Discovery of a New Filamentary Structure G358.85+0.47 - The Pelican

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Abstract.

We report the discovery of a new filamentary structure, G358.85+0.47, consisting of at least three mutually parallel but bent ‘strands’, located about 1.5$^\circ$ SW of the Sgr A complex. Unlike all the other known Galactic center filaments, G358.85+0.47 is oriented parallel to the galactic plane. Based on its appearance in a 20 cm image, we give it the name ‘the Pelican’ for further reference.

1. Introduction

The region within about 150 pc of the Galactic Center contains many unique radio structures. Particularly interesting among these are several linear, non-thermal structures termed ”arcs”, ”threads”, and ”filaments”. The Radio Arc which is a bundle of about a dozen parallel filamentary structures was discovered by Yusef-Zadeh, Morris and Chance (1984). Two isolated linear structures known as ”threads” (G0.08+0.15 and G359.96+0.09) were first reported by Morris and Yusef-Zadeh (1985). The other known linear structures near the Galactic center are G359.79+0.17, Sgr C (Liszt 1985), G359.54+0.18 (Bally and Yusef-Zadeh 1989) and G359.1-0.2 or the ”snake” (Gray et al 1991). The linear structures are tens of parsecs long and only a fraction of a parsec wide. Their origin is still not understood. Some of the known properties of these filaments are (Morris 1996, Lang 1999): (1) most of them seem to be oriented perpendicular to the Galactic plane and lie at positive Galactic latitudes, (2) the radio emission is non-thermal and strongly linearly polarized, (3) the spectra of the filaments, where they have been measured, is steep ($S \propto \nu^{-0.6}$), or, flat, or even inverted (Anantharamaiah et al 1991), (4) there are no obvious radio point sources associated with the filaments and (5) in every well studied case, there appears to be an association with a molecular cloud.

Although the origin of these filaments is still enigmatic, there is general agreement that there is an intimate connection between these filaments and the large scale magnetic field structure in the Galactic center region. In fact, most of the models that are proposed to explain these structures, make use of some type
of magnetic phenomenon including generation of magnetic loops (Heyvaerts, Norman and Pudritz 1988), induced electric field through the $v \times B$ interaction between a moving molecular cloud and a uniform field (Benford 1988), particle acceleration by field line annihilation around current pinches (Lesch and Reich 1992) and field annihilation at the surface of molecular clumps (Serabyn and Morris 1996).

In most of the models, the filaments are thus thought to define the magnetic field direction. Polarization measurements of some of the filaments do support this idea (Lang 1999). As these threads and filaments are oriented essentially perpendicular to the Galactic plane, these radio structures are often considered as strong evidence for the presence of an intense dipolar poloidal magnetic field in the galactic center region (Morris 1996).

In this paper we report the discovery of a new filamentary structure which is about 1.5° SW of the Sgr A complex. This filamentary structure is unique in that it is oriented parallel to the galactic plane whereas all the other previously known filaments are oriented roughly perpendicular to the galactic plane. The orientation of this filament may have implications for the large scale structure of the magnetic field in the galactic center region.

![Figure 1](image.png)

**Figure 1.** A sub-region of the wide-field image at 90 cm showing the new filament and three other previously known filaments. The beam depicted at the bottom left corner is $38'' \times 25''$. The contour levels are -10, 10, 20, 30, 40, 60, 80, 100, 140, ... 620 mJy/beam

2. Identification of the New Filament in a Wide-field 90 cm Image

Using the data at $\lambda = 90$ cm from all the four VLA configurations obtained by Pedlar et al (1989) and Anantharamaiah et al (1991), a new wide-field ($\sim 4^\circ$) radio image of the Galactic center region was recently made by Kassim et al (1999). Fig 1 shows a sub-region of this image. The new image was made using
a 3D-imaging algorithm developed by Cornwell and Perley (1992) which corrects for the non-coplanarity of the VLA and allows sensitive, distortion-free imaging of sources far from the field center. In a careful examination of the image made using the B+C+D configuration data with a resolution of 38" × 25", we identified a new linear structure which is located about 1.5° south-west of SgrA. In Fig 1, the new linear feature is located in the bottom right corner. The band of emission on the left hand side of Fig 1 is the emission from the Galactic plane. Fig 1 also shows three other previously known filamentary structures G359.54+0.18, Sgr C and the G359.1-0.2 (the Snake). The new linear feature is located at the position $\alpha_{1950} = 17^h 37^m 47^s$ and $\delta_{1950} = -29^\circ 38' 36''$ and is similar in appearance to the other linear structures but is oriented parallel to the Galactic plane. We designate this feature as G358.85+0.47 based on its galactic coordinates.

![Image](image_url)

Figure 2. Higher resolution (12") image of G358.85+0.47 at 90 cm made using only the A&B configuration data. The contour levels are -5, 5, 9, 13, 17 mJy/beam

This newly found linear feature was examined further at higher angular resolution using an image made with only the A and B configuration data. Fig 2 shows a 90 cm image of G358.85+0.47 at a resolution of 12". G358.85+0.47 has a linear extent of ~4' and appears barely resolved along its width. There are a few spots of enhanced emission along its length. The brightness of G358.85+0.47 ranges from 10 to 15 mJy/beam at $\lambda = 90$ cm.

