The Origem Loop
X. Y. Gao and J. L. Han

National Astronomical Observatories, Chinese Academy of Sciences, Jia-20 Datun Road, Chaoyang District, Beijing 100012, PR China

Received; accepted

ABSTRACT

Context. The Origem Loop in the Galactic anticentre was discovered in 1970s and suggested to be a large supernova remnant. It was argued later to be a chance superposition of unrelated radio sources.

Aims. We attempt to understand the properties of the Origem Loop.

Methods. Available multi-frequency radio data were used for the determination of radio spectra of different parts of the Origem Loop and the polarization properties of the loop.

Results. Newly available sensitive observations show that the Origem Loop is a loop of more than 6° in diameter. It consists of a large non-thermal arc in the north, which we call the Origem Arc, and several known thermal H II regions in the south. Polvanized radio emission associated with the arc was detected at 6.5 cm, revealing tangential magnetic fields. The arc has a brightness temperature spectral index of $\beta = -2.70$, indicating its non-thermal nature as a supernova remnant. We estimate the distance to the Origem Arc to be about 1.7 kpc, similar to those of some H II regions in the southern part of the loop.

Conclusions. The Origem Loop is a visible loop in the sky, which consists of a supernova remnant arc in the north and H II regions in the south.

Key words. ISM: supernova remnants – ISM: individual objects: G194.7–0.2, Origem Loop – Radio continuum: ISM

1. Introduction

Several giant loops were recognized in the early radio sky maps, i.e., Loop I (Hanbury Brown et al. 1960), Loop II (Large et al. 1962), Loop III (Quigley & Haslam 1965), and Loop IV (Large et al. 1966). By comparing the radio continuum, Hz, interstellar polarization and the H I observations of the four loops, Haslam et al. (1971) made a general review of these giant structures. Berkhuysen et al. (1971) summarized the geometric parameters of the four loops, and proposed their origin from supernova explosions. Besides these four giant loops, there are also loops with smaller sizes, i.e., the Lupus Loop (Gardner & Milne 1965) and the Cygnus Loop (Walsh & Brown 1955) which have been undoubtedly identified as supernova remnants (SNR) and are collected in the well-known SNR catalog compiled by Dave Green (Green 2009).

The Origem Loop is another known Galactic radio loop discovered in 1970’s by Berkhuysen (1974) on the 178 MHz radio map (Caswell & Crowther 1969) in the Galactic anti-centre region between the constellations Orion and Gemini. However, its nature is under debate. The loop was first proposed to be an old SNR at a distance of about 1 kpc with a diameter of about 5° (Berkhuysen 1974), but was later argued by Caswell (1985) to be a possible projection effect of several unrelated H II regions, many extra-Galactic sources and a discrete small SNR G192.8–1.1 (PKS 0607+17) with a diameter of about 80’. Note, however, that Gao et al. (2011a) have disproved G192.8–1.1 to be a SNR but a thermal emitter using the Urumqi 6 cm (Gao et al. 2010), the Effelsberg 111 cm (Fürst et al. 1990) and the Effelsberg 121 cm (Reich et al. 1997) survey data. Probably because of its large size, there were few follow-up observations of the Origem Loop after Berkhuysen (1974). Caswell (1985) discussed the region of G192.8–1.1 and some nearby H II regions, but did not study the northern part of the Origem Loop. Krymkin & Sidorchuk (1988) made brightness temperature scans to nearly the entire loop with the UTR-2 and RAtAN 600 radio telescopes at five frequencies, from 14.7 MHz to 3950 MHz. They claimed the discovery of a new feature, namely GR 0625+16, to be another possible discrete SNR besides the “SNR” G192.8–1.1. However, the GR 0625+16 exactly corresponds to the northern arc of the Origem Loop.

High quality multi-frequency radio survey data with sufficient sensitivity and angular resolution are now available, which can be used to investigate the properties of the Origem Loop. We introduce in Sect. 2 the data sets we use, and present the analysis in Sect. 3. A summary is given in Sect. 4.

