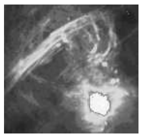
GCNEWS



The Newsletter of Galactic Center Research

Edited by Angela Cotera & Heino Falcke

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VLT Spectroscopy of the Galactic Center

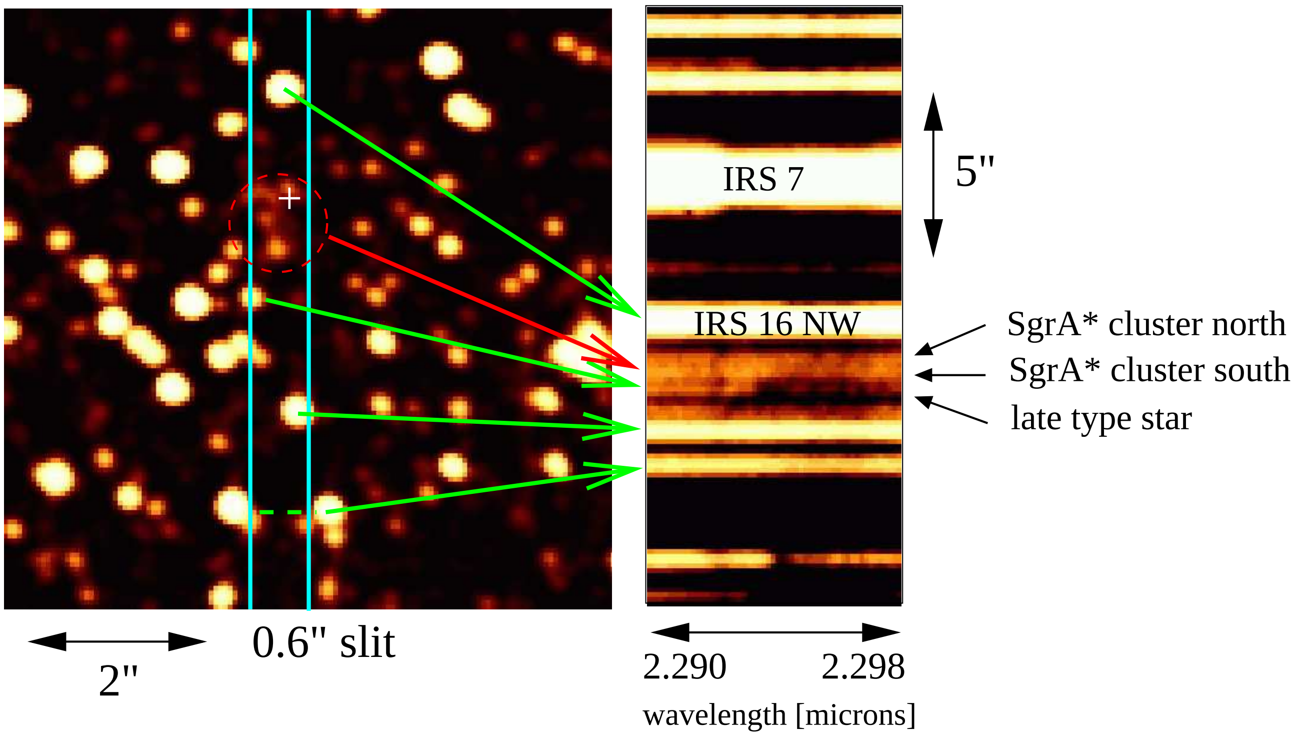

Figure 1: *Left:* Speckle image reconstruction of the new June 1999 SHARP data taken at the ESO NTT. *Right:* The central portion of a 5 minute, two dimensional spectroscopic exposure on the CO(2-0) bandhead absorption line taken in ∼0.3" IR seeing with ISAAC on the ESO VLT UT1 (ANTU). The position of Sgr A* (see Menten et al. 1997) is indicated by a cross in the SHARP image. *(Figure from Eckart, Ott, & Genzel; see inside)*

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Editorial:

Angela Cotera & Heino Falcke

Update on GCNEWS

Recently, one of us has been doing some searching of the literature with the ADS Abstract service (to make sure no relevant work is missed while writing up some recent observations), and noticed that, while GCNEWS has been successful in disseminating recent results, and has by far the best concentration of GC related papers, we are still missing some published GC papers. So, to advertise what GCNEWS can provide to you, our subscribers, we would like to let you know that currently, there are 275 of you on our mailing list, providing you wth the best way of letting the GC community learn of your work, and of learning yourself of the progress of others. Also, our webpage has a list of all the subscribers, with their email addresses and phone numbers, which provides an easy way to contact other GC researchers. Scanning over the subscribers list, however, there are still many GC researchers not subscribing to the service. So, make sure you send us your latest abstracts, bug your friends to subscribe, and be sure to use all the resources GCNEWS can provide.

This issue

Once again we have received a large number interesting results that have been submitted within the past months. First we have three papers (Yusef-Zadeh et al.; Backer & Sramek; Reid et al.) discussing the exact position and proper motion of Sgr A*. This is, of course, *THE* reference point for all astrometry in the Galactic Center and even the Galaxy. Probably most fascinating—from a technical point of view—is the fact that by observing Sgr A* with the VLBA (and the VLA) the rotation of our Sun around the Galactic Center can be measured. Considering it takes the Sun about 220 million years to complete an orbit, and that the VLBA can detect that motion in only two weeks, this is truly an amazing accomplishment.

On the subject of Sgr A*, another interesting bit of news has been provided in the papers by Bower et al. who have studied the polarization of this famous radio source. Although rumours abounded that it is (linearly) unpolarized, nobody realized that it is in fact a fairly strong circularly polarized source (see also Sault & Macquart). What is also curious is that this went unnoticed for this well-observed source for more than two decades. Perhaps this illustrates the point that there are still many new discoveries waiting to be made in the Galactic Center. As usual we currently lack any good explanations as to the causes of this unusual polarization.

Those of our readers more interested in stars in the GC and their evolution, will find a number of new papers and observations on the stellar content in the GC. Figer et al. present HST/NICMOS observations of the Arches and Quintuplet clusters which they find are indeed very young and suggest may be among the most massive in our Galaxy. In addition, NIR spectroscopy and even VLA observations (Lang et al.) directly probe the strong winds from these hot stars. Other papers discuss the stellar content on small scales near and far from the Black hole (Eckart et al., Philipp et al.). Can the stellar content be related to Sgr A*? Tal Alexander argues that it is, and explains how the stellar distribution and the presence of a black hole are naturally linked (see also Bailey & Davies).

In addition we also have an assortment of papers on the high-energy emission, non-thermal filaments, magnetic fields and a number of other facinating topics. As editors, we realize that we may have become so accustomed to the diverse and exciting results that pass through GCNEWS each month, that every now and again we need to sit back for a few moments, scan through the abstracts in GCNEWS, and enjoy diversity—again.

