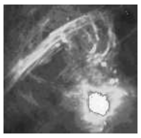
GCNEWS



The Newsletter of Galactic Center Research

Edited by Angela Cotera & Heino Falcke

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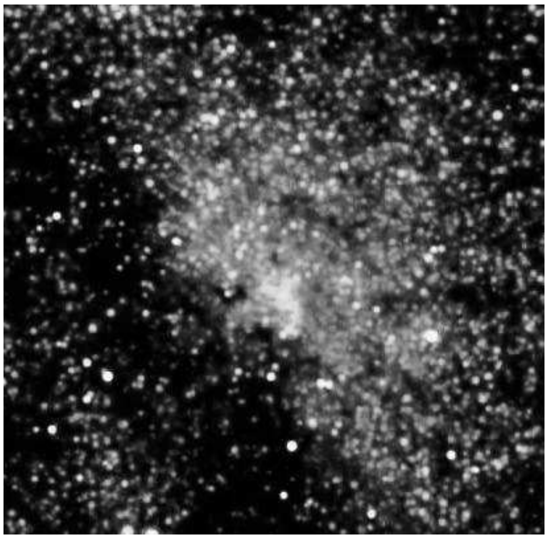
2 MASS and the Galactic Center



The Two Micron All Sky Survey (2MASS) is uniformly scanning the entire sky in three near-infrared bands. It among others will characterize the stellar populations and provide precise mapping of the interstellar extinction on small scales over a large spatial area toward the Galactic Center (van Dyk et al., inside)

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Editorial: GC98 is over, GCNEWS is back

Angela Cotera & Heino Falcke

GC98

Hard to believe that GC98 (the Galactic Center conference in Tucson) was over nine months ago. Perhaps that is because your GCNEWS editors have been recently working on the finishing touches needed before sending the proceedings to the publisher. In particular, we have had the discussions transcribed to text files and are working on editing them into highly enjoyable reading. However, with nontechnical clerical staff doing the majority of the job of transcribing, not all the technical (and some of the not so technical) words have made it to the written version. Some of our favorites are listed at the end of this newsletter. Needless to say, editting even the transcribed text takes a bit of time, and the many difficulties involved in getting the discussion sessions into publishable form has delayed the completion of the proceedings, but will, we believe, make these proceedings unique.

In general we can say that the conference was worth the effort. We were pleasantly surprised at how well the discussion sessions worked out, throughout the week. A word of thanks is due to the session moderators who were generally well prepared and kept the discussions both moving forward and relevant to the session topics. A lot of questions were thoroughly discussed in an atmosphere that was, without exception, friendly and constructive. It was also fun for us to get together with the GC crowd and put faces with the names we've come to know through this newsletter. We hope that this week generated many new ideas and encouraged new projects which will appear in future editions of GCNEWS!

GCNEWS

As many of you may have noticed recently, our website disappeared when the webserver at our host institution was restructured and upgraded. This made a number of changes necessary which were almost impossible to do for quite a while since both editors spent the winter in Tucson—far away from the server. A number of our subscribers got frustrated when they tried to find and use the information we usually offer. We apologize for any inconvenience this may have caused, but ask you to remember that GCNEWS is an extracurricular activity for us and as active scientists there are serious constraints to how much "extra" time is available. However, we figure that all of our subscribers know the frustrations encountered when software, operating systems, or computers are "upgraded". Suddenly, at least half of the software that used to work just fine suddenly doesn't work and it takes an indeterminate amount of time to get back to where you were *before* the upgrade. After the necessary efforts of this type, we are happy to let you know that we are back in business and trust that you will all continue to collaborate with us in this otherwise fruitful venture by sending in your abstracts.

This issue

This issue again contains a number of abstracts which will give a comprehensive summary of GC research in the last months. All of the abstracts had been distributed already in our newsflash service. Make sure to let us know if you have not received these emails. They are the fastest way to get up-to-date information on the GC. In addition to the abstracts we have an article by van Dyk et al. about 2MASS with a GC image from their survey. Along with the authors, we hope this will inspire some of our readers to use the available data in their own research.