2. Data

The Origem Loop clearly shows up in the 6 cm total intensity and polarization images from the Sino-German 6 cm polarization survey of the Galactic plane (Gao et al. 2010), which motivated us to seek for a better understanding of this large structure. Other public radio data are available from the Effelsberg 111 cm (2.7 GHz, Fürst et al. 1990) and 121 cm (1.4 GHz) Galactic plane survey (Reich et al. 1997), which can be downloaded from the survey sampler of the Max-Planck-Institut für Radioastronomie (MPIfR). The WMAP 7-year K-band (22.8 GHz, 1.3 cm) survey data (Jarosik et al. 2011) retrieved from the website of NASA1, the 121 cm Effelsberg Medium

1 http://zmtt.bao.ac.cn/6cm/
2 http://www.mpifr.de/old_mpifr/survey.html
3 http://lambda.gsfc.nasa.gov/product/map/dr4/maps_band_r9_iqus_7yr_get.cfm
Fig. 1. From top left (a), top right (b) to bottom left panel (c): \(\lambda\) 6 cm, \(\lambda\) 11 cm, and the \(\lambda\) 21 cm total intensity images of the Origem Loop. The angular resolutions are 9\(\,^\prime\)5, 9\(\,^\prime\)5, and 9\(\,^\prime\)4, respectively. The contours run from \(2^\circ\times3.6\times18.0\, (3\sigma)\, mK\, T_B\), (n = 0, 1, 2 ... ) for the \(\lambda\)6 cm image, \(2^\circ\times66.0\, (3\sigma)\, mK\, T_B\), (n = 0, 1, 2 ... ) for the \(\lambda\)11 cm image, and \(2^\circ\times66.0\, (3\sigma)\, mK\, T_B\), (n = 0, 1, 2 ... ) for the \(\lambda\)21 cm image. The white circle in the top left panel (a) indicates the boundary of the Origem Loop. Bottom right panel (d): Spectral index distribution for the Origem Loop area derived from the Urumqi \(\lambda\)6 cm, Effelsberg \(\lambda\)11 cm, and \(\lambda\)21 cm images at the same angular resolution of 9\(\,^\prime\)5.

Latitude Survey (EMLS) data [Uyaniker et al. 1998, 1999], and the DRAO \(\lambda\)21 cm polarization survey data [Wolleben et al. 2006], both of which were also obtained from the survey sampler of MPIfR. In the following discussions, we used the observing wavelength to indicate the data set. Specifically the \(\lambda\)21 cm data stands for the Effelsberg Galactic plane survey data [Reich et al. 1997], unless special statements are made. The angular resolution is 9\(\,^\prime\)5 for the \(\lambda\)6 cm image, 9\(\,^\prime\)3 for \(\lambda\)11 cm image, 9\(\,^\prime\)4 for \(\lambda\)21 cm image, 52\(\,^\prime\)8 for \(\lambda\)1.3 cm, 9\(\,^\prime\)35 for EMLS \(\lambda\)21 cm, and 36\(\,^\prime\) for DRAO \(\lambda\)21 cm images. Among them, the \(\lambda\)6 cm and \(\lambda\)1.3 cm observations provided both total intensity and polarization measurements, the DRAO \(\lambda\)21 cm data provided only the polarization image, while the rest give only the total intensity maps. The Effelsberg \(\lambda\)21 cm Galactic plane survey [Reich et al. 1997] has a latitude limit of \(b = \pm 4^\circ\). Therefore, we used the EMLS data to fill the blank region above \(b = 4^\circ\), but we do not have data for the region below \(b = -4^\circ\). Basic parameters of these data sets are summarized in Table 1. As done by Gao et al. [2011b], the “background filter” technique developed by Sofue & Reich [1979] was applied to \(\lambda\)6 cm, \(\lambda\)11 cm and \(\lambda\)21 cm images to separate the unrelated large-scale Galactic emission from the Origem Loop emission. A twisted hyper plane defined by the corner mean values of each image was subtracted to find the local zero level around the Origem Loop. The final \(\lambda\)6 cm, \(\lambda\)11 cm, \(\lambda\)21 cm total intensity images of the Origem Loop are shown in Fig. 1. The \(\lambda\)11 cm image was convolved to an angular resolution of 9\(\,^\prime\)5 to get a higher signal-to-noise ratio.
Table 1. Parameters of the survey data for the images of the Origem Loop

| Surveys  | Frequency (GHz) | HPBW (′) | r.m.s (mK T\text{\textsc{b}}) | References          |
|----------|-----------------|----------|-------------------------------|---------------------|
| Urumqi 6 cm | 4.8            | 9.5      | 1.2(TP)/0.5(PI)   | Gao et al. (2010)   |
| Effelsberg J11 cm | 2.7            | 4.3      | 18.0(TP)              | Fürst et al. (1990) |
| Effelsberg J21 cm | 1.4            | 9.4      | 22.0(TP)              | Reich et al. (1997) |
| WMAP 11.3 cm | 22.8           | 52.8     | 0.07(TP)/0.06(PI)    | Jarosik et al. (2011)|
| DRAO J21 cm | 1.4            | 36.0     | 12.0(PI)              | Wolleben et al. (2006)|
| EMLS J21 cm | 1.4            | 9.35     | 15.0(TP)              | Uyanıker et al. (1998)|