VLT Spectroscopy of the Sgr A* Stellar Cluster

Andreas Eckart, Thomas Ott & Reinhard Genzel (Max-Planck-Institut für Extraterrestrische Physik, Garching)

We have obtained new near-infrared observations of the central stellar cluster of our Galaxy carried out with the infrared spectrometer ISAAC at the ESO VLT and the MPE speckle camera SHARP at the ESO NTT. With ISAAC we used a spectral resolution of $\lambda/\Delta\lambda\sim$ 3500 on the 2.058 μm He I, 2.165μm Brγ emission lines, and 2.29 μm CO bandhead absorption line. The data demonstrate clearly that there is no strong CO bandhead absorption originating in the northern part (S1/S2 area) of the central stellar cluster at the position of Sgr A*. This makes it likely that the K$\sim$14.5 fast moving objects are O9 - B0.5 stars with masses of 15 to 20 $M_\odot$. Weak CO bandhead absorption in the southern part of the cluster (S10/S11 area) could be due to contributions from neighbouring stars. We have also detected Brγ and He I line emission at the position of the central stellar cluster which could be associated with the 'mini-spiral' rather than with the Sgr A* cluster itself. At the NTT we obtained another epoch to measure the proper motion structure and variability of sources in the central stellar cluster (see Ott, Eckart, Genzel 1999). The changes of source positions are consistent with the proper motion velocities derived from earlier epochs.

Introduction

The gas and stellar dynamics indicate the presence of a large unresolved central mass (Sellgren et al. 1990, Krabbe et al. 1995, Haller et al. 1996, Eckart and Genzel 1996, 1997, Genzel et al. 1996, 1997, Ghez et al. 1998, 1999). At its measured mass of about 2.6×10^6 $M_\odot$ and density ($\geq 2\times10^{12}$ $M_\odot pc^{-3}$) it cannot be stable and therefore is most likely present in the form of a massive black hole (Maoz 1998).
Genzel et al. (1997) reported first R=$\lambda/\Delta\lambda\sim$35 speckle spectroscopy measurements on individual objects in the central $\sim1''$ diameter stellar cluster at the position of Sgr A*(IR). In combination with other data this spectroscopic information can be used to derive a lower limit to the mass associated with the compact radio source. On 30 June and 1 July 1999 we obtained the first ESO VLT UT1 (ANTU) NIR spectroscopic data of the Sgr A* stellar cluster using ISAAC (Moorwood et al. 1998) at a spectral resolution of R$\sim$3500 on the 2.058 μm He I, 2.165μm Brγ emission lines, and the 2.29 μm CO bandhead absorption lines. The combination of these spectroscopic data taken in excellent seeing (0.3" to 0.5") and our new speckle image reconstructions based on SHARP NTT data strengthen the case for a compact mass and add to our understanding of the stellar population near the center of the Galaxy. Details of the observations are given in Eckart, Ott, Genzel (1999, A&A Dec.) Here we summarize some of the first results.

Recombination lines

Our high spatial and spectral resolution data clearly show the presence of Brγ and He I emission which is apparently spatially coincident with the location of the Sgr A* central stellar cluster. From our Brγ data we find a line width of <120 km/s and a velocity gradient of about 35 km/s between the southern part (S10/S12-region) and the northern part (S1/S2-region) of the cluster. In both slit settings this line emission appears to be connected to the more extended line emission over the remaining central cluster. Combined with the small line width at any position in that region this indicates that the emitting gas is not necessarily associated with the Sgr A* stellar cluster. If the emission would be associated with the cluster we would expect a larger line width due to the higher gravitational potential indicated by the rapid motions of the stars. However, broad and weak emission components could still be present at very low flux levels.

CO absorption

Fig.1 (cover) shows our new speckle image reconstruction based on data taken with the MPE speckle camera SHARP at the NTT in June 1999. In this figure we compare the image with a section of the two dimensional ISAAC spectroscopic exposure on the CO(2-0) bandhead absorption line. One can clearly identify the individual sources that contributed to the flux density in the 0.6" slit. At the high angular

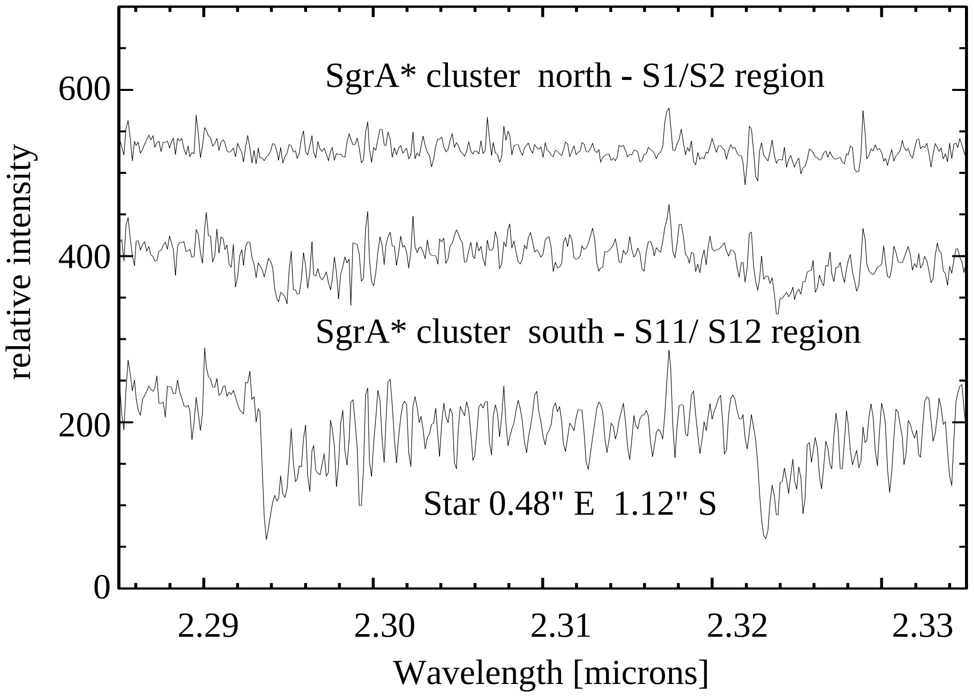

Figure 2: Spectra of the northern and southern part of the Sgr A* cluster as well as the late type star 1.12" south of the center. No strong CO(2-0) and CO(3-1) bandhead absorption is measured towards the northern part containing the fast moving sources S1 and S2. The spectra of the southern part and the late type star have been shifted down by 150 and 300 units, respectively.

resolution (∼0.3" seeing) of the exposure one can distinguish between the northern and southern part of the Sgr A* stellar cluster as well as a star 1.12" south of the the center with obvious bandhead absorption. In Fig.2 we show the corresponding spectra There is only very weak bandhead absorption on the northern Sgr A* cluster which is in agreement with an expected contribution from the more extended underlying stellar cluster. The bandhead absorption on the southern part of the central stellar cluster is probably due to a significant flux density contribution from late type stars in the immediate vicinity. These new findings are in full agreement with our initial results that we obtained via R∼ 35 speckle spectroscopy measurements on the individual objects S1, S2, S8, and S11. It also indicates that most of the other S-sources - especially near the position of Sgr A* - can not be stars with strong CO bandhead absorption.

