584 Å backgrounds over the sky. These are formed by scattering of solar radiation by interstellar atoms penetrating into the Solar system. The solar wind creates a double-layer shock wave at the boundary of the ISM (Baranov *et al.*, 1979), limiting the heliosphere. The outer layer accommodates ISM particles. The shock wave is a boundary between solar and interstellar magnetic fields, as well as between charged particles of the solar wind and the ISM, closely coupled to the magnetic fields. Neutral species (i.e. atoms of HI, HeI, and the like) meet almost no obstacle in passing through the media interface and penetrating into the solar system. Inside the solar system, these neutral species move under the action of two forces: solar gravitation and solar radiation pressure (Kurt, 1982). For HI, 1216 Å radiation pressure prevails over gravitation, but for HeI quite the opposite relation of forces occurs. The atoms of HI are being ionized at an average distance of about 5 AU from the Sun, and HeI at about 0.3 AU, thus creating miniature HII and HeII regions around the Sun (e.g. Bertaux *et al.*, 1976; Dalaudier *et al.*, 1984).

Scattered background was discovered by Kurt (1965) in Lα and currently was studied in Lα, Lβ and HeI 584 Å lines. Analysis of the lines permits the determination of physical characteristics in the interstellar neutral component near the heliosphere and parameters of the motion of the solar system through the ISM. The most detailed analysis (Chassefiere *et al.*, 1988) shows that the neutral component of the ISM at a distance of 50–100 AU from the Sun (in the outer parts of the heliosphere) has a temperature $T = 7000 \pm 2000$ K, number densities $n(\text{HI}) = 0.065 \pm 0.010\ \text{cm}^{-3}$ and $n(\text{HeI}) = 0.008 \pm 0.004\ \text{cm}^{-3}$, and is moving with a velocity $V = 21.5 \pm 2.5$ km/s relative to the Sun. Outside the heliosphere, T is approximately the same and n can be greater than inside by the factor of $\leqslant 2$. The degree of ionization is undetermined but probably is comparable to 0.5 or a little less. Pressure is typical for the ISM: $nT \simeq 1000$–$2000\ \text{cm}^{-3}$ K.

Interstellar absorption lines in the spectra of nearby stars indicate that, within the region 2–5 pc around the Sun, the conditions in the LISM are relatively uniform, being similar to those over 1–5 pc distance, which vary within the range 0.05–0.2 cm^{-3} (McClintick *et al.*, 1978; Gry *et al.*, 1985; Murthy *et al.*, 1987). The kinematics of the gas is complicated (Lallement *et al.*, 1986; Ferlet *et al.*, 1986). Observation of the stars within 5–50 pc of the Sun has demonstrated that in most directions HI column density is $N = (1\text{–}3)\ 10^{18}\ \text{cm}^{-2}$, showing no growth with distance, while mean densities fall off with distance down to $<0.003\ \text{cm}^{-3}$ towards β and ε CMa (Paresce, 1984). This means that beyond the first 3–10 pc, the medium is much more rarified (see, e.g. McClintock *et al.*, 1978; Bruhweiler, 1984). The degree of the ISM ionization near the Sun is unknown (see discussion in Reynolds, 1986, 1990; Frisch *et al.*, 1987; Bochkarev, 1987a, b).

The largest column density of HI (near $10^{20}\ \text{cm}^{-2}$) is connected with the HI filament first described by Sancini and Van Woerden (1970). This consists of a

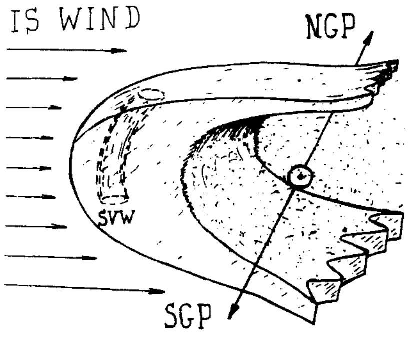

Figure 1 A schematic diagram of the interstellar wind flowing around the Local Cloud. The Sancisi–van Woerden filament (SvW) is embedded in the cloud at the left (Bochkarev, 1987a, b).

cold ($T < 200$ K), dense ($n \simeq 30\,\mathrm{cm}^{-3}$) gas. Centurion and Vladilo's (1991) UV absorption line analysis suggests the presence of a wall of gas at 40 ± 25 pc from the Sun.