Note: TP: total power, PI: polarization intensity

Fig. 2. J6 cm total intensity image with the prominent H II regions marked with “+” and labeled with the names. The disproved SNR, G192.8−1.1, was also marked with a circle of the pink dashed line. The outer red dotted line delineates the common area of the observations by Krymkin & Sidorchuk (1988) and our image, while the red dashed line indicates the field shown in Caswell (1985). The white dashed-dot line shows the declination of δ = 14° (Epoch 1950). The region on the left side of this line was not included in the 178 MHz map used by Berkhuijsen (1974). The area outlined by the black dashed line, containing the Origem Arc, and was used for the TT-plot in Sect.3.1. A probable new H II region G195.60-2.95 is marked using a circle with the letter “N” inside.

3. Results

Radio images in Fig. 1 at three different wavelengths resemble each other in structures. At J6 cm, the circle which indicates the loop in Fig 1 (a) has a radius of 200′ and is centred at ℓ = 194.7, b = −0.2. These values are different from those of Berkhuijsen (1974), because we included the region below δ = 14° (B1950), which was not included in the 178 MHz map used by Berkhuijsen (1974). Our new sensitive measurements enable us to detect fainter and more extended emission near the boundary of the Origem Loop than ever before. The loop consists of four major parts: an elongated arc structure extending from ℓ = 197:6 to ℓ = 192:1 in the north, which can also be recognized in the 178 MHz map shown by Berkhuijsen (1974); the H II region BFS 52; and two complexes formed by several known H II regions e.g. SH 2-261, SH 2-254 to SH 2-258, the object G192.8−1.1 in the south and south west; and another group of H II regions SH 2-268, SH 2-270 in the south east. We marked the names of these known H II regions in Fig. 2.

3.1. Spectral indices and their distribution

Spectral indices and their distribution are important properties for understanding the nature of the extended radio sources. Shell-type SNRs usually have a brightness temperature spectral index of β ~ −2.5 (T\text{\textsc{b}} ~ ν^2), while the spectrum of an optically thin H II region is much flatter, normally being β ~ −2.1. We derived the brightness temperature spectral index distribution of the Origem Loop (see Fig. 1 (d)) using the J6 cm, J11 cm and the J21 cm images at an angular resolution of 9.5′. A systematic error of such a spectral index map comes from the uncertainties...
of the baselevel determination due to the foreground/background subtraction. In Fig. 1(d), the spectral index map shows reasonable thermal spectra for all known H II regions, which demonstrates that the result is acceptable. The northern arc of the Origem Loop, which we call the Origem Arc, obviously has a non-thermal brightness temperature spectral index around \( \beta \approx -2.7 \) (flux density spectral index \( \alpha = \beta + 2 \approx -0.7 \)). This region was once singled out by Krymkin & Sidorchuk (1988) in their brightness temperature scans and designated as GR 0625+16. They suggested that GR 0625+16 is a discrete SNR with an integrated radio spectral index of \( \alpha = -0.48 \pm 0.05 \). Although this spectral index is larger than that we derived from our new data, both indicate the non-thermal nature of the Origem Arc.

The TT-plot method (Turtle et al. 1962) was used to verify the spectra (see Fig. 3). The background point sources were subtracted first, as done in Gao et al. (2011b). All images were then smoothed to a common angular resolution of 9'5. For the entire Origem Arc spanning from \( \ell = 197:6 \) to \( \ell = 192:1 \) as indicated in Fig. 3, we obtained the spectral index of \( \beta_{0-11} = -2.43 \pm 1.23 \) from all the data pixels of 6cm and \( \lambda 11 \) cm, and \( \beta_{b-21} = -2.70 \pm 0.28 \) for 6cm and \( \lambda 21 \) cm. Although the temperature measurements for each pixel are not independent, the TT-plots give the correct brightness temperature spectral indices and the uncertainty estimates, as we tested by using the independent pixels. The TT-plots of the brighter part (high signal-to-noise ratio) of the arc \( \beta_{0-11} = 2.45 \pm 1.06 \) and \( \beta_{b-21} = -2.65 \pm 0.29 \). All these spectral values agree well with the spectral index map shown in Fig. 1(d).