2MASS and the Galactic Center

S.D. Van Dyk, R.M. Cutri, & M.F. Skrutskie (IPAC/Caltech)

About 2MASS

The Two Micron All Sky Survey (2MASS) is uniformly scanning the entire sky in three near-infrared bands to detect and characterize point sources brighter than about 1 mJy in each band, with signal-to-noise ratio greater than 10, with astrometric accuracy better than 0.5". It will achieve an 80,000-fold improvement in sensitivity relative to earlier surveys.

2MASS is designed to close the gap between our current technical capability and our knowledge of the near-infrared sky. In addition to providing a context for the interpretation of results obtained at infrared and other wavelengths, 2MASS will provide direct answers to immediate questions on the large-scale structure of the Milky Way and the Local Universe. The optimal use of the next generation of infrared space missions, such as HST/NICMOS, the Space Infrared Telescope Facility (SIRTF), and the Next Generation Space Telescope (NGST), as well as powerful ground-based facilities, such as Keck I, Keck II, and Gemini, require a new census with vastly improved sensitivity and astrometric accuracy than that previously available.

2MASS uses two new, highly-automated 1.3-m telescopes, one at Mt. Hopkins, AZ, and one at CTIO, Chile. Each telescope is equipped with a three-channel camera, each channel consisting of a 256×256 array of HgCdTe detectors, capable of observing the sky simultaneously at J (1.25 μm), H (1.65 μm), and K_s (2.17 μm). The northern 2MASS facility began routine operations in 1997 June, and the southern facility in 1998 March. As of 1999 Jan 26, the sky coverage is 53%.

The University of Massachusetts (UMass) is responsible for the overall management of the project, and for developing the infrared cameras and on-site computing systems at both facilities. The Infrared Processing and Analysis Center (IPAC) is responsible for all data processing through its Production Pipeline, and construction, distribution, and archiving of the data products. The 2MASS project is funding by the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF).

The immediate scientific benefits from the 2MASS survey include: 1) An unprecedented view of the Milky Way nearly free of the obscuring effects of interstellar dust, which will reveal the true distribution of luminous mass, and thus the largest structures, over the entire length of the Galaxy; 2) the first all-sky photometric census of galaxies brighter than $K_s = 13.5$ mag, including galaxies in the 60°-wide "Zone of Avoidance," where dust within the Milky

Way renders optical galaxy surveys incomplete. The catalog of >1,000,000 galaxies will provide a rich statistical database, including photometric measurements in three wavelengths and a few structural parameters for large samples of galaxies in differing environments, measured at wavelengths which are sensitive to the stellar populations dominating the luminous mass; and, 3) the statistical basis to search for rare but astrophysically important objects, which are either cool, and thus extremely red (e.g., extremely low-luminosity stars and brown dwarfs), or heavily obscured at optical wavelengths (e.g., dust-obscured AGNs and globular clusters located in the Galactic plane).

2MASS will produce the following data products: 1) A digital atlas of the sky comprising approximately 4 million $8' \times 16'$ (compressed) Atlas Images, having about $4''$ spatial resolution in each of the three wavelength bands; 2) a point source catalog containing accurate positions and fluxes for ~300 million stars and other unresolved objects; and, 3) an extended source catalog containing positions and total magnitudes for more than 1,000,000 galaxies and other nebulae.

2MASS will release the data products on the approximate schedule: 1) The 2MASS Sampler of one northern night's of data is currently available; 2) the first large incremental release of northern hemisphere data in the spring of 1999; and, 3) incremental releases every 6 months to 1 year thereafter, of both northern and southern hemisphere data. Each night of released data will consist of about 250,000 point sources, 2000 galaxies, and 5000 images, or about 0.5 GB of data per night.

The Galactic Center

2MASS will characterize the stellar populations and provide precise mapping of the interstellar extinction on small scales over a large spatial area towards the Galactic Center. As an example, we show in Figure 1 the color-color diagram based on the $6° \times 8.5'$ 2MASS tile area immediately around the Galactic Center, for ~100,000 stars with $\sigma \leq 0.1$ mag in all three bands. Extinction of $A_V \sim 20$–25 affecting the stars towards the Galactic Center, as well as a range of populations, are readily apparent from this diagram.