Our new data indicates that the $m_K \sim 14.5$ sources in the central Sgr A* cluster are most likely moderately luminous (L∼5,000 to 10,000 $L_\odot$) early type stars. If these objects are on the main sequence they would have to be O9 - B0.5 stars with masses of 15 to 20 $M_\odot$. Backer (1996, 1999) and Reid et al. (1999) have shown that the proper motion of Sgr A* itself is ≤ 16-20 km/s which is close to a factor of 100 smaller than the velocity of the fast moving stars in its vicinity. N-body simulations using 20 $M_\odot$ as an upper limit of the mass distribution of these high velocity stars result in a lower limit of 10^3 $M_\odot$ for Sgr A* (Reid et al. 1999, see also Genzel et al. 1999, 1997). The corresponding mass density is larger than 10^{18} $M_\odot pc^{-3}$, if this mass is enclosed within the radio size of Sgr A* of ≤ 1 AU. At the measured mass and mass density any dark cluster of stellar remnants (neutron stars, stellar black holes), low luminosity stars (e.g. white dwarfs) or sub-stellar objects would have a lifetime less than $\approx 10^7$ years. This short live time in addition to the high compactness is inconsistent with any currently known dynamical system. It appears that the most probable configuration of the central mass concentration is a massive, but currently inactive black hole (e.g. Quataert, Narayan, Reid 1999, Falcke & Melia 1997, Blandford & Begelman 1999).

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Abstracts

The Position of Sgr A* at the Galactic Center

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The absolute position of the compact radio source at the dynamical center of the Galaxy, Sgr A*, was known only to an accuracy of 0.2″ in spite of its accurate location with respect to near-IR stellar sources to within 30 milliarcsecond (mas). To remedy this poor positional accuracy, we have selected 15 high-resolution, high-frequency VLA observations of Sgr A* carried out in the last 13 years and determined the weighted average position with the average epoch 1992.4 to be at α, $\delta[1950]$ = $17^{h}42^{m}$ $29\overset{s}{.}3076\pm0.0007$, $-28°59'18.484 \pm 0.014''$, or α, $\delta[2000]$ = $17^{h}45^{m}$ $40\overset{s}{.}0383\pm0.0007$, $-29°00'28.069 \pm 0.014''$ which agrees with earlier published values to within the 0.2″ error bars of the earlier measurements. An accurate absolute position of Sgr A* can be useful for its identification with sources at other wavelengths, particularly, in soft and hard X-rays with implications for the models of a massive black hole at the Galactic center.

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Proper Motion of the Compact, Nonthermal Radio Source in the Galactic Center, Sagittarius A*

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Proper motions and radial velocities of luminous infrared stars in the galactic center have provided strong evidence for a dark mass of 2.5×10^6 $M_\odot$ in the central 0.05 pc of the galaxy. The leading hypothesis for this mass is a black hole. High angular resolution measurements at radio wavelengths find a compact radio source, Sagittarius (Sgr) A*, that is either the faint glow from a small amount of material accreting onto the hole with low radiative efficiency or a miniature AGN core-jet system. We provide in this paper a full report on the first program that has measured the apparent proper motion of Sgr A* with respect to background extragalactic reference frame. Our current result is:

$$\mu_{l,*} = [-6.18 \pm 0.19] \;\; \text{mas y}^{-1}$$

$$\mu_{b,*} = [-0.65 \pm 0.17] \;\; \text{mas y}^{-1}.$$

The observations were obtained with the NRAO Very Large Array at 4.9 GHz over sixteen years. The proper motion of Sgr A* provides an estimate of its mass based on equipartition of kinetic energy between the hole and the surrounding stars. The measured motion is largest in galactic longitude. This component of the motion is consistent with the secular parallax that results from the rotation of the solar system about the center, which is a global measure of Oort's constants (A-B), with no additional peculiar motion of Sgr A*. The current uncertainty in Oort's galactic rotation constants limits the use of this component of the proper motion for a mass inference. In latitude we find a small, and weakly significant, peculiar motion of Sgr A*, -19 ± 7 km s^{-1} after correction for the motion of the solar system with respect to the local standard of rest. We consider sources of peculiar motion of Sgr A* ranging from unstable radio wave propagation through intervening turbulent plasma to the effects of asymmetric masses in the center. These fail to account for a significant peculiar motion. One can appeal to an $m = 1$ dynamical instability that numerical simulations have revealed. However, the measurement of a latitude peculiar proper motion of comparable magnitude and error but with opposite sign in the companion paper by Reid et. al. (1999) leads us to conclude at the present time that our errors may be underestimated, and that the actual peculiar motion might therefore be closer to zero. Improvement of these measurements with further observations and resolving the differences between independent experiments will provide the accuracies of a few km s^{-1} in both coordinates that will provide both a black hole mass estimate and a definitive determination of Oort's galactic rotation constants on a global galactic scale.

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HST/NICMOS Observations of Massive Stellar Clusters Near the Galactic Center

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We report *Hubble Space Telescope* (*HST*) Near-infrared Camera and Multi-object Spectrometer (NICMOS) observations of the Arches and Quintuplet clusters, two extraordinary young clusters near the Galactic Center. For the first time, we have identified main sequence stars in the Galactic Center with initial masses well below 10 $M_\odot$. We present the first determination of the initial mass function (IMF) for any population in the Galactic Center, finding an IMF slope which is significantly more positive ($\Gamma \approx -0.65$) than the average for young clusters elsewhere in the Galaxy ($\Gamma \approx -1.4$). The apparent turnoffs in the color-magnitude diagrams suggest cluster ages which are consistent with the ages implied by the mixture of spectral types in the clusters; we find $\tau_{\rm age} \sim 2\pm1$ Myr for the Arches cluster, and $\tau_{\rm age} \sim 4\pm1$ Myr for the Quintuplet. We estimate total cluster masses by adding the masses of observed stars down to the 50% completeness limit, and then extrapolating down to a lower mass cutoff of 1 $M_\odot$. Using this method, we find $\gtrsim 10^4$ $\mathrm{M}_\odot$ for the total mass of the Arches cluster. Such a determination for the Quintuplet cluster is complicated by the double-valued mass-magnitude relationship for clusters with ages $\gtrsim$ 3 Myr. We find a lower limit of 6300 $M_\odot$ for the total cluster mass, and suggest a best estimate of twice this value which accounts for the outlying members of the cluster. Both clusters have masses which place them as the two most massive clusters in the Galaxy.

