Catalogue of far-infrared loops in the Galaxy: Description of catalogue entries and additional data products

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1 Quest for loops on far-infrared maps

We investigated the 60 and 100 μm ISSA plates (IRAS Sky Survey Atlas, Wheelock et al., 1994) in order to explore the distribution of dust emission in the 2^{nd} Galactic Quadrant. We created composite images of the $12\overset{\circ}{.}5\times12\overset{\circ}{.}5$ sized individual ISSA plates using the "geom" and "mosaic" procedures of the IPAC-Skyview package, both at 60 and 100 μm. These images were built up typically from ~10-15 ISSA plates, reaching a size of $\sim 40°\times40°$. Loop-like intensity enhancements were searched by eye on the 100 μm mosaic maps. Loops by our definition must show an excess FIR intensity confined to an arc-like feature, at least 60% of a complete ellipse-shaped ring. A loop may consist of a set of bright, more or less isolated, extended spots, or may be a diffuse ring or part of a ring. The size of the mosaic image limits the maximal size of the objects found. On the other hand, due to the relatively large size of the investigated regions, loop-like intensity enhancements with a size of $\leq 1°$were not searched. The original ISSA I_{60}^{ISSA} and I_{100}^{ISSA} surface brightness values were transformed to the COBE/DIRBE photometric system, using the conversion coefficients provided by Wheelock et al. (1994):

- $I_{60} = 0.87 \times I_{60}^{ISSA} + 0.13\,\mathrm{MJysr^{-1}}$
- $I_{100} = 0.72 \times I_{100}^{ISSA} - 1.47\,\mathrm{MJysr^{-1}}$

Dust IR emission maps by Schlegel et al. (1998) (SFD) were investigated to derive parameters describing our loop features (see Sect. 2.2). The main differences of the SFD 100 μm map compared to the ISSA maps are the following:

(1) Fourier-destripping was applied,

(2) asteroids and non-Gaussian noise were removed,

(3) IRAS and DIRBE 100 μm maps were combined, preserving the DIRBE zero point and calibration,

(4) stars and galaxies were removed.

We analysed the radial surface brightness profiles of the loops on the SFD 100 μm map in order to check the effect of the removal of the sources mentioned above. We also used the SFD E(B−V) maps derived from the dust column density maps. In the case of these maps the colour temperature was derived from the DIRBE 100 and 240 μm maps, and a temperature corrected map was used to convert the 100 μm cirrus map to a map proportional to dust column density.

Shape: We approximated the shape of a possible loop by an ellipse, which was then fitted using a 2D least-square fit method. An ellipse shape is expected from SN or stellar wind shells, since (1) non-spherical explosion (wind) may occur, in the most extreme case creating a ring, rather than a shell, and (2) originally spherical shells are distorted to ellipsoidal (i) due to the shear in the direction of galactic rotation (Palouš et al., 1990) and (ii) due to the vertical gravitational field in the galactic disk (see e.g. Ehlerová & Palouš, 1996).

The fitted ellipse is defined with the central (galactic) coordinates, the minor and major semi-axis of the ellipse, and the position angle of the major axis to the circle of galactic latitude at the centre of the ellipse. This latter was defined to be '+' from East to North (or counter-clockwise).

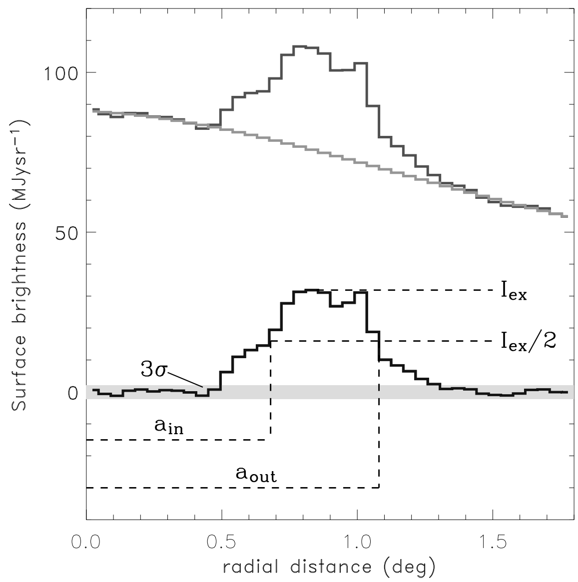

Figure 1: Intensity profile before (top) and after (bottom) background removal (gray solid line) with the main derived parameters (I_{ex}, σ_{ex}, a_{in}, a_{aout}, see Sect. 2.2)

Intensity profile: For all of our loops we extracted radially averaged surface brightness profiles, extended to a distance of twice the major (and minor) axis of the fitted ellipse, using 40 concentric ellipsoidal rings. These surface-brightness profiles (ISSA 100 and 60 μm, SFD 100 μm and SFD reddening maps) were used in the following to determine the basic parameters of the FIR emission in the loop. An example is shown is Fig. 1

2 Derived parameters

Significance: The local background was determined using the 'non-loop' points in the radial surface brightness profiles, fitting a 3rd order polynomial. This appropriate background was removed from each surface brightness profile points. The intensity excess I_{ex} was derived as the maximum value of this background removed profile. In order to check if this value is above the 'noise', we calculated the standard deviation of the background removed intensity in the 'non-loop' values, σ_{ex}, and defined the significance of the loop as $\Psi = I_{ex}/\sigma_{ex}$. We derived significance parameters on 60 and 100 μm ISSA maps and on the SFD 100 μm point source removed sky brightness and reddening maps. The higher the value of Ψ the higher the intensity excess of the loop over the background, therefore we use this parameter as a 'quality indicator' in the following.