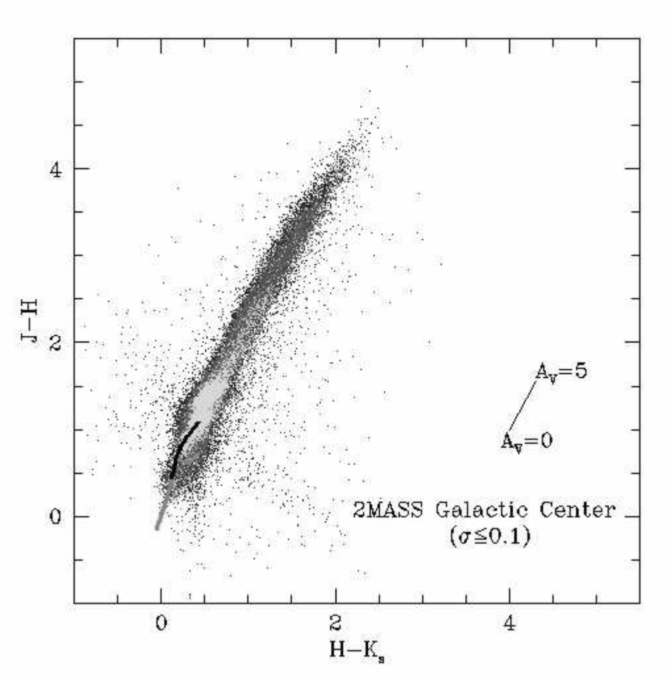

Figure 1: The color-color diagram for the 0.85 square degrees around the Galactic Center from 2MASS near-infrared data. The datapoints have been color-contoured to correspond to signal-to-noise ratio. Also shown are the tracks for dwarfs (*green/gray*) and giants (*black*) from Bessell & Brett (1988, PASP, 100, 1134), and a reddening vector from Rieke & Lebofsky 1985, ApJ, 288, 618).

IPAC/2MASS Website on the GC: http://www.ipac.caltech.edu/2mass/gallery/galcen/

Abstracts

The Pistol Star and Massive Stars in the Galactic Center

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A significant portion of the massive stars in the Galaxy are located within 50 pc of the Galactic Center. The stars have a variety of ages between 1 and 10 Myr, giving rise to Wolf-Rayet and red supergiant types. Most of these stars reside in three massive clusters: the Central Cluster, Quintuplet Cluster, and Arches Cluster. The clusters have similar masses, $\approx 10^4\ M_\odot$, but the first two are substantially older (3-5 Myr) than the last (1-2 Myr). This spread in age, with most other parameters being equal, gives us a unique opportunity to test models which predict massive star evolution. We discuss the content in these clusters, with a particular emphasis on how well they fit into our current understanding of stellar evolution. In particular, we discuss the Pistol Star, one of the most luminous, and, therefore, initially most massive, stars in the Galactic Center. Its evolutionary status places the star in the unstable Luminous Blue Variable stage, providing an extraordinary opportunity to test stellar evolution models for massive stars near their Eddington limits. We find a lower luminosity limit of $10^{6.6}\ L_\odot$, $T_{\rm eff} \approx 10^{4.15}$ K, and a helium-enriched surface, consistent with the star's advanced evolutionary status. Our evolutionary tracks suggest an initial mass of $\sim 200\ M_\odot$ and age of 1.7−2.1 Myrs. We interpret the star and its surrounding nebula as an LBV which has recently ejected large amounts of material. We expect that many of the massive stars in the Galactic Center will soon progress through an LBV stage and eventually become supernovae at a rate of ≈ 1 per 20,000 years for the next several Myr.

Ref.: to appear in Unsolved Problems in Stellar Evolution 1998, STScI
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http://www.astro.ucla.edu/~figer/papers.html

Sgr A*: A supermassive black hole or a spatially extended object?