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The Proper Motion of Sgr A*: I. First VLBA Results

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We observed Sgr A* and two extragalactic radio sources nearby in angle with the VLBA over a period of two years and measured relative positions with an accuracy approaching 0.1 mas. The apparent proper motion of Sgr A* relative to J1745–283 is 5.90 ± 0.4 mas /yr, almost entirely in the plane of the Galaxy. The effects of the orbit of the Sun around the Galactic Center can account for this motion, and any residual proper motion of Sgr A*, with respect to extragalactic sources, is less than about 20 km s^{-1}. Assuming that Sgr A* is at rest at the center of the Galaxy, we estimate that the circular rotation speed in the Galaxy at the position of the Sun, Θ_0, is 219±20 km/s scaled by R_0/8.0 kpc. Current observations are consistent with Sgr A* containing all of the nearly 2.6×10^6 $M_\odot$, deduced from stellar proper motions, in the form of a massive black hole. While the low luminosity of Sgr A*, for example, might possibly have come from a contact binary containing of order 10 $M_\odot$, the lack of substantial motion rules out a "stellar" origin for Sgr A*. The very slow speed of Sgr A* yields a lower limit to the mass of Sgr A* of about 1,000 $M_\odot$. Even for this mass, Sgr A* appears to be radiating at less than 0.1% of its Eddington limit.

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Eprint: astro-ph/990507501

A Radio Polarimetric Study of the Galactic Center Threads

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Multi-frequency, polarimetric VLA observations of the non-thermal filaments (NTF's), G0.08+0.15, and G359.96+0.09, also known as the Northern and Southern Threads are presented at 20, 6, 3.6 and 2 cm, with high enough spatial resolution to be resolved for the first time at 6 and 3.6 cm. The 20 cm image reveals a wealth of new detail in the radio sources lying within the inner 60 pc of the Galaxy. The Southern Thread has a prominent split along its length, similar to splitting at the ends of previously studied NTF's. With resolutions as fine as 2", the 3.6 and 6 cm images reveal a high degree of continuity and little substructure internal to the filament. The spectral index of the Northern Thread has been determined over a broad range of frequencies. Its flux density falls with frequency, alpha=-0.5 between 90 and 6 cm, and becomes much steeper (alpha=-2.0) between 6 and 2 cm. The spectral index does not vary significantly along the length of the Northern Thread, which implies either that the diffusion timescale for the emitting electrons is less than their synchrotron lifetime, or that the emitting electrons are reaccelerated continuously at multiple positions along the filament. Because of the lack of spectral index variation, we have not located the source of relativistic electrons. Polarization observations at 6 and 3.6 cm confirm the non-thermal nature of the emission from the Northern Thread. The fractional polarization in the Northern Thread reaches 70 rotation measures (RM > 2000 rad/m^2) have been observed with irregular variations across the filament.

The intrinsic magnetic field in the Northern Thread is predominantly aligned along its long axis.
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Discovery of a Non-Thermal Galactic Center Filament (G358.85+0.47) Parallel to the Galactic Plane

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We report the discovery of a new non-thermal filament, G358.85+0.47, the "Pelican", located ~225 pc in projection from SgrA, and oriented parallel to the Galactic plane. VLA continuum observations at λ20 cm reveal that this 7′ (17.5 pc) structure bends at its northern extension and is comprised of parallel strands, most apparent at its ends. Observations at λ6 and λ3.6 cm reveal that the Pelican is a synchrotron-emitting source and is strongly linearly polarized over much of its extent. The spectral index of the filament changes from $\alpha_{20/6}=-0.8$ to $\alpha_{6/3.6}=-1.5$. The rotation measures exhibit a smooth gradient, with values ranging from -1000 rad m^{-2} to $+500$ rad m^2. The intrinsic magnetic field is well-aligned along the length of the filament. Based on these properties, we classify the Pelican as one of the non-thermal filaments unique to the Galactic center. Since these filaments (most of which are oriented perpendicular to the Galactic plane) are believed to trace the overall magnetic field in the inner Galaxy, the Pelican is the first detection of a component of this field *parallel* to the plane. The Pelican may thus mark a transition region of the magnetic field orientation in the inner kiloparsec of the Galaxy.

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High Resolution Infrared Imaging and Spectroscopy of the Pistol Nebula: Evidence for Ejection

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We present new infrared images, obtained with the *Hubble Space Telescope* (*HST*) Near-infrared Camera and Multi-object Spectrometer (NICMOS), and Br-α (4.05 μm) spectroscopy, obtained using CGS4 on UKIRT, of the Pistol Star and its associated nebula. We find strong evidence to support the hypothesis that the Pistol Nebula was ejected from the Pistol Star. The Pa-α (1.87 μm) NICMOS image shows that the nebula completely surrounds the Pistol Star, although the line intensity is much stronger on its northern and western edges. The Br-α CGS4 spectra show the classical ring-like signature of quasi-spherical expansion. The blueshifted emission ($V_{max} \approx -60$ km s^{-1}) is much weaker than the redshifted emission ($V_{max} \approx +10$ km s^{-1}), where the velocities are with respect to the velocity of the Pistol Star; further, the redshifted emission spans a very narrow range of velocities, i.e., it appears "flattened" in the position-velocity diagram. These data suggest that the nebula was ejected from the star several thousand years ago, with a velocity between the current terminal velocity of the stellar wind (95 km s^{-1}) and the present expansion velocity of gas in the outer shell of the nebula (60 km s^{-1}). The Pa-α image reveals several emission-line stars in the region, including two newly-identified emission-line stars north of the Pistol Star, both of which are likely to be the hottest known stars in the Galactic center with spectral types earlier than WC8 and $T_{eff} > 50{,}000$ K). The presence of these stars, the morphology of the Pa-α emission, and the velocity field in the gas suggest that the side of the nebula furthest from us is approaching, and being ionized by, the hot stars of the Quintuplet, and that the highest velocity redshifted gas has been decelerated by winds from the Quintuplet stars. We also discuss the possibility that the nebular gas might be magnetically confined by the ambient magnetic field delineated by the nearby nonthermal filaments.

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Eprint: astro-ph/9906479

Radio Detections of Stellar Winds from the Pistol Star and Other Stars in the Galactic Center Quintuplet Cluster

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VLA images of the Sickle and Pistol H II regions near the Galactic center at 3.6 and 6 cm reveal six point sources in the region where the dense Quintuplet stellar cluster is located. The spectral indices of five of these sources between 6 cm and 3.6 cm have values of $\alpha = +0.5$ to $+0.8$, (where $S_\nu \propto \nu^\alpha$), consistent with the interpretation that the radio sources correspond to ionized stellar winds of the massive stars in this cluster. The radio source associated with the Pistol Star shows $\alpha = -0.4\pm0.2$, consistent with a flat or slightly non-thermal spectrum.

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Detection of Circular Polarization in the Galactic Center Black Hole Candidate Sagittarius A*

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We report here the detection of circular polarization in the Galactic Center black hole candidate, Sagittarius A*. The detection was made at 4.8 GHz and 8.4 GHz with the Very Large Array. We find that the fractional circular polarization at 4.8 GHz is $m_c = -0.36 \pm 0.05\%$ and that the spectral index of the circular polarization is $\alpha = -0.6 \pm 0.3$ ($m_c \propto \nu^\alpha$). The systematic error in m_c is less than 0.04% at both frequencies. In light of our recent lower limits on the linear polarization in Sgr A*, this detection is difficult to interpret with standard models. We consider briefly whether scattering mechanisms could produce the observed polarization. Detailed modeling of the source and the scattering medium is necessary. We propose a simple model in which low energy electrons reduce linear polarization through Faraday depolarization and convert linear polarization into circular polarization. Circular polarization may represent a significant new parameter for studying the obscured centimeter wavelength radio source in Sgr A*.