Analysis of the polarimetric data of Tinbergen (1982) shows that stars with perceptible polarization ($p > 0.014\%$) occupy a broad patch in the sky. This "Tinbergen polarization patch" is centered near the Sancini–van Woerden filament, but the patch extends more than over 180°, approximately along the direction of the filament. It evidently surrounds the Sun from three sides, as portrayed in Figure 1 (Bochkarev, 1987a, b).

Thus, the solar system is embedded in a warm HI or HII corona of a local cloud of horseshoe-like shape.

5.3. *The Local Cavity*

As a result of detailed analysis of the complex of observational data relevant to the LISM, Bochkarev (1987a, b; 1990a) has drawn the picture of the Local bubble shown in Figure 2. The picture qualitatively corresponds to the one portrayed by Weaver (1979) and Cox and Reynolds (1987). There are a lot of details in the picture.

The center of the bubble is located in the well-studied old B-stellar association Sco-Cen (see Bochkarev, 1987b; 1990a and references therein). The cluster parallax of the association members gives a mean value of 0.0060″, which corresponds to a distance to the centre of the association equal to 170 pc (Bertiau, 1958). The age of the association is 6–20 million years and is different for different parts of the association (Underhill and Doasen, 1982). No O-star is within it, but the most massive (18–24 $M_\odot$) star Antares, was an O-star less than a million years ago (Bochkarev, 1987b). Interstellar matter within the association has a complicated structure and is studied in many details (Cappa de Nicolau and Poppel, 1986).

The Sun is embedded in the outer part of the Local Cavity, which is bordered by a system of elongated HI filaments recognized on all sky maps of the HI distribution (Heiles and Jenkins, 1976; Colomb *et al.,* 1980). Most of the cavity volume is filled by coronal gas with a temperature near $T = 1$ million K, number density $n \simeq 0.003\,\mathrm{cm}^{-3}$ and emission measure $\mathrm{EM} = 0.001$–$0.01\,\mathrm{pc\,cm}^{-6}$. It is observed mainly in soft X-rays (0.1–0.5 keV) (McCammon *et al.,* 1983). The

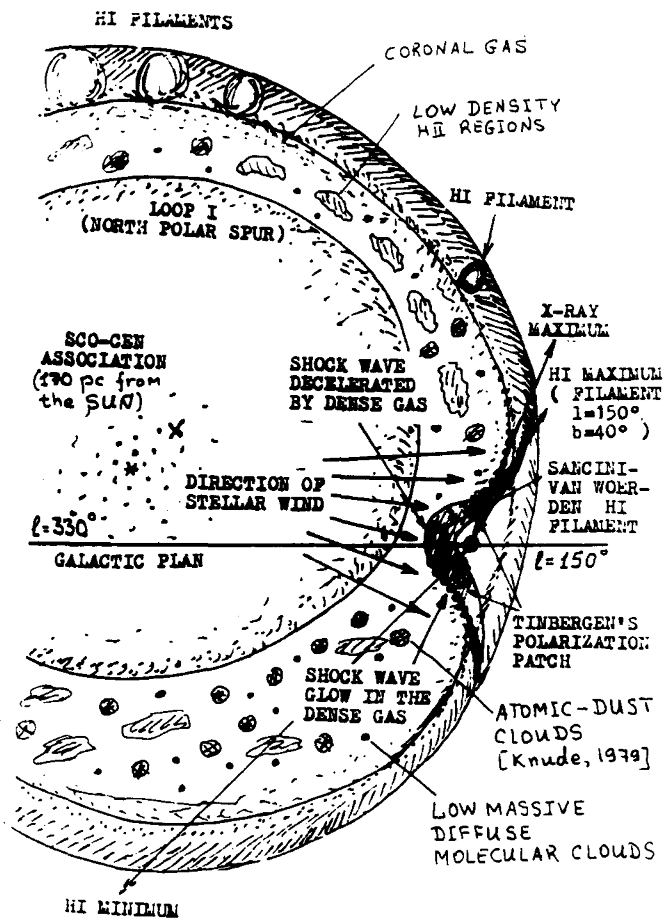

Figure 2 A schematic cross section of the Local Bubble by the 330°/150° galactic meridian. The Sun is at the circled dot (Bochkarev, 1987b, 1990).