The other parts of the Origem Loop have different properties. The well-known H II region, BFS 52 (Blitz et al. 1982), has the central coordinates of \( \ell = 191:90, b = 0:85 \), and the quasar J061357.6+130645 (Aslan et al. 2010) is located at \( \ell = 197:00, b = -2:15 \). Both have a flat spectrum \( (\beta \approx -2.1) \). A circular region centered at \( \ell = 195:60, b = -2.95 \) with a diameter of 1' was found to be very interesting. It has a brightness temperature spectral index of about \( \beta \approx -2.5 \) according to Fig. 1(d). TT-plot of this region gives a consistent result of \( \beta_{b-21} = -2.33 \pm 0.23 \), but this also implies a possibility of being a flat-spectrum thermal emission. We assign its name G195.60–2.95 and marked it using a circle with a central “N” in Fig. 2 and 4. It has strong H\( \alpha \) emission and ring-shaped dust emission (see Fig. 3 and 7). The large ratio between the 60\( \mu \)m infrared and the 6cm continuum emission \( (~ 1400) \) indicates it as a probable thermal H II region. G192.8–1.1 has a flat thermal spectrum and is not a SNR, as discussed in Gao et al. (2011a).

3.2. Polarization

Observations of polarized emission at 6cm, \( \lambda 1.3 \) cm and DRAO \( \lambda 21 \) cm were available for the Origem Loop region. However, only the 6cm data shows the weak polarized emission associated with the Origem Arc (see the left panel of Fig. 4), in addition to the diffuse polarized background emission in the lower part of the map. At 6cm, the polarized emission is clearly detected within the arc even at the western end where the total intensity becomes very weak. The polarization fraction is about 40% on average. The polarization B-field vectors \( (E + 90^\circ) \) are found to follow the arc, indicating the presence of tangential magnetic fields. We also noticed that the depolarization zones seen at 6cm are correlated with the enhanced H\( \alpha \) emission (see the right panel of Fig. 4), e.g., the area around \( \ell \sim 192:0, b \sim 3:0 \), probably due to the Faraday rotation caused by the magnetic fields and the thermal electrons. A shuttle-shaped depolarization zone is found to cross the Origem Arc from northwest to southeast, where bright H\( \alpha \) filaments have good positional correspondences and morphological similarities.

In the southern part of the Origem Loop region, a few large polarization patches were detected within and outside the loop. However, none of them seems to be related either to the Origem Loop or G192.8–1.1 (Gao et al. 2011a). No arc-shaped structure in polarization can be found. In the area of \( \ell = 194:10, b = -1.85 \), H II region SH 2-261 acts as a Faraday screen.
At 1.3 cm, no polarized emission is visible in the entire area of the Origem Loop. Using the average brightness temperature of the polarized emission in the arc at 1.6 cm, 5.0 mK $T_b$, and the spectral index of $\beta = -2.70$, we estimated the brightness temperature of the polarized emission of the arc at 1.3 cm, to be about 0.07 mK $T_b$. It is about the same level of the noise in the K-band data, which could account for the non-detection of polarization.

At 2.1 cm, no correlated polarized emission was detected in the Origem Arc from the DRAO data, neither. The beam size of the DRAO data is 36'. Beam and depth depolarization could diminish any polarized emission. The non-detection might also imply a very near polarization horizon at 2.1 cm in this direction.

### 3.3. Distances of the Origem Arc and HII regions

The observed tangential magnetic fields within the Origem Arc and the non-thermal spectrum are key evidence for its identification as a SNR. To verify if this SNR and the HII regions located in the southern part of the Origem Loop are physically related, we need to know their distances first.

Despite of the large uncertainty, the empirical relation between surface brightness and diameter ($\Sigma$-D) of SNRs provides distance estimates of shell-type SNRs in case that no related HII or molecular clouds (MC) are associated with the SNR. For the entire Origem Arc, a sector with an opening angle $H I$ or molecular clouds (MC) are associated with the SNR. For the entire Origem Arc, a sector with an opening angle $H I$ or molecular clouds (MC) are associated with the SNR. The distance estimates of shell-type SNRs in case that no related HII or molecular clouds (MC) are associated with the SNR. For the entire Origem Arc, a sector with an opening angle $H I$ or molecular clouds (MC) are associated with the SNR. The distance estimates of shell-type SNRs in case that no related HII or molecular clouds (MC) are associated with the SNR. For the entire Origem Arc, a sector with an opening angle $H I$ or molecular clouds (MC) are associated with the SNR. The distance estimates of shell-type SNRs in case that no related HII or molecular clouds (MC) are associated with the SNR.

