Comparison of the large scale structure of the ISM in the 2^{nd} and 3^{rd} Galactic Quadrants

Vera Könyves[1] and Csaba Kiss[2]
[1]Eötvös Loránd University, Department of Astronomy
H-1518 Budapest, P.O.Box 32., Hungary
[2]Konkoly Observatory of the Hungarian Academy of Sciences
H-1525 Budapest, P.O.Box 67., Hungary
E-mail:[1]V.Konyves@astro.elte.hu,[2]pkisscs@konkoly.hu

Abstract

In this paper we are questing the large scale structure of the interstellar medium (ISM) using IRAS/ISSA 60 and 100 μm maps in the 3^{rd} Galactic Quadrant (GQ). Here we identified 41 loop-like intensity enhancements and analysed their far-infrared (FIR) properties. We found major differences in the distribution and characteristics of these features when comparing the results of the 2^{nd} and the 3^{rd} GQs. This discrepancy can be satisfactorily explained by basic differences of the structure of the ISM in these two Galactic Quadrants.
Keywords: *ISM, far-infrared: diffuse emission, galactic structure*

1. Introduction

Shell or arc like local density enhancements have been long since known. These structures may be formed by various processes and are reported in many tracers of the ISM, including radio, infrared, optical, ultraviolet and X-ray wavelengths. Most of the loops are explained as dense expanding shells of supernova (SN) explosions and stellar winds of supermassive stars. Moreover it is just possible that gas and dust loops form as a result of supersonic turbulences of the interstellar medium.

Loop-like structures were detected in the far-infrared wavelength range owing to the features of the dust emission and the characteristics in the distribution of young embedded objects. Loops containing diffuse and discrete emission can be found on IRAS images. Schwartz (1987) catalogued 16 star-forming loops in the outer Galaxy ($60° \leq l \leq 300°$ and $|b| \leq 7°$). The study by Marston (1996) presented IRAS Skyflux images of 49 suspected shells in the environment of galactic Wolf-Rayet stars. One of the most prominent far-infrared loops, the Cepheus bubble was discovered by Kun et al. (1987). The 2D projected easily visible ring, both at 60 and 100 microns, might well be a result of stellar winds

from massive stars in the Cep OB2 associations and several supernova events. Besides these events the infall of high-velocity clouds from the galactic halo has also been proposed to form large shells in the HI disc (Tenorio-Tagle, 1980). The North Celestial Pole (NCP) loop is the most remarkable example of infalling cloud – galactic disc interactions (Meyerdierks et al. , 1991).

Tóth et al. (1996) performed a survey of FIR loops in the 2^{nd} Galactic Quadrant ($90° \leq l \leq 180°$). This survey extended to high galactic latitudes ($-90° \leq b \leq 90°$) and significantly increased the number of known loops (141).

In this paper we present the results of a similar survey in the 3^{rd} Galactic Quadrant ($180° \leq l \leq 270°$; $-90° \leq b \leq 90°$), as part of our all-sky survey program.

2. Data analysis

2.1. Searching for loops on IRAS/ISSA images

The visual search for loop like features has been carried out on the computer readable, zodiacal light removed ISSA (IRAS Sky Survey Atlas) plates (Wheelock et al., 1994) especially at 60 and 100 μm. The investigation required huge connected areas, much larger than the $12\overset{\circ}{.}5 \times 12\overset{\circ}{.}5$ sized ISSA maps. The final images (with a size of $\sim 40° \times 40°$) on which the search was carried out were built up by using the "geom" and "mosaic" procedures of the IPAC-Skyview package.

According to the definition (Tóth et al., 1996) loops must show an excess FIR intensity as compared to its surrounding. A shell - by definition - must be at least 60 % of a complete ellipse-shaped ring. It may consists of a set of bright spots, or may be a diffuse ring or part of a ring.

2.2. Parameters of the loops

Using the IPAC-Skyview package, we fitted an ellipse to our suspected loops on the 100 μm ISSA images. The fitted parameters were the central galactic coordinates, the minor and major semiaxes of the ellipse and the inclination of the major axis to the circle of galactic latitude at the center of the ellipse. This was defined to be '+' from East to North.

We extracted a radially averaged surface intensity profile for the loops, extended to a distance of twice the axes of the fitted ellipse, using 20 concentric ellipsoidal rings. In the following calculations we used these surface-brightness profiles to obtain e.g. the significance of the loops.