Local Cloud isolates the Sun from the coronal gas (Bochkarev, 1987b) but not from X-rays. The reason of the latter is not clear. It could be a result of filamentary structure of the Local Cloud with the angular diameter of the filaments smaller than the angular resolution of X-ray observations (6–15°) and the number density of the gas between the filaments less than $0,8 \times 10^{19}\,\mathrm{cm}^{-2}$ (Juda *et al.*, 1991) or/and the fluorescence of the continuum X-ray flux by inner electronic shells of the ISM atoms. In any case, the hardness of soft X-ray background C/B (here B (130–180 eV) and C (160–280 eV) are Wisconsin survey bands—McCammon *et al.* 1983) toward the Local Cloud is about twice as large as that in the opposite direction (Snowden *et al.*, 1990).

Bochkarev (1987a) suggests that the interaction of the stellar winds of the Sco-Cen association with the Local Cloud (Sect. 5.2) produces maxima of soft X-ray emission in the bands B (130–180 eV) and C (160–284 eV) observed near the Galactic poles. He interpretes this as arising from a shock wave surrounding the Local Cloud. The northern brightening seems to be a caustic caused by a bend in a shock front shown in Figure 2: in this directions we are looking along the front.

The central part of the bubble volume is occupied by the North Polar Spur (Loop I). It is a giant SNR (Shklovsky and Sheffer, 1971) developed within very rarified hot coronal gas. Its radius is $\simeq 140$ pc and the gas is heated by a shock wave to $T = 3$–5 million K and has EM $\simeq 0.001$–0.01 pc cm^{-6} (Rocchia *et al.*, 1984).

5.4. *Low-density HII Regions in the Local Bubble*

Reynolds (1984a, b) has made a large-scale investigation of HII regions with low surface brightness. During the last decade, with a team of his co-workers he has been studying, using a large-aperture Fabry-Perct interferometer, a very faint sky luminescence in the hydrogen Hα line and a number of lines of other elements. The sensitivity of the instruments used (no worse than 0.5 Rayleigh and 0.1 R recently—Kutyrev and Reynolds (1989) and references therein) enables one to detect HII regions with emission measure on the order of 1 cm^{-6} pc. Measurements of this kind were begun at the Sternberg Astronomical Institute (Moscow, USSR) under the supervision of P. G. Scheglov (Zhidkov 1970, 1971) and are carried on by Kutyrev (1985) and Shestakova *et al.* (1988).

Comparison of the emission measures evaluated by an optical technique in the direction toward 72 radio pulsars with the dispersion measures of these pulsars has demonstrated that the emission originates in HII regions with density 0.1–0.2 cm^{-3}, and that the radiating regions occupy 10–30% of the ISM volume (Reynolds 1984a, b). These HII regions should extend over dozens of pc and be present not only in the LISM, but in other places of the ISM too.

Sources of ionizing photons for supporting the HII regions are not known. It is necessary to have 1.8×10^{48} photons/s for supporting ionization of the HII regions in the LISM (Reynolds, 1984a). According to Bochkarev's (1987a, b) calculations, stars of the Sco-Can association are emitting 1.1×10^{48} photons/s, but part of the photons are absorbed in faint HII regions around emitting stars (Bochkarev, 1990a). The HII regions in the LISM can be relics (Bochkarev, 1987b), because Antares was an O-star and emitted the proper quantity of ionizing photons only a few hundred thousand years ago.

Absorption lines of O VI and N V ions are very common in the UV spectra of the stars embedded in the LISM and are formed in the ISM (Jenkins, 1978, 1984). The most probable places of the line formation are the boundaries of the coronal gas with the aforementioned low-density HII regions (the so-called warm gas), or with cold gas clouds in the LISM (Jenkins, 1984). Inside the LISM, C IV and Si IV ions exist most plausibly in faint HII regions around hot white dwarfs (Cowie *et al.*, 1981; Dupree and Raymond, 1983), but there are probably several other important sources of the ions (Chevalier and Fransson, 1984; Suchkov, 1985; Suchkov and Shchekinov, 1986) located mainly beyond the LISM, e.g. in the galactic corona.