3. Follow up Observations at $\lambda = 20$ cm

Follow up observations of G358.85+0.47 were made on Aug 24, 1998 using the B-configuration of the VLA at $\lambda = 20$ cm. Data was acquired in two frequency bands each of width 50 MHz and two orthogonal (RR and LL) polarizations. The amplitudes were calibrated using the source 3C286 and initial phase calibration.
was performed using frequent observations of the source 1748-253. The final image made after self-calibration and combining both the frequency bands is shown in Fig 3 in grey scale and in Fig 4 in contours.

Figure 3. 20 cm image of the new filament G358.85+0.47 in Gray scale. The beam size is $8.4'' \times 3.4''$, PA = -7°.

The filamentary nature of the new feature is obvious from Figs 3 and 4. There could be little doubt that this feature belongs to the same category of radio filaments such as Sgr C, G359.54+0.18, G359.79+0.17, the Snake and the 'threads' G0.08+0.15 and G359.96+0.09. The distinguishing feature of the new filament is that it is oriented parallel to the galactic plane. Although we do not yet have any radio polarization data for the new filament, based on what is known about the other filaments (Lang 1999), it is reasonable to expect that the magnetic field lines will be aligned along the length of the filament or in other words parallel to the galactic plane. Such a orientation of the field lines will have to be reconciled with the strong poloidal magnetic field that has been
postulated based on the orientation of the previously known filaments. It is possible that the location and the orientation of the new filament may set limits on the distance from the galactic center up to which a dipolar field may be extended. For example, the new filament may indicate the position where the field lines are turning around to close the loop.

The overall structure of the new filament is also unique. It consists of at least three sub-filaments which are bent in an inverted S-shape. The bend in the northernmost filament is particularly pronounced. The distortion in the filaments implies either that the field lines in this region are themselves distorted or that the structure of the filament is not dominated by the magnetic field. The minimum magnetic field in the northern sub-filament implied by assuming that radio emission at 1.4 GHz is due to synchrotron emission is 70 $\mu$G.
It is not clear why there are significant differences in the structure of the filament at 90 cm and 20 cm (Figs 2 and 4). The differences persist even when the images are compared at the same angular resolution (12″). While the filamentary structure is obvious in the 20 cm image, at 90 cm there are several peaks along the length of the filament and the northern most bent filament is absent in Fig 2. The 90 cm image is limited by the dynamic range of the wide-field image. Note that at 90 cm, the field of view of the VLA includes the emission from the entire Sgr A complex and thus the image in Fig 2 had to be made after subtracting strong emission from other regions. Because of these differences, the determination of the spectral index between 90 cm and 20 cm is uncertain. At the peak of the source the derived spectral index is $-0.1 \pm 0.2$. While this spectral index is consistent with the flat or inverted spectrum exhibited by several other filaments (Anantharamaiah et al 1991), higher frequency observations are required for a better estimate.

As there are a number of unique radio features near the galactic center, it is essential to assign identifying names to these features for easy reference. Based on the visual appearance of its image in Fig 3, we suggest the name 'Pelican' for the new filament. Further observations of the pelican-shaped filament in Fig 3 are underway to determine its radio spectral index, polarization and possible association with molecular gas.

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References

Anantharamaiah, K.R., Pedlar, A., Ekers, R.D. & Goss, W.M. 1991, MNRAS, 249, 262
Bally, J. & Yusef-Zadeh, F. 1989, ApJ, 336, 173
Benford, G. 1988, ApJ, 333, 735
Cornwell, T.J. & Perley, R. 1992, A&A, 261, 353
Gray, A.D., Cram, L.E., Ekers, R.D. & Goss, W.M. 1991, Nature, 353, 237
Kassim, N.E., LaRosa, T.N., Lazio, T.J.W & Hyman, S.D.1999 (this book)
Lang, C.C. 1999 (this proceedings)
Heyvaerts, J., Norman, C. & Pudritz, R. 1988, ApJ, 330, 718
Lesch, H. and Reich, W. 1992, A&A, 264, 493
Liszt, H.S., 1985, ApJ, 203, L65
Pedlar, A., Anantharamaiah, K.R., Ekers, R.D., Goss, W.M., Van Gorkom, J.H., Schawarz, U.J., & Zhao, J.H. 1989, ApJ, 342, 769
Morris, M. 1996, Unsolved Problems of the Milky Way, ed. L. Blitz & P. Teuben, (Kluwer) p247
Morris, M. & Yusef-Zadeh, F. 1985, AJ, 90, 2511
Serabyn, E. & Morris, M. 1994, ApJ, 424, L91
Yusef-Zadeh, F., Morris, M., & Chance, D. 1984, Nature, 310, 557