Loop-like intensity enhancements were searched by eye on our ISSA mosaic maps because man's eye is the best pattern-recognition tool, especially in such cases when strict role can hardly be defined. In order to filter out many subjective effects due to the eye-investigation and check if our loops really show the FIR intensity excess over the local background, we derived a "significance" parameter, denoted as "Ψ" in the following. Ψ was defined as the relative intensity excess over the background in the radially averaged intensity profile (for a more detailed explanation see Kiss et al. 2002).

Another characteristic of the loops is the "color index" ΔI(60)/ΔI(100), defined as the slope of the COBE/DIRBE corrected ISSA 60 and 100 μm scatter plot, which may account for temperature differences in the shells.

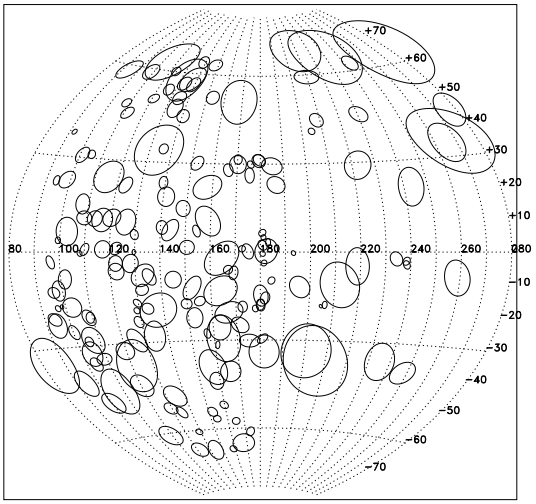

Figure 1: Sky distribution of GIRLs in the 2^{nd} and 3^{rd} GQs (galactic coordinate system). Ellipses were drawn using the fitted parameters of the loops (see text).

3. Statistical results

In the 3^{rd} GQ we found 41 Galactic far-InfraRed Loops (GIRLs), identified on ISSA 100 μm images. The catalogue is available at the following URL: `http://astro.elte.hu/IRASLoops3/IRASLoops3e.html`. The distribution of GIRLs in the 2^{nd} and 3^{rd} Galactic Quadrants is presented together in Fig. 1.

We have defined a characteristic size for our loops as the geometrical mean of the semi minor and -major axis of the fitted ellipse, $\langle R_{eff} \rangle = \langle \sqrt{a_i \times b_i} \rangle_i$.

This yielded $\langle R_{eff} \rangle = 3.^{\circ}2$ and $3.^{\circ}9$ for the 2^{nd} and 3^{rd} quadrants, respectively.

The distribution of GIRLs found in the 2^{nd} and 3^{rd} GQs (see Fig 2.) were expected to somehow reflect the exponential disc hypothesis. The Galactic Disc contains most of the ISM in the Galaxy, accordingly regions closed to the galactic plane should be the most populated parts of sky in loops, and this number should decrease nearly exponentially by the increasing galactic latitude.

Color indices distribute uniformly in galactic latitude and approximately show cirrus-like color, in contrast to the 2^{nd} GQ where a significant deviation can be observed at low galactic latitudes to higher color indices.

3.1. Comparison of the GIRL distribution in the 2^{nd} and 3^{rd} Galactic Quadrants

As shown by Kiss et al. (2002) many of the GIRLs identified in the 2^{nd} GQ - and located at low galactic latitudes - were probably formed by the stellar wind of massive stars. According to Humphreys (1970) the distribution of these energetic sources along the Galactic Plane is quite different in the 2^{nd} and 3^{rd} GQs, since the 2^{nd} one contains a more richer population. The 2^{nd} GQ contains a significant part of the Local Arm (Orion Spur) and almost the whole Perseus Arm. In the 3^{rd} GQ there is no significant sign of the galactic spiral structure, only a small fraction of the Orion Spur (at $l \approx 180^{\circ}$) and part of the Local Arm (along $l \approx 270^{\circ}$ up to a distance of ~ 2 kpc) are present.

Blitz and Spergel (1991) assumed a quadrupole term in the galactic potential derived from the asymmetry of the spheroid component. Observations of the 21 cm absorpsion features and further considerations suggested that there is roughly 20 % more gas in the 4^{th} quadrant than in the 1^{st}, and roughly the same amount more in the 2^{nd} than in the 3^{rd}.