5.5. *Cold Gas in the Local Bubble*

Knude (1979, 1984) has carried out a number of careful measurements of color excess for 1200 A and F stars brighter than the 10th magnitude that had been

Table 1 High-latitude diffuse molecular clouds with estimated distances (Bochkarev, 1990a, b).

Cloud	*Coordinates (deg)*		*Distance (pc)*	*A_V in cloud center (mag)*
	l	*b*		
MBM55	89.2	−40.9	⩽175	0.5
MBM55A	105.1	−39.9	⩽275	0.5
L1228	112.0	+22.0	≃150	—
MBM26	136.4	+32.6	175 ± 50	0.6
MBM32	146.4	+39.6	⩽275	0.5
MBM7	150.4	−38.1	125 ± 50	0.9
MBM12 = L1457/8	159.4	−34.3	65 ± 5	0.4
MBM16	171.7	−37.7	60 ÷ 95	1.9
Pleiades	175.0	−18.0	140 ÷ 15	1.6
MBM18 = L1569	189.1	−36.0	⩽175	1.1
MBM20 = L1642	210.9	−36.5	70 ÷ 125	1.4
No. 113*	337.8	−23.0	⩽90	—
No. 126*	355.5	−21.1	≃100	—

MBM—Magnani, Blitz and Mundy (1985).
* Andreani *et al.* (1988).

selected specifically for the absence of peculiarities. Within this observational program, he has distinguished about 200 dust clouds, their diameters being about 4 pc, density 30 cm^{-3}, and mass 30 $M_\odot$. Within 75–100 pc of the Sun, the mean spatial density of the clouds is 0.00044 clouds pc^{-3}. These clouds occupy 2% of the volume, being characterized by a random distribution in space.

Low *et al.* (1984) have reported the discovery by IRAS of five clouds with diameters ≃1–3° at galactic latitudes higher than 60°. They are called "infrared cirrus". They are nearby objects, $r \leqslant 100$–200 pc (de Vries, 1986). Burton *et al.* (1986) described cirri of large angular sizes. They are probably connected with nearby HI clouds. The cirri are described in detail by Deul (1988).

Blitz *et al.* (1984) have discovered 29 low-mass (2–260 $M_\odot$) molecular clouds at galactic latitudes $|b| > 30°$. The average distance to these clouds is $r \leqslant 100$ pc. Magnani *et al.* (1985) have found 60 such clouds with a typical diameter of 1° (1–5 pc). Magnani *et al.* (1986, 1988) studied the clouds in detail. Sky coverage by the clouds is 0.45%. For $r < 100$ pc, the number of these clouds is suggested to be ≃120 with the total mass ≃5000 $M_\odot$. Parameters of such low-mass molecular clouds, as well as IR cirri, are compiled by Bochkarev (1990a, b) and presented in Tables 1–3.

Table 2 Main IR cirri (Deul, 1988)

Name	*Coordinates (deg)*		*Size (deg)*	*$\langle V_r \rangle$ km/s*	*N_H 10^{20} cm^{-2}*
	l	*b*			
D	43	−53	6 × 6	0	4 ÷ 10
in Hercules	46	+24	7 × 6	+10	6 ÷ 13
Pintcher	54	+15	20 × 12	−60, +25	3 ÷ 18
Coathanger	90	−37	15 × 15	0	4 ÷ 10
Angle	247	+72	10 × 7	−30, 0	2 ÷ 5
Helene	248	+15	9 × 7.5	0	5 ÷ 17
B	275	+75	2 × 3	−18	1.5 ÷ 5
X	276	+73	24 × 10	−8	

Table 3 HI clouds near the Sun (Bochkarev, 1990b)

Name		*Coordinates (deg)* *l*	*b*	*Distance* *pc*	*log* N_H cm^{-2}	$\langle n_H \rangle$ cm^{-3}	*T* *K*	V_{LSR} *km/s*
Sancini–van Woerden	from	343	+16	10–20	20	30	≤200	−13
	to	358	+33					
to star HD 2151		305	−40	6	18.6	18	—	—
to α Ophiuchi	from	30	+25	10–17	—	—	70 ÷ 500	−8
	to	55	+10					

Thus, several new types of interstellar objects were found and studied in detail in the LISM: faint HII regions, IR cirri, and low-mass molecular clouds. The principal parameters of the LISM structures are presented in Table 4.

