SYMMETRICAL STRUCTURES IN THE GALACTIC CENTRE REGION

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ABSTRACT. Symmetrical structures do exist in the Galactic Centre region. In this article we attempt to summarize their properties and draw the attention of the scientific community to the advantages of taking them into account when working with models of the Centre of our Galaxy. Our work is corroborated by two new maps of the region at 10.7 GHz.

1. INTRODUCTION

It is only human to search for symmetries and organized structures. In fact, up to very recently, the only way that theory could exploit experimental data and thus advance our understanding of the surrounding nature, has been by studying symmetrical, organized and well behaved phenomena. This data can be modeled and explained by using tools of Physics and Mathematics, sciences that tend to simplify and beautify the real world.

In the Centre of our Galaxy up to now there have been very few symmetries known. This resulted in rather poor models with very few degrees of freedom. Recent observations have led to new insight into our understanding of the region by revealing new symmetries and well organized structures. Here we give a list of these symmetries which theorists should take into account when working with their models.

M. Morris (ed.), The Center of the Galaxy, 237–242.

2. SYMMETRICAL STRUCTURES

2.1. Large Scale Symmetries

a) The Centre of our Galaxy is the *centre of mass distribution*

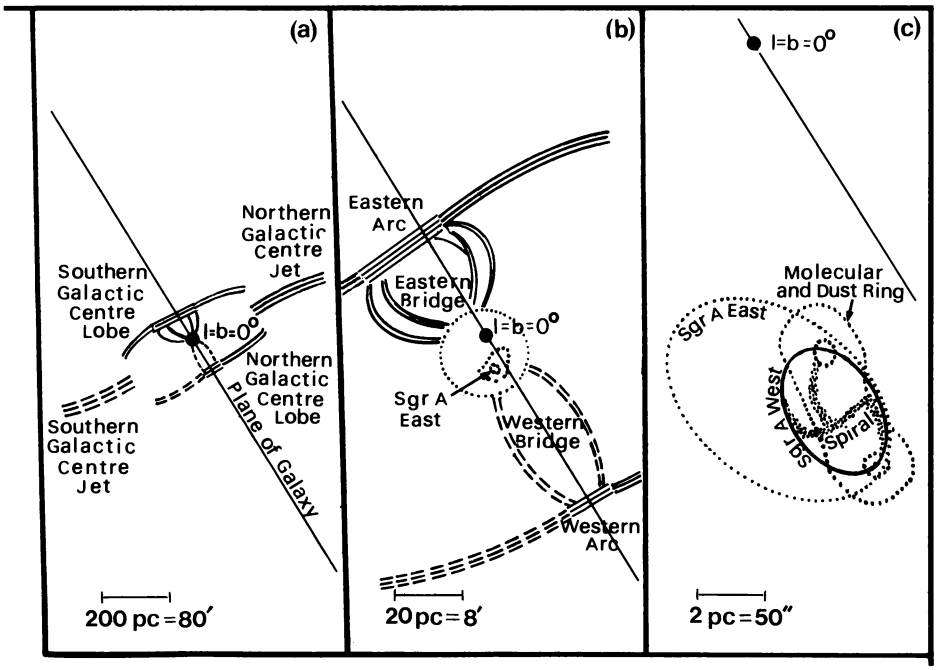

Figure 1. A schematic view of the Galactic Centre morphology. Features already detected are depicted with continuous or dotted lines. Expected features are depicted with dashed lines. a) Large scale view showing the *Galactic Centre Lobes* and *Jets*. b) Medium scale view showing the *Arcs* and *Bridges*. c) Small scale view showing Sgr A East and West, the *Molecular and Dust Ring* and the *Spiral*.

in the disk shaped Milky Way. This is a well established centre of symmetry first postulated by Shapley (1918) and refined thereafter (e.g. Bailey 1980, Allen, Hyland and Jones 1984).

b) The Centre of our Galaxy is the *centre of the kinematic velocities* in the Milky Way. This is also a well established centre of symmetry (e.g. Oort and Rougoor 1960). The velocity dispersion of the ionized gas increases towards the Centre with radial velocities reaching ±260 km/s within 0.7 light years of the Centre (Lacy et al. 1980).