Ref.: accepted in ApJL
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Eprint: astro-ph/9907215
http://www.nrao.edu/ gbower/publications.html

The distribution of stars near the super-massive black hole in the Galactic Center

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We analyze three sets of infrared star counts in the inner 0.5 pc of the Galactic Center. We perform statistical tests on the star counts and model in detail the extinction field and the effects of dwarf-giant collisions on the luminosity function. We find that both the star counts and the depletion of the brightest stars in the inner 0.05 pc can be explained by a $r^{-\alpha}$ stellar cusp with α in the range 3/2 to 7/4, in which the envelopes of the brightest giants are destroyed by stellar collisions. Such a cusp is consistent with the Bahcall-Wolf solution for the distribution of stars that have undergone two-body relaxation around a black hole. We show that systematic uncertainties due to variable extinction and unrelaxed stars are probably small, but deeper star counts are required to confirm these results. We estimate that the tidal disruption rate of cusp stars by the black hole is few $\times\ 10^{-5}\ \mathrm{yr}^{-1}$.

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Email: tal@sns.ias.edu
Eprint: astro-ph/9907241

The Linear Polarization of Sagittarius A* II. VLA and BIMA Polarimetry at 22, 43 and 86 GHz

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(1) National Radio Astronomy Observatory, Socorro, NM, (2) Max Planck Institut für Radioastronomie, Bonn, Germany, (3) Astronomy Department & Radio Astronomy Laboratory, University of California, Berkeley, CA

We present a search for linear polarization at 22 GHz, 43 GHz and 86 GHz from the nearest super massive black hole candidate, Sagittarius A*. We find upper limits to the linear polarization of 0.2%, 0.4% and 1%, respectively. These results strongly support the conclusion of our centimeter wavelength spectro-polarimetry that Sgr A* is not depolarized by the interstellar medium but is in fact intrinsically depolarized.

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Eprint: astro-ph/9907282
http://www.nrao.edu/ gbower/publications.html

Three New Supernova Remnant OH Masers Near the Galactic Center: Evidence for Large Scale Maser Emission from Supernova Remnants

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A survey of the inner $8^\circ \times 1^\circ$ of the Galactic plane toward the Galactic center has been carried out at the 1720 MHz transition of OH molecule using the VLA in its D configuration with a resolution of $\approx 70'' \times 45''$. The detection of compact 1720 MHz OH masers associated with three supernova remnants G357.7+0.3, G1.13–0.1 (Sgr D) and G1.4–0.1 as well as new extended maser line emission from G357.7+0.3 and G357.7–0.1 (the Tornado Nebula) were then followed up by A-array observations with spectral and spatial resolutions of 0.3 km $s^{-1}$and $\approx 3'' \times 2''$, respectively. The 1720 MHz OH maser line emission is considered to be a powerful shock diagnostic and is collisionally pumped by H_2 molecules at the site where C-type supernova shocks drive into adjacent molecular clouds. The new observations show clear evidence of extended features coincident with compact and bright masers, the best example of which is a coherent feature over a scale of about 20 pc surrounding the shell of the SNR G357.7+0.3. We argue that this remarkable feature is an OH maser and is physically associated with the remnant. This implies that the ambient molecular cloud is uniform in its density and temperature with restricted range of pumping conditions and survives the passage of a large-scale shock front.

Ref.: ApJ, in press
Email: zadeh@oort.astro.nwu.edu
Eprint: astro-ph/9907370

Red giant collisions in the galactic centre

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We simulate collisions involving red-giant stars in the centre of our galaxy. Such encounters may explain the observed paucity of highly luminous red giants within $\sim 0.2\,\mathrm{pc}$ of Sgr $A^\star$. The masses of the missing stars are likely to be in the range $\sim 2\,\mathrm{M}_\odot - 8\,\mathrm{M}_\odot$. Recent models of the galactic centre cluster's density distribution and velocity dispersion are used to calculate two-body collision rates. In particular we use stellar-evolution models to calculate the number of collisions a star will have during different evolutionary phases. We find that the number of two-body collisions per star is $\lesssim 1$ in the central $0.1\,\mathrm{pc} - 0.2\,\mathrm{pc}$, depending strongly on the galactocentric radius, with some uncertainty from the assumed cluster models and stellar-evolution models. Using a 3D numerical hydrodynamics code (SPH) we simulate encounters involving cluster stars of various masses with a $2\,\mathrm{M}_\odot$ red giant and an $8\,\mathrm{M}_\odot$ red giant. The instantaneous mass loss in such collisions is rarely enough to destroy either giant. A fraction of the collisions do, however, lead to the formation of common envelope systems where the impactor and giant's core are enshrouded by the envelope of the giant. Such systems may evolve to expel the envelope, leaving a tight binary; the original giant is destroyed. The fraction of collisions that produce common envelope systems is sensitive to the local velocity dispersion and hence galactocentric radius. Whereas most of our collisions lead to common envelope formation at a few parsecs from Sgr $A^\star$, very few collisions do so within the central $0.2\,\mathrm{pc}$. Using our collision-rate calculations we then compute the time-scales for a giant star to suffer such a collision within the galactic centre. These time-scales are $\gtrsim 10^{9-10}$ years and so are longer than the lifetimes of stars more-massive than $\sim 2\,\mathrm{M}_\odot$. Thus the observed paucity of luminous giants is unlikely to be due to the formation of common envelope systems as a result of two-body encounters involving giant stars.

Ref.: MNRAS, in press
Email: vbailey@ast.cam.ac.uk
Eprint: astro-ph/9907309

The X–ray Diffuse Emission from the Galactic Center

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A long BeppoSAX observation of the Galactic Center region shows that the spectrum of the diffuse X–ray emission from the SgrA Complex can be described with the sum of two thermal plasma models with temperatures of ∼0.6 keV and ∼8-9 keV. The spatial distribution of the diffuse emission is energy dependent. While the hard X–ray emission has a nearly symmetric distribution elongated along the Galactic Plane, the soft X–rays ($E < 5$ keV) are remarkably well correlated with the triangular radio halo of SgrA East. The parameters derived for the soft component support the interpretation of the SgrA East shell in terms of an evolved supernova remnant.

Ref.: to appear in A&A Letters
Email: sidoli@ifctr.mi.cnr.it
Eprint: astro-ph/9908164

Diffuse Galactic Soft Gamma-Ray Emission

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The Galactic diffuse soft gamma-ray (30-800 keV) emission has been measured from the Galactic Center by the HIREGS balloon-borne germanium spectrometer to determine the spectral characteristics and origin of the emission. The resulting Galactic diffuse continuum is found to agree well with a single power-law (plus positronium) over the entire energy range, consistent with RXTE and COMPTEL/CGRO observations at lower and higher energies, respectively. We find no evidence of spectral steepening below 200 keV, as has been reported in previous observations. The spatial distribution along the Galactic ridge is found to be nearly flat, with upper limits set on the longitudinal gradient, and with no evidence of an edge in the observed region. The soft gamma-ray diffuse spectrum is well modeled by inverse Compton scattering of interstellar radiation off of cosmic-ray electrons, minimizing the need to invoke inefficient nonthermal bremsstrahlung emission. The resulting power requirement is well within that provided by Galactic supernovae. We speculate that the measured spectrum provides the first direct constraints on the cosmic-ray electron spectrum below 300 MeV.