5.6. *Galactic Environment of the LISM*

The shape of the LISM envelope deviates significantly from a sphere. In the direction of the Sun it spreads to a larger distance than in the majority of other directions (Bochkarev, 1987b). This is probably a result of a lower average ISM density in this direction. It is the direction (Figure 3) where an oval HI component of Gould's Belt is located (the so-called detail A of the HI distribution near the Sun—Lindblad, 1967; Lindblad *et al.*, 1973; Olano, 1982; Taylor *et al.*, 1987; see discussion in Bochkarev, 1990a), which is assumed to be a remnant of a late-giant envelope connected with the former star formation region of Gould's Belt. In this direction, the Local Bubble is spreading inside the older Gould's Belt bubble.

In the direction of the third galactic quadrant (near $l = 240°$), there is a gas (and dust) free tunnel (Lucke, 1978; Paresce, 1984; Bochkarev, 1987b, 1990a). Interstellar absorption is almost absent in this direction up to the next spiral arm Hidayat and Djamaluddin, 1986), i.e. for $r \leqslant 2 - 2.5$ kpc. The tunnel is probably the remnant of an older bubble connected with the so-called detail C/H or the Other Local Feature in kinematics of the nearby HI gas. This HI detail has been

Table 4 Principal parameters of LISM structures with different density (Blochkarev, 1990a)

No.	*Object*	*Number density* (cm^{-3})	*Temperature* (*K*)	*Typical diameter* (*pc*)	*Filling factor* (*%*)	*Number of objects per 1 kpc*
1	Diffuse molecular clouds	≃100	≃10	3	0.03	0.2
2	Atomic clouds	10–30	≃100	≃4	2	7
3	Warm HI regions (cloud coronae)	≃0.3	≃10,000	∞10#	10#	10#
4	Low density HII regions	0.1–0.3	≃10,000	∞30	10–30	≃5
5	NV–OVI regions (transition lowers between Nos. 2–3 and 6	0.03–0.001	10^5–10^6	thickness ≤1	0.1–1	6
6	Hot gas	0.001–0.003	≃10^6	—	60–80	—

#—The data are very uncertain.

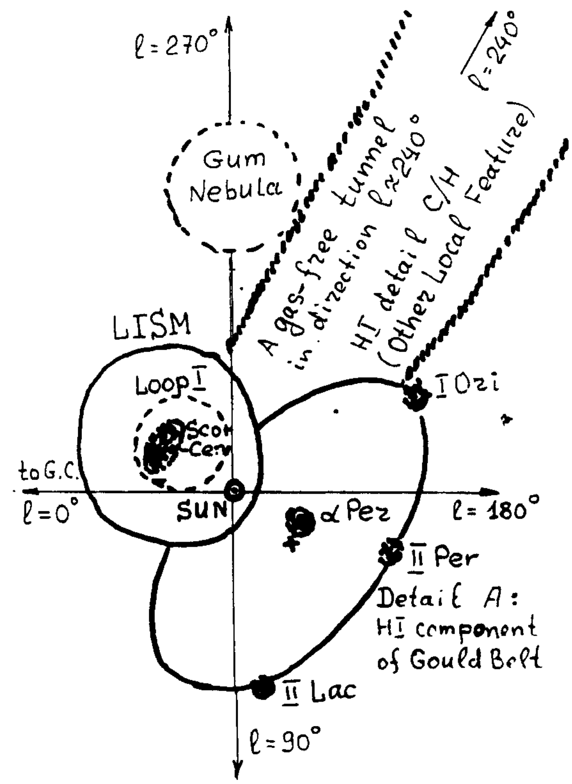

Figure 3 The galactic environment of the LISM.

found by Lindblad (1967) and studied by Sandqvist *et al.* (1976, 1988). Differential galactic rotation has made this old bubble elongated strongly toward $1 \simeq 240°$.

Bochkarev (1987b) discussed a number of other sufficiently small scale inhomogeneities which can change the LISM envelope shape. The largest one among them is the Loop IV envelope (Iwan, 1980) interacting with the LISM envelope (Bochkarev, 1987b, 1990a).

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