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We report here on a calculation of possible orbits of the fast moving infrared source S1 which has been recently observed by Eckart & Genzel (1997) near the Galactic center. It is shown that tracking of the orbit of S1 or any other fast moving star near Sgr A* offers a possibility of distinguishing between the supermassive black hole and extended object scenarios of Sgr A*. In our calculations we assumed that the extended object at the Galactic center is a non-baryonic ball made of degenerate, self-gravitating heavy neutrino matter, as it has been recently proposed by Tsiklauri & Viollier (1998a,b).

Ref.: submitted to ApJ Lett.
Email: dt@pc021.phy.uct.ac.za
Eprint: astro-ph/9808219
http://pc021.phy.uct.ac.za/tsiklauri/pub.html

Massive Star Evolution in Different Environments

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We review the properties of massive star evolution in different environments, where the major environmental factor is metallicity. Comparisons between evolutionary models and observations of massive OB, WR stars and related objects are presented. We also review several observations asking for future improvements of stellar models and theoretical developments in this respect. We summarize evolutionary scenarios for the most massive stars and try to clarify recent questions regarding their evolutionary status as core-H or core-He burning objects. Another environmental effect, which might affect stellar evolution is a cluster environment with a high stellar density. As test cases of massive star evolution in dense clusters we summarize recent work on the densest known resolved young clusters: R136, NGC 3603, and the three Galactic Center (GC) star clusters – the central cluster, Quintuplet and the "Arches" cluster. For the central cluster we present new comparisons between stellar parameters of

emission line stars derived by Najarro et al.(1994, 1997), and appropriate evolutionary models. From their parameters we argue that most of these stars can be regarded as WNL stars, and do hence not necessarily represent a peculiar class. We suggest that some apparent differences with well known WR stars can be understood in terms of their core burning stage and/or other changes due to a high metallicity. Based on our present knowledge we conclude that in young clusters with central stellar densities up to $\rho_c \sim 10^{5-6}\,M_{\odot}\mathrm{pc}^{-3}$ no compelling evidence for a secondary effect influencing the evolution of massive stars has yet been found.

Ref.: Invited review to appear in "Active Galactic Nuclei, Dense Stellar Systems and Galactic Environments", Eds. A.C. Baker, S. Lamb, J.J. Perry, ASP Conf. Series, 1998
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Infalling Gas Towards the Galactic Center

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VLA maps of ammonia emission were made for the Galactic Center region. The $NH_3(1,1)$ and $NH_3(2,2)$ transitions were observed in three $2'\times2'$ fields covering Sgr A* and the region $3'$ immediately south of it. In the central 3 parsecs surrounding Sgr A* we find emission which appears to be associated with the circumnuclear disk (CND), both morphologically and kinematically. This central emission is connected to a long, narrow 2 pc×10 pc streamer of clumpy molecular gas located towards the south, which appears to be carrying gas from the nearby 20 km sec^{-1} giant molecular cloud (GMC) to the circumnuclear region. We find a velocity gradient along the streamer, with progressively higher velocities as the gas approaches Sgr A*. The streamer stops at the location of the CND, where the line width of the NH_3 emission increases dramatically. This may be the kinematic signature of accretion onto the CND. The ratio of the $NH_3(2,2)/NH_3(1,1)$ emission indicates that the gas is heated at the northern tip of the streamer, located inside the eastern edge of the CND. The morphology, kinematics and temperature gradients of the gas all indicate that the southern streamer is located at the Galactic Center and is interacting with the circumnuclear region.