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Email: boggs@srl.caltech.edu
Eprint: astro-ph/9908170

ASCA Observations of the Sgr B2 Cloud: An X-Ray Reflection Nebula

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We present the ASCA results of imaging spectroscopy of the giant molecular cloud Sgr B2. The X-ray spectrum is found to be very peculiar; it exhibits a strong emission line at 6.4 keV, a low energy cutoff below about 4 keV and a pronounced edge-structure at 7.1 keV. The X-ray image is extended and its peak position is shifted from the core of the molecular cloud toward the Galactic center by about 1–2 arcminute. The X-ray spectrum and the morphology are well reproduced by a scenario that X-rays from an external source located in the Galactic center direction are scattered by the molecular cloud Sgr B2, and come into our line of sight. Thus Sgr B2 may be called an *X-ray reflection nebula.* Possible implications of the Galactic center activity related to this unique source are presented.

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Email: hiro@cr.scphys.kyoto-u.ac.jp
Eprint: astro-ph/9908229

Interstellar extinction towards the inner Galactic Bulge

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DENIS observations in the J ($1.25\,\mu$m) and K_S ($2.15\,\mu$m) bands together with isochrones calculated for the RGB and AGB phase are used to draw an extinction map of the inner Galactic Bulge. The uncertainty in this method is mainly limited by the optical depth of the Bulge itself. A comparison with fields of known extinction shows a very good agreement. We present an extinction map for the inner Galactic Bulge ($\sim 20\,\mathrm{deg}^2$)

Ref.: accepted for A&A Letters
Email: shashi@prl.ernet.in
Eprint: astro-ph/9908349
http://www-denis.iap.fr/articles/extinction

Dark matter annihilation at the galactic center

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If cold dark matter is present at the galactic center, as in current models of the dark halo, it is accreted by the central black hole into a dense spike. Particle dark matter then annihilates strongly inside the spike, making it a compact source of photons, electrons, positrons, protons, antiprotons, and neutrinos. The spike luminosity depends on the density profile of the inner halo: halos with finite cores have unnoticeable spikes, while halos with inner cusps may have spikes so bright that the absence of a detected neutrino signal from the galactic center already places interesting upper limits on the density slope of the inner halo. Future neutrino telescopes observing the galactic center could probe the inner structure of the dark halo, or indirectly find the nature of dark matter.

Ref.: Physical Review Letters, 30 August
Email: gondolo@mppmu.mpg.de

The First Stellar Abundance Measurements in the Galactic Center: the M Supergiant IRS 7

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The first measurement of the photospheric abundances in a star at the Galactic Center are presented. A detailed abundance analysis of the Galactic Center M2 supergiant IRS 7 was carried out using high-resolution near-infrared echelle spectra. The Fe abundance for IRS 7 was found to be close to solar, [Fe/H] = -0.02 ± 0.13, and nearly identical to the Fe abundances we obtained for the nearby M supergiants α Ori and VV Cep. Analysis of the first and second overtone lines of CO was used to derive an effective temperature of 3600 ± 230 K, a microturbulent velocity of 3.0 ± 0.3 km s^{-1}, and a carbon abundance log ϵ (C) = 7.78 ± 0.13, or [C/H] = -0.77. In addition, we find a high depletion of 0.74 ± 0.32 dex in O and an enhancement of 0.92 ± 0.18 dex in N. These abundances are consistent with the dredge-up of CNO-cycle products but require deep mixing in excess of that predicted by standard models for red supergiants. In light of our measured solar Fe abundance for IRS 7, we discuss other indicators of metallicity at the Galactic Center, the interpretation of low-resolution near-infrared spectra of late-type giants and supergiants, including the need for caution in using such spectra as measures of metallicity, and the evolution of massive young stars at the Galactic Center. We suggest the possibility that rapid stellar rotation is common for stars formed under conditions in the Galactic Center, and that extra internal mixing induced by high rotation rates, rather than evolution at high metallicity, is the explanation for many of the unusual properties of the hot emission-line stars in the Galactic Center.

Ref.: Accepted by ApJ
Email: sellgren@astronomy.ohio-state.edu
Eprint: astro-ph/9909037
ftp://ftp.astronomy.ohio-state.edu/pub/sellgren/carr_irs7.tar.gz

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The Nuclear Bulge I: K Band Observations of the Central 30 pc

S. Philipp[1,2], R. Zylka[2], P.G. Mezger[1], W.J. Duschl[2,1], T. Herbst[3] & R.J. Tuffs[4]

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Out of ∼ 500 individual source images we have constructed a mosaic map of the K band surface brightness in an area $\Delta\alpha \times \Delta\delta \sim 650'' \times 710''$ ($R_{\rm equiv} \sim 15.8$ pc for $R_0 = 8.5$ kpc) centered approximately on Sgr A*. An observing technique was used which allows us to recover an extended background emission. To separate sources from an unresolved background continuum we fitted Lorentzian distributions to the sources and find that about one half of an integrated, not dereddened K band flux density of 752 Jy is contributed by $\sim 6 \times 10^4$ stars with flux densities $S'_{\rm K} \gtrsim 100\,\mu$Jy and the remainder is contributed by an extended continuum provided by about 6×10^8 stars too weak to be observed as individual sources. We estimate that $\gtrsim 80\%$ of the integrated flux density of the mosaic is contributed by stars in the Nuclear Bulge (NB; $R \lesssim 300$ pc); the remaining $\lesssim 20\%$ come from stars located along the line of sight in the Galactic Bulge (GB; $0.3 \lesssim R/{\rm kpc} \lesssim 3$) and Galactic Disk (GD; $R > 3$ kpc). We determine the K band luminosity functions (KLF) of the mosaic and of subareas dominated by Nuclear Bulge, Galactic Bulge and Disk stars, respectively, and construct *difference* KLFs which relate to the specific stellar populations of these regions. The detection limit is $S'_{\rm K} \sim 100\,\mu$Jy, for the completeness limit we estimate $S'_{\rm K} \sim 2\,000\,\mu$Jy. We find that the stellar population of the Nuclear Bulge contains considerably more bright stars (i.e. with reddened K band flux densities $S'_{\rm K} \gtrsim 5 \times 10^3\,\mu$Jy), most of which are probably early O stars, Giants and Supergiants. The stellar population of the Galactic Bulge on the other hand is dominated by stars which appear to be lower mass ($\lesssim 6 M_\odot$) Main Sequence (MS) stars. A *model* KLF constructed with a Salpeter Initial Mass Function (IMF) for stars of spectral type O9 or later ($S'_{\rm K} \lesssim 2\,000\,\mu$Jy) explains the observations satisfactorily and connects well with the *observed* KLF of more luminous stars. About 6×10^8 stars with masses ranging from 0.06 to 6 $M_\odot$ account for the unresolved continuum. Combining observed and model KLF we obtain a mosaic KLF which increases $\propto S'^{-1}_{\rm K}$ for $10^6 \gtrsim S'_{\rm K}/\mu{\rm Jy} \gtrsim 10^3$ and $\propto S'^{-0.6}_{\rm K}$ for $10^3 \gtrsim S'_{\rm K}/\mu{\rm Jy} \gtrsim 3 \times 10^{-3}$. ... shortened ... We present and discuss the radio/IR spectrum of the central 30″ (∼ 1.25 pc) and derive dust and Lyman continuum (Lyc) luminosities of $7.5 \times 10^7\,L_\odot$ and $1.2 \times 10^{50}\,s^{-1}$, respectively.