2.2. Medium Scale Structures

a) The *Eastern Arc* with its filaments lying east of the Galactic Centre (Yusef-Zadeh, Morris and Chance 1984) has its symmetrical counterpart (the *Western Arc*) west of the Galactic Centre close to Sgr C (Liszt 1985).Both *arcs* are perpendicular to the Galactic Plane

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and exhibit non-thermal, polarized emission and fine filamentary structure indicative of strong magnetic fields. The centre of symmetry is the Galactic Centre (Fig. 1 and 2). The *Western Arc* near Sgr C is fainter and at about twice the distance from the Galactic Centre than its eastern counterpart. This "asymmetry" could be connected with an asymmetric distribution of gas in the region.

b) An *Eastern Bridge* of gas (also mentioned as *Arch* by some authors), emitting thermal radiation, connects the halo surrounding Sgr A to the *Eastern Arc*. This *Bridge* of material has two symmetrical components. A strong component arching from the Sgr A halo to the northern tip of the *Eastern Arc* and a weaker component arching towards the southern tip. The centre of symmetry is the Plane of the Galaxy (Fig. 1 and 2).

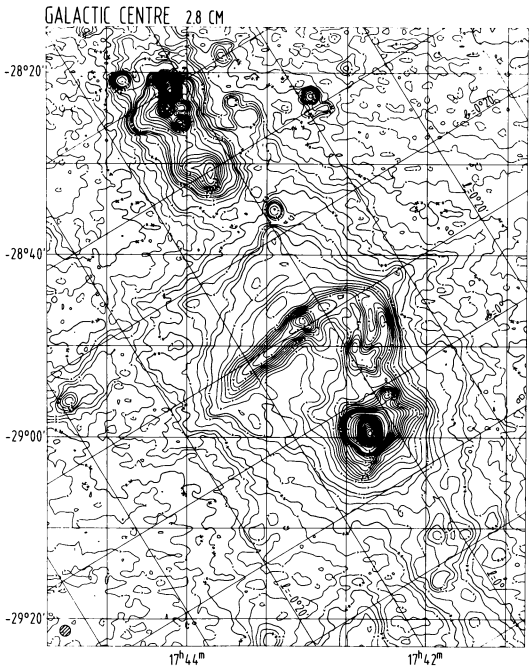

Figure 2. 10.7 GHz (2.8 cm) total intensity continuum emission from a region 52'x68' around the Galactic Centre. The contour steps are 0.1, 0.15,...,0.55, 0.6, 0.7,...,0.9, 1.0, 1.25,...,4.75, 5, 6,...,15, 17.5, 30 Jy/beam area. The half power beam of the 100m telescope at Effelsberg, W.Germany, is shown as a hatched circle at the lower left corner.

c) Polarization data along the *Eastern Arc* (Fig. 3) shows a remarkable symmetry (centre core flanked by two jet-like lobes, Seiradakis et al. 1985, Tsuboi et al. 1986). The centre of symmetry lies close to the Galactic Plane.

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2.3. Small Scale structures

a) There exists a *ring of molecular gas and dust* (also mentioned as *circumnuclear disk* or *circumnuclear ring* by some authors) surrounding a 2 pc cavity around the Centre of the Galaxy. Molecular line observations (Genzel et al. 1982, 1984, 1985, Serabyn et al. 1986) have shown that this is part of a flattened torus or disk of gas which rotates about the Galactic Centre with a velocity of ~100 km/s. The centre of symmetry is the Centre of the Galaxy.

b) Very close to the Centre of the Galaxy there exists a conspicuous *spiral structure* (Ekers et al. 1983). The western arc of this spiral could be the ionized inner edge of the molecular ring.