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Email: acoil@mars.berkeley.edu
Eprint: astro-ph/9809068

Intrinsic Size of Sgr A*: 72 Schwarzschild Radii

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Recent proper motion studies of stars at the very center of the Galaxy strongly suggest that Sagittarius (Sgr) A*, the compact nonthermal radio source at the Galactic Center, is a 2.5×10^6 M$_\odot$ black hole. By means of near-simultaneous multi-wavelength Very Long Baseline Array measurements, we determine for the first time the intrinsic size and shape of Sgr A* to be 72 $R_{sc}(\star)$ by < 20 $R_{sc}(\star)$, with the major axis oriented essentially north-south, where $R_{sc}(\star)$ ($\equiv$ 7.5×10^{11} cm) is the Schwarzschild radius for a 2.5×10^6 M$_\odot$ black hole. Contrary to previous expectation that the intrinsic structure of Sgr A* is observable only at $\lambda \leq 1$ mm, we can discern the intrinsic source size at λ 7 mm because (1) the scattering size along the minor axis is half that along the major axis, and (2) the near simultaneous multi-wavelength mapping of Sgr A* with the same interferometer makes it possible to extrapolate precisely the minor axis scattering angle at λ 7 mm. The intrinsic size and shape place direct constraints on the various emission models for Sgr A*. In particular, the advection dominated accretion flow model may have to incorporate a radio jet in order to account for the structure of Sgr A*.

Ref.: ApJ Letters, in press
Email: zshen@hotaka.mtk.nao.ac.jp
Eprint: astro-ph/9809222

High-resolution Observations of OH(1720 MHz) Masers Toward the Galactic Center

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High-resolution VLA observations of 1720 MHz OH maser emission from Sgr A East and the circumnuclear disk with spatial and spectral resolutions of $\approx 2''\!.5 \times 1''\!.3$ and 0.27 km s^{-1} are reported. This follow-up observational study focuses on the recent discovery of a number of such OH maser features and their intense circularly polarized maser lines detected toward these Galactic center sources. The 1720 MHz maser line of OH arises from collisionally excited gas behind a C-type shock and is an important diagnostic of the interaction process that may occur between molecular clouds and associated X-ray emitting shell-type supernova remnants. The present observations have confirmed that the observed Stokes V signal is due to Zeeman splitting and that the OH masers are angularly broadened by the scattering medium toward the Galactic center. The scale length of the magnetic field fluctuations in the scattering medium toward the Galactic center is estimated to be greater than 0.1-0.2 pc using the correlation of the position angles of the scatter-broadened maser spots. In addition, the kinematics of the maser spots associated with Sgr A East are used to place a 5 pc displacement between this extended radio structure and the Galactic center.

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Email: ZADEH@OSSENU.ASTRO.NWU.EDU
Eprint: astro-ph/9809279

2 μm Narrow–Band Imaging of the Sagittarius D H II Region

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We present 2 μm narrow–band images of the core H II region in the Galactic star forming region Sagittarius D. The emission–line images are centered on 2.17 μm (Brγ) and 2.06 μm (He I). The H II region appears at the edge of a well defined dark cloud, and the morphology suggests a blister geometry as pointed out in earlier radio continuum work. There is a deficit of stars in general in front of the associated dark cloud indicating the H II region is located in-between the Galactic center and the sun. The lesser spatial extent of the He I line emission relative to Brγ places the effective temperature of the ionizing radiation field below 40,000 K. The He I 2.06 μm to Brγ ratio and Brγ / far infrared dust emission put $T_{\rm eff}$ at about 36,500 K to 40,000 K as derived from ionization models.

Ref.: to appear in the ApJ Feb 1999
Email: blum@ctiowe.ctio.noao.edu
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http://www.ctio.noao.edu/ftp/pub/blum/sgrd.ps

SPH Simulations of Galactic Gaseous Disk with Bar: Distribution and Kinematic Structure of Molecular Clouds toward the Galactic Center