Ref.: A&A, 348, 768
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The Nuclear Bulge of the Galaxy II. The K band Luminosity Function of the Central 30 pc

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Philipp et al. (1999, Paper I) investigated the *K* band emission from a mosaic of size $\Delta\alpha \times \Delta\delta \sim 650'' \times 710''$ centered approximately on Sgr A* ($R_{\rm equiv} \sim 15.8$ pc for $R_0 = 8.5$ kpc). For the $\sim 6 \times 10^4$ stars above

the detection limit ($S'_{\rm K} \sim 100\,\mu$Jy) an *observed* K-band luminosity function (KLF) has been obtained. Below the completeness limit ($S'_{\rm K} \sim 2\,000\,\mu$Jy), an ever increasing fraction of stars merges into the background continuum. In this paper we combine the *observed* with *model* KLFs and thus obtain a *complete* KLF for the flux density range $3 \times 10^{-3} \gtrsim S'_{\rm K}/\mu{\rm Jy} \gtrsim 2{\times}10^6$. The overall KLF consists of four sectors obeying power laws of the form $dN(S'_{\rm K})/d{\rm log}S'_{\rm K} \propto S'^{\gamma_1+1}_{\rm K}$, where $\gamma_1 + 1$ decreases from –0.6 to –1.75. Sector I corresponds to a Salpeter Initial Mass Function (IMF) and represents Main Sequence (MS) stars with $M_* \lesssim 1\,{\rm M}_\odot$, which account for $\sim 90\,\%$ of the dynamical mass but only $\sim 6\,\%$ of the K band flux density. Sector II represents MS stars with $M_* \gtrsim 1\,{\rm M}_\odot$ and red giants. These stars account for only $\sim 6\,\%$ of the dynamical mass and a similar percentage of the integrated K-band surface brightness but represent $\sim 80\,\%$ of the bolometric stellar luminosity in the mosaic. The Mass Function (MF) of MS stars is $dN/dM_* \propto M_*^{-2.35}$ (i.e., the Salpeter IMF) for $M_* \lesssim 1\,{\rm M}_\odot$ and $dN/dM_* \propto M_*^{-4.5}$ for more massive stars, which is similar to the Present Day MF in the solar vicinity. Part of sector II of the KLF, as well as sectors III and IV, represent giants and supergiants which, though they account for only a small fraction of the mass, dominate the integrated K-band surface brightness. ... shortened .. Paper I shows, in agreement with earlier observations, that massive stars are preferentially formed in the central parsec. A preliminary discussion of star formation rates suggests that bimodal star formation (introduced by Güsten & Mezger [1983] for the spiral arm region of the Galactic Disk) may also apply to the central 30 pc. Preferential formation of stars with masses $M_* \gtrsim M_c \sim 1{-}5\,{\rm M}_\odot$ would make conversion of matter into radiation by star formation much more efficient and could be the process which powers star burst galaxies. There is an overabundance of evolved stars which can be explained by a strongly increased star formation rate $\sim 10^8 - 10^9$ yrs ago.

Ref.: A&A, 348, 457
Email: sphilipp@mpifr-bonn.mpg.de
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The Role of Magnetic Field Dissipation in the Black Hole Candidate Sgr A*

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The compact, nonthermal radio source Sgr A* at the Galactic Center appears to be coincident with a $\sim 2.6 \times 10^6\ M_\odot$ point-like object. Its energy source may be the release of gravitational energy as gas from the interstellar medium descends into its deep potential well. However, simple attempts at calculating the radiative spectrum and flux based on this picture have come tantalizingly close to the observations, yet have had difficulty in accounting for the unusually low efficiency in this source. Regardless of whether the radiating particles in the accretion flow are thermal or nonthermal, there now appear to be two principal reasons for this low conversion rate of dissipated energy into radiation: (1) the plasma separates into two temperatures, with the protons attaining a significantly higher temperature than that of the radiating electrons, and (2) the magnetic field **B** is sub-equipartition, which reduces the magnetic bremsstrahlung emissivity, and therefore the overall power of Sgr A*. In this paper, we investigate the latter with a considerable improvement over what has been attempted before. In particular, rather than calculating **B** based on some presumed model (e.g., equipartition with the thermal energy of the gas), we instead infer its distribution with radius empirically with the requirement that the resulting spectrum matches the observations. Our assumed ansatz for **B**(r) is motivated in part by earlier calculations of the expected magnetic dissipation rate due to reconnection in a compressed flow. We find reasonable agreement with the observed spectrum of Sgr A* as long as its distribution consists of 3 primary components: an outer equipartition field, a roughly constant field at intermediate radii ($\sim 10^3$ Schwarzschild radii), and an inner dynamo (more or less within the last stable orbit for a non-rotating black hole) which increases **B** to about 100 Gauss. The latter component accounts very well for the observed sub-millimiter hump in this source.

Ref.: ApJ, submitted
Email: rfc@gc.physics.arizona.edu
Eprint: astro-ph/9909411

Confirmation and Analysis of Circular Polarization from Sagittarius A*

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Recently Bower et al. (1999b) have reported the detection of circular polarization from the Galactic Center black hole candidate, Sagittarius A*. We provide an independent confirmation of this detection, and provide some analysis on the possible mechanisms.

Ref.: to appear in ApJ Letters
Email: Bob.Sault@atnf.csiro.au
Eprint: astro-ph/9910052

The Dynamics of Molecular Material Within 15 Parsecs of the Galactic Center

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(2) Harvard-Smithsonian Center for Astrophysics, Cambridge, MA

We report the results of a 5-field mosaic of the central 15pc of the Galaxy in the (1,1) and (2,2) lines of NH_3. Two narrow filaments or streamers are seen running parallel to the Galactic plane. The southern streamer appears to carry gas directly toward the nuclear region from the 20 km s^{-1}cloud. The eastern streamer, which we will denote the molecular ridge, appears to be the denser part of the 50 km s^{-1}cloud which lies immediately east of the Sgr A East complex and extends in the south towards the 20 km s^{-1}cloud. This ridge of gas carries the kinematical signatures of interactions with Sgr A East as well as a SNR which lies south of the Galactic center. The bulk motion of the gas, the enhanced line widths, and the heating of the molecular material all suggest an active evolutionary phase for the gas immediately adjacent to the nucleus.