### 3.4. Signatures at other wavelengths

Berkhuijsen (1974) searched for possible HI structures associated with the Origem Loop, however, no clue was found. Denoyer et al. (1977) proposed that an H I jet, which appears at $\ell \sim 197^\circ, b \sim 2^\circ$ may be related to the Origem Arc, although the jet is extended beyond its boundary. This jet is a part of the prominent H I structure, the Anti-centre shell (ACS), which was discovered by Heiles (1985). We checked the new HI data from the Leiden/Argentina/Bonn HI survey (Hartmann & Burton 1997; Kalberla et al. 2005) and the GALFA H I DR1 data for a much larger area ($20^\circ \times 20^\circ$). We found that the ACS is prominent in the negative velocity map and disappears in the positive velocity map. This clearly differs from the positive CO radial velocity associated with the HII regions discussed above. Moreover, the ACS has a much larger size ($\sim 30^\circ$ in diameter) than the Origem Loop. For the velocity 0.0 to 32.5 km/s, no associated HI structure is found around the Origem Loop.

The TT-plot can be used to reveal different emitting components with different spectral indices (e.g., Xiao et al. 2008). The TT-plot of the southern half of the Origem Loop shows that thermal emission is overwhelmingly dominant. Unlike in the northern arc, no evidence was found for any detectable unambiguous non-thermal emission component in the south (see Fig. 5).

Berkhuijsen (1974) investigated the relation between the Origem Loop and the HII regions. Based on the age of the loop and the evolution timescale from protostars to the HII regions, it was hard to tell whether the Origem Loop triggered the star formation that leads to the HII regions in the south. Using the physical size determined in this work, adopting equation (3) in Berkhuysen (1974), the Origem Arc is about 1 to 3 Myr old. Chavarria et al. (2008) estimated the ages of the HII regions SH 2-254 to 258 from an expansion model of a Strömgren sphere, ranging between 0.1 Myr to 5.0 Myr. Bieging et al. (2009) proposed a sequential star formation scenario from interaction between the HII regions and molecular clouds which indicates that at least the younger HII regions SH 2-255 to 257 were triggered by SH 2-254.

Fig. 5. TT-plot for the southern part of the Origem Loop between $\lambda 6$ cm and $\lambda 21$ cm. The inner small image is the zoom-in picture for the value $T_H \lesssim 25$ mK $T_b$. The red line in the small image represents the same spectral index as in the large image.

---

\(^4\) [https://purcell.ssl.berkeley.edu/index.php](https://purcell.ssl.berkeley.edu/index.php)
**Table 2.** Distance of the known H II regions. The source names are listed in the column (1) and the central coordinates are in the columns (2) and (3). The radial velocities of the peak CO emission associated with the H II regions are given in the column (4). The columns (5) and (6) are the distances in Berkhuijsen (1974, B74), and Caswell (1985, C85). The distances from the recent literature are listed in the column (7) with the distance measurement method given in the column (8), and the references are given in the column (9).

| Name  | ℓ    | b    | CO velocity | Distance (B74) | Distance (C85) | Recent distance | Method | References |
|-------|------|------|-------------|---------------|---------------|----------------|--------|------------|
|       | (°)  | (°)  | (km/s)      | (kpc)         | (kpc)         | (kpc)          |        |            |
| BFS 52 | 191.90 | +0.85 | 7.3±0.5     | ...           | ...           | 2.10±0.02/0.06  | p    | 1/2        |
| SH 2-253 | 192.23 | +3.59 | 14.4±0.5    | ...           | ...           | 5.1±1.5         | s    | 3          |
| SH 2-254 | 192.49 | -0.15 | 7.5±0.7     | 1.1±0.92      | 2.5           | 1.59±0.06       | p†   | 2          |
| SH 2-255 | 192.64 | -0.01 | 7.5±0.7     | 0.88±0.80     | 2.5           | 1.59±0.07       | p†   | 2          |
| SH 2-256 | 192.62 | -0.13 | 7.5±0.7     | ...           | 2.5           | 1.59±0.06       | p†   | 2          |
| SH 2-257 | 192.61 | -0.07 | 7.5±0.7     | 1.3±0.95      | ...           | 1.59±0.06       | p†   | 2          |
| SH 2-258 | 192.73 | +0.05 | 7.5±0.7     | ...           | 2.5           | 1.59±0.06       | p†   | 2          |
| SH 2-259 | 192.94 | -0.58 | 22.8±0.5    | ...           | 8.3           | 8.9±2.7         | s    | 3          |
| SH 2-261 | 194.10 | -1.90 | ...         | 0.9±0.80      | 2.3±2.1       | 1.6±0.5         | s    | 3          |
| SH 2-266 | 195.66 | -0.08 | 31.2±1.1    | ...           | ...           | ~4.2           | s    | 4          |
| SH 2-267 | 196.20 | -1.20 | ...         | ...           | ...           | 1.3±0.4         | s    | 3          |
| SH 2-268 | 196.40 | -2.80 | 4.8±0.5     | ...           | ...           | ...             | s    | 3          |
| SH 2-269 | 196.40 | -1.70 | 17.5±0.7    | 1.8±0.80      | ...           | 5.2±0.24        | p    | 5          |
| SH 2-270 | 196.84 | -3.11 | 25.6±0.4    | ...           | ...           | 6.8±2.3         | k    | 3          |
| SH 2-271 | 197.77 | -2.31 | 20.5±0.5    | ...           | ...           | 5.1±1.1         | s    | 3          |
| SH 2-272 | 197.81 | -2.28 | 20.5±0.5    | ...           | ...           | 5.1±1.1         | s    | 3          |