These differences may account for the discrepancy observed in the characteristics in the GIRL properties and distribution in the 2^{nd} and 3^{rd} GQs. Additional differences between the two quadrants may be conspitious because of the relatively high number of small arcs and shells which were ignored in the 3^{rd} GQ, while kept in the 2^{nd}. These small features did not show an obvious FIR intensity excess over the background. Smaller bubble candidates of this quadrant - perhaps formed by turbulence in a lower amount of ISM - cannot form shells dense phased and bright enough to significantly exceed the background intensity. On the other hand loops may grow larger in the 3^{rd} GQ than in the 2^{nd} in the case of the same input energy due to the smaller amount of ISM .

It seems that the mass and density in the 3^{rd} GQ are not high enough to

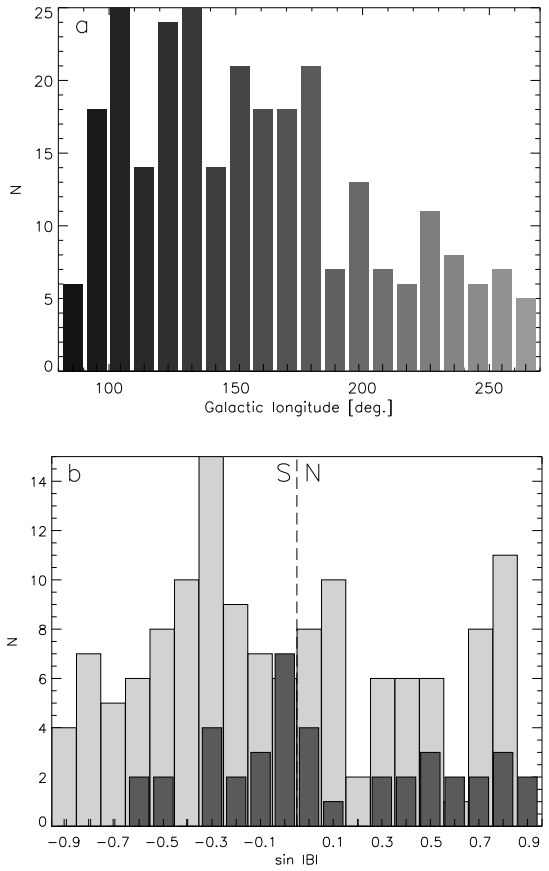

Figure 2: Distribution of GIRLs in the 2^{nd} and 3^{rd} GQs. (**a**) Loop-counts vs. galactic longitude. (**b**) Loop-counts vs. galactic latitude for the 2^{nd} quadrant (light grey bars) and for the 3^{rd} GQ (dark grey bars).

produce star-formation in an efficiency comparable to that in the 2^{nd} GQ. The relatively low intensity excess of the loops in the 3^{rd} GQ also explains the fact, that these loops show cirrus-like ΔI(60)/ΔI(100) values, in contrast to the 2^{nd} quadrant.

4. Summary

In this paper we presented the results of a search for GIRLs (Galactic InfraRed Loops) in the 3^{rd} Galactic Quadrant. Our objects are suspected to be the remnants of high pressure events, seen as far-infrared intensity enhancements

on IRAS/ISSA plates.

The investigation for FIR loops in the 3^{rd} GQ is part of an all-sky survey program, - which was first set in the 2^{nd} Galactic Quadrant (Kiss et al. , 2002) - and will have an impact on the better understanding of the large scale structure of the ISM in the galactic neighbourhood of our Solar System.

Acknowledgements

This research was partially supported by the Hungarian Research Found (OTKA), under the number T034998.

References

Blitz L., Spergel D.N., 1991, ApJ 370, 205
Humphreys R.M., 1970, ApJ 75, 602
Kiss Cs., Moór A., Tóth L.V., 2002, A&A, submitted
Könyves V., 2001, MS Thesis, Eötvös University, Budapest [in Hungarian]
Kun M., Balázs L.G., Toth I., 1987, Ap&SS 134, 211
Marston A.P., 1996, AJ 112, 2828
Meyerdierks H., Heithausen A., Reif K., 1991, A&A 245, 247
Schwartz P.R., 1987, ApJ 320, 258
Tenorio-Tagle, G., 1980, A&A 88, 61
Tóth L.V., Kiss Cs., Moór A., 1996, in: *The role of dust in the formation of stars*, eds. Käufl H.U., Siebenmorgen R., publ. Springer-Verlag Berlin Heidelberg, p.125-128
Wheelock S.L., Gautier T.N., Chillemi J., et al., 1994, IRAS Sky Survey Atlas Explanatory Supplement, JPL Publ. 94-11