Ref.: to appear in ApJ
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A Wide Field 90 cm VLA Image of the Galactic Center Region

T. N. LaRosa, Namir E. Kassim,
T. Joseph W. Lazio, & S. D. Hyman

We present a wide-field, high dynamic range, high resolution long wavelength (λ = 90 cm) VLA image of the Galactic center region. The image is centered on Sgr A, covers an area of $4^\circ \times 5^\circ$ with an angular resolution of $43''$ and has a rms sensitivity of $\approx$ 5 mJy/beam. The image was constructed from archival VLA data of Pedlar et al. (1989) and Anantharamaiah et al. (1991) using new 3-D image restoration techniques. These 3-D imaging techniques resolve the problem of non-coplanar baselines encountered at long wavelengths and yield distortion free imaging of far-field sources with improved sensitivity. At λ = 90 cm the VLA is sensitive to both thermal and nonthermal emission and the resulting image gives an unprecedented contextual perspective of the large-scale radio structure in this unique and complicated region. We have catalogued over a hundred sources from this image and present for each source its 90 cm flux density, position, and size. For many of the small- diameter sources, we also derive the 20/90 cm spectral index. The spectral index as a function of length along several of the isolated nonthermal filaments has been estimated and found to be constant. We have found six new small-diameter sources as well as several extended regions of emission that are clearly distinct sources that have not been previously identified at higher frequencies. These data are presented as a first epoch of VLA observations that can be used to search for source variability in conjunction with a second epoch of observations that were recently initiated.

Ref.: Astronomical Journal, 2000 January
Email: lazio@sne.nrl.navy.mil
http://rsd-www.nrl.navy.mil/7213/lazio/GCatlas/

The Sgr A* Stellar Cluster: New NIR Imaging and Spectroscopy

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We report preliminary results based on new near-infrared observations of the central stellar cluster of our Galaxy conducted with the infrared spectrometer ISAAC at the ESO VLT UT1 and the MPE speckle camera SHARP at the ESO NTT. We obtained $\lambda/\Delta\lambda \geq$ 3000 K-band spectroscopy of the 2.058 μm He I, 2.165μm Brγ emission lines, and 2.29 μm CO bandhead absorption line. These data demonstrate clearly that there is no strong CO bandhead absorption originating in the northern part (S1/S2 area) of the central stellar cluster at the position of Sgr A*. This makes it likely that these K$\sim$14.5 stars are O9 - B0.5 stars with masses of 15 to 20 $M_\odot$. Weaker CO bandhead absorption in the southern part of the cluster (S10/S11 area) could be due to contributions from neighbouring stars. We also report the detection of Brγ line emission at the position of the central stellar cluster which could be associated with the 'mini-spiral' rather than with the Sgr A* cluster itself. At the NTT we obtained another epoch epoch of proper motion measurements. The changes of source positions are consistent with the proper motion velocities derived from earlier epochs.

Ref.: Accepted by A&A
Email: ott@ibm-s-1.mpe-garching.MPG.DE
Eprint: astro-ph/9911011

GC98 Workshop Proceedings: Table of Contents

The proceedings of last year's Galactic Center workshop have appeared. If you are a participant and have not received a copy you should complain to us. If you are not a participant and still hesitate to buy a copy we list the table of contents in the following. The reference for the book is

"The Central Parsecs of the Galaxy", eds. H. Falcke, A. Cotera, W. Duschl, F. Melia, M. Rieke, ASP Conf. Series, Vol. 186

Session I: What is the Central Matter Distribution?

Session II: Can VLBI Constrain the Size and Structure of Sgr A*?

Session III: How to Reconcile Models and Observations of Sgr A*?

Session IV: How are the Various Components of Sgr A West Related?

Session V: How, When, Where and Why are Stars Formed in the Galactic Center?

Session VI: What is the Metallicity as Determined from Old and New Stars?

Session VII: How Do the Various Components of the Inner 100 Parsecs Interact With Each Other?

Session VIII: What is the Strength and Influence of the Magnetic Field in the Galactic Center?

Session IX: What Would the Galactic Center Look Like from 1 Mpc?

Session X: What Can We Learn from High-Energy Emission in the Galactic Center?

Summary

And finally ... !

- Fulivo Melia and Heino Falcke are going to write a **review for Annual Reviews of Astronomy and Astrophysics about the Galactic Center** with special emphasis on Sgr A*, its interaction with the environment, and theoretical models. They would appreciate any preprints that might be of relevance for this article. Of course, a primary source of information will also be GCNEWS, and every article that has been or will be submitted will get noticed. Please remember to include a web link with your submission so that the full paper can be retrieved.

- The following is a question GCNEWS got from an amateur astronomer and the answer we got from Susanne Hüttemeister (University of Bonn). Anyone is invited to comment or provide corrections.

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Dear Jim,

GCNews forwarded me your question

> Can you tell me which Satellite Galaxy is moving fastest towards the
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> Galactic center?

My answer is a little spontaneous and not totally reliable, but I
think that the Phoenix dwarf galaxy is a good candidate. This is a
rather distant and intrinsically faint object (D ~ 450 kpc, absolute
magnitude -10.1, an intermediate type between a dwarf irregular and a
dwarf spheroidal). It approaches the sun, but other dwarfs have far
larger negative velocities. However, if you correct for the motion of
the sun, Phoenix ends up (at least according to some models) as the
galaxy with the largest residual negative velocity.

Other "high velocity" objects are e.g. IC 1613 or LGS3, but these
belong to the M31 group (within the local group), they are not really
satellites of the Milky Way.

Susanne
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- Chandra has observed the GC for 50 ksec. First results are expected at the next AAS meeting.
- The following two sessions at the AAS meeting in Atlanta will focus on the GC:

  Session 5. Looking Towards The Galactic Center Display, Wednesday, 9:20am-6:30pm, Grand Hall
  Session 62. Sgr A* and Milky Way Oral, Thursday, January 13, 2000, 2:00-3:30pm, Regency VII

  The program of these sessions can be viewed at http://www.aas.org/meetings/aas195/program
- For those of you who have read or participated in the discussion at GC98 in Tucson about the evidence for a dark mass at the Galactic Center and remember that one big concern was the straight paths of the fast moving stars we have some news: at a recent ESO workshop in Garching, Andrea Ghez reported the finding of curvature in the stellar "orbits" in her most recent Keck observations. And guess what .... the stars curve in the right direction, i.e. towards Sgr A*! Think of all the problems that would have been raised had they turned the other way or kept going straight ...
- Heino Falcke has produced a little electronic slide show about the Galactic Center balck hole for educational purposes. It features a number of nice pictures and animations together with some (mostly) simple explanations. Check it out at http://www.mpifr-bonn.mpg.de/staff/hfalcke/bh
- GCNEWS is looking for an eager young grad student or postdoc to help us get the newsletter out on a regular basis. The job will take about 8-10 hours every four months, has absolutely no money attached, but the volunteer will become a co-editor of the newsletter. Here is your chance to volunteer (before we draft you)!

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