**Notes:**
- **p:** parallax;
- **p**: associated with SH 2-252 or SH 2-254;
- **p:** SH 2-254 to 258 are regarded to have the same distance;
- **s:** stellar distance;
- **k:** kinematic distance.

**References.** (1) Reid et al. (2009), (2) Rygl et al. (2010), (3) Russell (2003), (4) Lahulla (1987), (5) Honma et al. (2007).

---

**Fig. 6.** Left panel: CO intensity map integrated from 0.0 to 32.5 km/s, overlaid by the $\lambda$6 cm total intensity contours as shown in Fig. 1. Each pixel value was normalized by deviding by the maximum integrated intensity in the image. The green crosses represent the proto-stellar candidates selected from the IRAS point source catalog by the criteria introduced by Junkes et al. (1992) while the blue-white triangles are the massive YSOs found in the Red MSX survey. Top right panel: Normalized CO emission profile for the two areas marked with the black “plus” in the left panel. Bottom right panel: CO spectra for the H II regions SH 2-254 to 258, BFS 52, SH 2-253, and SH 2-269. The brightness temperature in each region was also normalized.
The interaction between the SNR shock and the ambient molecular clouds should broaden the linewidth. For example, IC 443, a famous SNR-MC interaction case, clearly shows a high CO J=3–2/CO J=2–1 ratio and the broadening of CO emission lines (Xu et al. 2011). Broadened CO J=1–0 lines were also detected in another SNR-MC interaction case (Byun et al. 2006). Public CO J=3–2 and CO J=2–1 data covering the Origem Loop region are not available. We checked the CO J=1–0 data of the Origem Loop region from the CO survey (Dame et al. 2001). The radial velocities of the CO emission peaks associated with these H II regions were previously measured and given by Blitz et al. (1982), as we listed in our Table 2. Therefore, we integrated the CO emission in the velocity range from 0.0 km/s to 32.5 km/s and show the result in the left panel of Fig. 6. We find that the most intense CO emission comes from the area of G192.8–1.1. It has a roughly similar morphology as the .6 cm continuum emission as illustrated by the contour lines in Fig. 6. An obvious gap of CO emission is seen at the edge of the continuum emission in the southwest of G192.8–1.1. We checked the velocity-intensity relation at two positions indicated by “plus” in the left panel of Fig. 6 and also the velocity-intensity plots for the H II region SH 2-254 to SH 2-258, BFS 52 for the possible interaction group and the H II regions SH 2-253, SH 2-269 for the non-interaction group. As shown in the right panel of Fig. 6 all of the radial velocities corresponding to the peak CO emission for the H II regions are consistent with those found by Blitz et al. (1982). We checked the linewidths for several hundred non-interacting H II regions (Anderson et al. 2009; Russell & Castets 2004) and found the average values are in the range of 3–6 km/s. SH 2-254 to 258, BFS 52, SH 2-253 and SH 2-269 have similar linewidths and no significant rising of the line wings can be seen. Therefore there are no hints for the interaction between SNR and clouds for H II region formation.