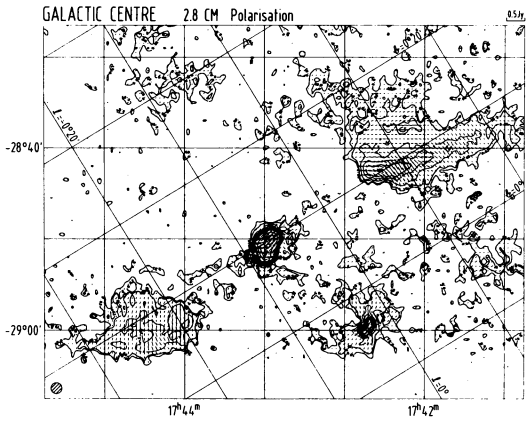

Figure 3. 10.7 GHz (2.8 cm) percentage linearly polarized emission from a region 52'x41' around Sgr A. The contour step is 0.05 Jy/beam starting from 0.05 Jy/beam area. The 0.03 Jy/beam area contour is also shown. The direction of the magnetic field is perpendicular to the superimposed polarization E-vectors. A 0.5 Jy/beam area vector is shown at the upper right corner.

3. EXPECTED SYMMETRICAL STRUCTURES (?)

More symmetrical structures may be present in the Galactic Centre region although true one-sided (asymmetric) phenomena can also exist (i.e. Sofue and Fujimoto, 1988). If the *Northern Galactic Centre Lobe* (Sofue and Handa 1984), lying north of the Plane of the Galaxy, was caused by a large explosion some 10^6 years ago (Sofue 1984) with the 4 kpc *Northern Galactic Centre Jet* (Sofue 1988) emanating away from it, then we may expect similar structures south of the Plane. Of course, if the distribution of material around the region of the explosion was highly asymmetrical, then the present structures may only show weak symmetry or even exhibit true one-sided features.

Absorption does not seem to offer a realistic explanation for the observed asymmetries. If the cm-radio waves are absorbed by interstellar matter, the following possibilities may be considered: (a) Free-free ab-

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sorption by thermal electrons (plasma). This means that the plasma is optically thick and that it should be observed with a brightness temperature of about 10^4 K, which is not the case. (b) Synchrotron absorption by cosmic ray electrons and magnetic field. The absorbing material would then be a strong emitter for reasons similar to (a). (c) Scattering by dust grains: The grain size must be greater than a few cm in order to scatter cm-radio waves. For the optically thick case, at least one grain should exist along the line of sight. The mass of this grain can be calculated, $M_{Dust} \sim d^2 \lambda \rho \sim 10^{8-10} M_\odot$. Here d ~ 100 pc is the size of the absorbed object, λ ~ a few cm is the wavelength and ρ ~ a few g cm^{-3} is the grain density. It is highly unlikely that such "grains" exist in the interstellar medium. Moreover, such grains should emit strong IR radiation which is not observed.

Symmetrical structures that we may expect in the Galactic Centre region are:

a) A *Southern Galactic Centre Lobe* south of the Galactic Plane might exist as a counterpart to the *Northern Galactic Centre Lobe*.

b) A *Southern Galactic Centre Jet* might exist as a counterpart of the *Northern Galactic Centre Jet*.

c) Finally, weak symmetrical arched filaments west of the Galactic Centre (the *Western Bridge*, connecting the Sgr A halo to the *Western Arc* (near Sgr C) could be expected as counterparts to the *Eastern Bridge* east of the Galactic Centre.

4. CONCLUSIONS

Any attempt to model the region around the Centre of our Galaxy should take advantage of the existing symmetries. These symmetries are not always obvious mainly because of distortions due to the peculiar distribution of gases in the area. We hope that future, more sensitive, observations may shed new light on the processes that occur in the Galactic Centre region.

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