Relative width: Inner and outer edges of the loop wall along the major axis (a_{in} and a_{out}, respectively) are defined as the radial distance at the full width at half power of the background removed intensity profile, $I_{ex}/2$ (Fig. 1) We distinguish three regions for a specific loop: (1) loop interior ($a < a_{in}$), (2) loop wall ($a_{in} \leq a \leq a_{out}$), (3) outer region ($a > a_{out}$). The relative width of the wall of the fitted ellipse is defined as $W = 1 - a_{in}/a_{out}$.

Colour index: We derived a colour index for our loops $\Delta I_{60}/\Delta I_{100}$, from the radially averaged 60 and 100 μm surface brightness profile. This is defined as the slope of the I_{60} vs. I_{100} scatter plot using the data points of the surface brightness profile in the positions of the loop wall ($a_{in} \leq a \leq a_{out}$) only.

3 The catalogue

We identified 145 loops in the 2nd Galactic Quadrant. We call these objects '**GIRL**'-s, abbreviating '**G**alactic **I**nfra**R**ed **L**oops'.

The entries of the catalogue are the following:

1.) Name of the loop, derived from the galactic coordinates of the loop centre. The format is : GIRLlllsbb, where the 'GIRL' prefix stands for 'Galactic InfraRed Loops', 'lll' is the galactic longitude in degrees, 's' is the sign of the galactic latitude (+/–), and 'bb' is the absolute value of the galactic latitude of the loop centre.

2.) Central galactic coordinates of the loop (l and b)

3.) Semi major and minor axis of the fitted ellipse

4.) Position angle of the fitted ellipse. The position angle is defined as '+' from East to North. Zero position angle is pointed to the East in galactic coordinates.

5.) Major axes corresponding to the inner and outer edge of the loop wall, derived from the 100 μm surface brightness profile

6.) 100 μm significance parameter Ψ_{100} of the loop

7.) colour index $\Delta I_{60}/\Delta I_{100}$ of the loop wall

In the electronic version of the catalogue (URL: "http://astro.elte.hu/CFIRLG") we provide the following additional features:

8.) 100 μm ISSA image of the loop with the possible associated objects overlaid

9.) background removed surface brightness profiles

10.) List of objects apparently associated with the loop

An associated object has to be placed in the wall or in the interior of the loop (defined by concentric ellipses, as described above). We considered the following type of possible associated objects (references are indicated)

- dark clouds (Dutra & Bica, 2002)
- supernova remnants (Green, 1994, 2001)
- OB-associations (Lang, 1992)
- pulsars (Taylor et al., 1993)
- HII regions (Sharpless, 1959)

This list of possible associated object does not take into account the distances of the individual objects, therefore all objects projected to the loop wall or to the interior are included.

3.1 Description of the associated object file:

Associated objects listed in HTML files. Each loop possesses an 'assoc' file (¡loopname¿.assoc.html) even if there's no object associated with the present loop. In this case the 'assoc' file contains the headline only. The columns of the 'assoc' file are the following:

i) object name; sometimes multiple names are provided

ii) code of object type:

- DC – dark cloud
- SNR – supernova remnant
- PSR – pulsar
- HII – HII region
- MC – IRAS point source with molecular core FIR colours
- TT – IRAS point source with T Tau star-like FIR colours
- ASSOC – OB association

iii) relative position to the loop wall. An objects is included in an 'assoc' file if a.) it is inside the inner edge of the loop wall ($a \leq a_{in}$, "**in**") or b.) if it is on the wall of the loop ($a_{in} < a \leq a_{out}$, "**ring**")

iv–v) galactic coordinates (l, b)

vi) extent. Some object types has no extent ("–"). For HII regions an effective diameter is presented (arcmin). For dark clouds the size is specified via their major/minor axes (arcmin). In the case of OB associations the limits of extent are supplied in galactic coordinates (deg).

3.2 Description of the surface brihtness profile files

Background removed surface brightness profiles are extracted for all loop using the four data products desribed above (ISSA 60 & 100 μm, SFD 100 μm, SFD reddening maps). The fits header contains all relevant information, via some specific fits keywords. A sample fits header is shown below (it should be, anyhow, self-explanatory...).

```
SIMPLE  =                    T / Written by IDL:  Thu Oct 19 16:59:10 2000
BITPIX  =                  -32 /
NAXIS   =                    1 /
NAXIS1  =                   40 /
LOOPNAME= 'GIRL154-57'         /Name of the loop
UNIT    = 'MJy/sr  '           /Surface brightness profile unit
MAJOR_AX=              1.56667 /Major axis (deg)
MINOR_AX=              1.28333 /Minor axis (deg)
AB_RATIO=              1.22078 /Ratio of major-to-minor axis
DELTA_A =            0.0783333 /Radial distance steps along major axis (deg)
DATAORIG= 'SFD_100 '           /Origin of data
END
```

3.3 PostScript images

We provide PostScript (PS) images of our loops with the associated objects overlaid. The PS format was choosen for (our) convenience. There are many sophisticated tools to transform it to other (in some environments more common) image formats... The overlaid symbols are the following:

- black triangles: dark clouds (DC)
- red stars: T Tau stars (TT)
- black squares: molecular cores (MC)
- red triangles: HII regions
- blue stars: pulsars
- blue circles: SNRs

References

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