We searched for massive young stellar objects in the Origem Loop region from the Red MSX Source Survey database and for the protostellar candidates in the IRAS point source catalog. They are marked in the Fig. 6. Several of them are coincident and most of them are located in the regions where CO emission is prominent. The young stellar objects in the Origem Loop region do not show over density neither on the northern Origem Arc nor on the shell-like structure where the continuum-CO boundary exists.

Infrared (dust) image was also checked by Berkhuijsen (1974), nothing coincided with the Origem Arc (see her Fig. 3). From the IRIS 100μm dust image (Miville-Deschênes & Lagache 2005) of the Origem Loop region shown in Fig. 7, we found that the dust emission is well correlated with the H II regions in the south. The two interacting H II regions SH 2-255 and SH 2-257 triggered star formation in between them (Ojha et al. 2011). A large number of YSOs were identified on their boundary. The object G195.6-2.95 has an incomplete ring structure, and the infrared emission gets enhanced between it and the known H II regions SH 2-268 which is about 1.3 kpc away. However, we do not get any YSOs on the intensive infrared emission zone. It might be due to limitation of the infrared data sets we use. The apparent sizes of the infrared bubbles in the inner Galaxy are generally smaller than the one around G195.6-2.95 (Simpson et al. 2012), which may imply a small distance to G195.6-2.95. An infrared loop was also found around the SNR (Koo et al. 2008). However, the polarization measurement at .6 cm and the infrared/radio ratio of G195.6-2.95 strongly suggest that it is an H II region.

We checked the 0.1-0.4 keV and 0.4-2.4 keV ROSAT X-ray image (http://www.xray.mpe.mpg.de/cgi-bin/rosat/rosat_survey) no associated structure with the Origem Loop was found.

4. Summary

We used multi-frequency survey data to revisit the Origem Loop in the antecentre of the Galaxy. The Origem Arc is a polarized non-thermal emission structure with a spectral index of $\beta = -2.70$, indicating that it is a shell-type SNR. We estimated its distance to be $1.7\pm0.8$ kpc.

Using the new radio data, we discussed the possibilities of a physical association between the SNR and the H II regions located in the south of the Origem Loop. Inspection of TT-plots for different emission components, the width of CO lines and age estimates did not give evidence of a non-thermal southern arc or the interaction between the SNR and the H II regions in the south. Associated infrared emission is seen to be well related to the H II regions in the southern part of the loop. No H I or X-ray emission correlated with the Origem Loop was found.

Acknowledgements. We would like to thank the referee, Dr. Elly Berkhuijsen for constructive and helpful comments, which significantly improve the paper. The Sino-German .6 cm polarization survey was carried out with a receiver system constructed by Mr. Omar Lochner at MPIfR mounted at the Nanshan 25-m telescope of the Urunqui Observatory of NAOC. The MPG and the NAOC/CAS supported the construction of the receiving system by special funds. We thank Mr. Maozheng Chen and Mr. Jun Ma for qualified maintenance of the receiving system for many years. The authors are supported by the National Natural Science foundation of China (10833003) and the Partner group of the MPIfR at NAOC in the frame of the exchange program between MPG and CAS for many bilateral visits. XYG is additionally supported by the Young Researcher Grant of National Astronomical Observatories, Chinese Academy of Sciences. This paper made use of information from the Red MSX Source survey database at www.ast.leeds.ac.uk/RMS which was constructed with support from the Science and Technology Facilities Council of the UK. This paper also utilizes data from

---

5 http://www.cfa.harvard.edu/rtdc/CO/
6 http://www.ast.leeds.ac.uk/RMS/
7 http://www.xray.mpe.mpg.de/cgi-bin/rosat/rosat_survey
Galactic ALFA HI (GALFA HI) survey data set obtained with the Arecibo L-band Feed Array (ALFA) on the Arecibo 305m telescope. Arecibo Observatory is part of the National Astronomy and Ionosphere Center, which is operated by Cornell University under Cooperative Agreement with the U.S. National Science Foundation. The GALFA HI surveys are funded by the NSF through grants to Columbia University, the University of Wisconsin, and the University of California.

References
Anderson, L. D., Bania, T. M., Jackson, J. M., et al. 2009, ApJS, 181, 255
Aslan, Z., Gumerov, R., Jin, W., et al. 2010, A&A, 510, A10
Asvarov, A. I. 2006, A&A, 459, 519
Berkhuijsen, E. M. 1974, A&A, 35, 429
Berkhuijsen, E. M., Haslam, C. G. T., & Salter, C. J. 1971, A&A, 14, 252
Bieging, J. H., Peters, W. L., Vila Vilaro, B., Schlottman, K., & Kulesa, C. 2009, AJ, 138, 975
Blitz, L., Fich, M., & Stark, A. A. 1982, ApJS, 49, 183
Byun, D.-Y., Koo, B.-C., Tatenuma, K., & Sunada, K. 2006, ApJ, 637, 283
Case, G. L., & Bhattacharya, D. 1998, ApJ, 504, 761
Caswell, J. L. 1985, AJ, 90, 1076
Caswell, J. L., & Crowther, J. H. 1969, MNRAS, 145, 181
Chavarría, L. A., Allen, L. E., Hora, J. L., Brunt, C. M., & Fazio, G. G. 2008, ApJ, 682, 445
Dame, T. M., Hartmann, D., & Thaddeus, P. 2001, ApJ, 547, 792
Denoyer, L. K., Button, L., Chaffin, D., & Nieznanski, J. 1977, ApJ, 213, 379
Fürst, E., Reich, W., Reich, P., & Reif, K. 1990, A&AS, 85, 691
Gao, X. Y., Han, J. L., Reich, W., et al. 2011a, A&A, 529, A159
Gao, X. Y., Reich, W., Han, J. L., et al. 2010, ApJ, 715, A64
Gao, X. Y., Sun, X. H., Han, J. L., et al. 2011b, A&A, 532, A144
Gardiner, F. F., & Milne, D. K. 1965, AJ, 70, 754
Green, D. A. 2009, Bull. Astron. Soc. India, 37, 45
Hanbury Brown, R., Davies, R. D., & Hazard, C. 1960, The Observatory, 80, 191
Hartmann, D. & Burton, W. B. 1997, Atlas of Galactic Neutral Hydrogen, ed. Hartmann, D. & Burton, W. B.
Haslam, C. G. T., Kahn, F. D., & Meaburn, J. 1971, A&A, 12, 388
Heiles, C. 1984, ApJS, 55, 585
Hofmeyr, M., Boshlema, T., Choi, Y. K., et al. 2007, PASJ, 59, 889
Jarosik, N., Bennett, C. L., Dunkley, J., et al. 2011, ApJS, 192, 14
Junkes, N., Fuerst, E., & Reich, W. 1992, A&A, 261, 289
Kalberla, P. M. W., Burton, W. B., Hartmann, D., et al. 2005, A&A, 440, 775
Koo, B.-C., McKee, C. F., Lee, J.-J., et al. 2008, ApJ, 673, L147
Krymski, V. V., & Sidorchuk, M. A. 1988, A&A, 200, 185
Lahulla, J. F. 1987, AJ, 94, 1062
Large, M. I., Quigley, M. F. S., & Haslam, C. G. T. 1966, MNRAS, 131, 335
Large, M. I., Quigley, M. J. S., & Haslam, C. G. T. 1962, MNRAS, 124, 405
Miville-Deschênes, M., & Lagache, G. 2005, ApJS, 157, 302
Ojha, D. K., Samal, M. R., Panley, A. K., et al. 2011, ApJ, 738, 156
Quigley, M. J. S., & Haslam, C. G. T. 1965, Nature, 208, 741
Reich, P., Reich, W., & Fürst, E. 1997, A&AS, 126, 413
Reid, M. J., Menten, K. M., Brunthaler, A., et al. 2009, ApJ, 693, 397
Russell, D. 2003, A&A, 397, 133
Russeil, D., & Castets, A. 2004, A&A, 417, 107
Rygl, K. L. J., Brunthaler, A., Reid, M. J., et al. 2010, A&A, 511, A2
Simpson, R. J., Povich, M. S., Kendrew, S., et al. 2012, MNRAS, 424, 2442
Sofue, Y., & Reich, W. 1979, A&AS, 38, 251
Turtle, A. J., Pugh, J. F., Kendeldine, S., & Pauliny-Toth, I. I. K. 1962, MNRAS, 124, 297
Uyaniker, B., Fürst, E., Reich, W., Reich, P., & Wielebinski, R. 1998, A&AS, 132, 401
Uyaniker, B., Fürst, E., Reich, W., Reich, P., & Wielebinski, R. 1999, A&AS, 138, 31
Walsh, D., & Brown, R. H. 1955, Nature, 175, 808
Wolleben, M., Landecker, T. L., Reich, W., & Wielebinski, R. 2006, A&A, 448, 411
Xiao, L., Fürst, E., Reich, W., & Han, J. L. 2008, A&A, 482, 783
Xu, J.-L., Wang, J.-J., & Miller, M. 2011, ApJ, 727, 81