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We have performed Smoothed Particle Hydrodynamic (SPH) simulations to study the response of molecular clouds in the Galactic disk to a rotating bar and their subsequent evolution in the Galactic Center (GC) region. The Galactic potential in our models is contributed by three axisymmetric components (massive halo, exponential disk, compact bulge) and a non-axisymmetric bar. These components are assumed to be invariant in time in the frame corotating with the bar. Some noticeable features such as an elliptical outer ring, spiral arms, a gas-depletion region, and a central concentration have been developed due to the influence of the bar. The rotating bar induces non-circular motions of the SPH particles, but hydrodynamic collisions tend to suppress the random components of the velocity. The velocity field of the SPH particles is consistent with the kinematics of molecular clouds observed in HCN $(1-0)$ transition; these clouds are thought to be very dense clouds. However, the $l-v$ diagram of the clouds traced by CO is quite different from that of our SPH simulation, being more similar to that obtained from simulations using collisionless particles. The $l-v$ diagram of a mixture of collisional and collisionless particles gives better reproduction of the kinematic structures of the GC clouds observed in the CO line. The fact that the kinematics of HCN clouds can be reproduced by the SPH particles suggests that the dense clouds in the GC are formed via cloud collisions induced by rotating bar.

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Eprint: astro-ph/9810043

Spectral Models of Advection-Dominated Accretion Flows with Winds

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We calculate spectral models of advection-dominated accretion flows, taking into account the possibility that significant mass may be lost to a wind. We apply the models to the soft X-ray transient V404 Cyg in quiescence

and the Galactic center source Sgr A*. We show that there are qualitative degeneracies between the mass loss rate in the wind and parameters characterizing the microphysics of the accretion flow; of particular importance is δ, the fraction of the turbulent energy which heats the electrons. For small δ, current observations of soft X-ray transients and Sgr A* suggest that at least $\sim 10\%$ of the mass originating at large radii must reach the central object. For large $\delta \sim 0.3$, however, models with significantly more mass loss are in agreement with the observations. We also discuss constraints on advection-dominated accretion flow models imposed by recent radio observations of NGC 4649 and other nearby elliptical galaxies. We conclude by highlighting future observations which may clarify the importance of mass loss in sub-Eddington accretion flows. *Subject headings:* accretion, accretion disks – black hole physics

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Eprint: astro-ph/9810136

A High Velocity Molecular Cloud Near the Center of the Galaxy

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We report the detection of a peculiar molecular cloud, CO 0.02–0.02, lying about 5′ Galactic-east from the center of the Galaxy. ^{12}CO images taken with NRO 45 m telescope showed that it is relatively compact ($\sim 3 \times 4$ pc^2) as well as having a very large velocity width ($\Delta V \geq 100$ km s^{-1}). The cloud has a virial mass about one order of magnitude larger than the LTE mass, $9 \times 10^4 M_\odot$, indicating the cloud is apparently gravitationally unbound. New observations with the JCMT 15 m and the NRO 45 m telescope show that CO 0.02–0.02 is very bright in the CO J=3D3–2, and in the HCN and HCO$^+$ J=3D1–0 lines. It appears that the environment may have an unusually high density and temperature, which may be related to the very broad CO line-width. We propose that CO 0.02–0.02 may have been accelerated, heated and compressed in a series of supernovae shocks which have occurred within the last (3–5) $\times 10^4$ years.

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http://crow.riken.go.jp/~oka/papers/GChvel/GChvel.tar.gz

A Large-Scale CO Survey of the Galactic Center

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We present high-resolution CO images of the Galactic center region taken with the 2×2 focal-plane array receiver mounted on the 45 m telescope of Nobeyama Radio Observatory[1] . We have collected about 44000 ^{12}C^{16}O (J=1–0) spectra and over 13000 ^{13}C^{16}O (J=1–0) spectra with a 34″(1.4 pc) grid spacing. ^{12}CO mapping area is roughly $-1.5° \leq l \leq +3.4°$ and $-0.6° \leq b \leq +0.6°$, which covers almost the full extent of the molecular gas concentration in the Galactic center. These CO images demonstrate extremely complex distribution and kinematics of molecular gas in the Galactic center. While its large-scale behavior can be attributed to the well-known coherent features, bright CO emission arises from a number of compact ($d \leq 10$ pc) clouds with large velocity widths ($\Delta V \geq 30$ km s^{-1}). Small-scale structure of molecular gas is characterized by filaments, arcs, and shells. The boisterous molecular gas kinematics there may be a result of violent release of kinetic energy by a number of supernova explosions and/or Wolf-Rayet stellar winds.

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K-band Microlensing of Stars by the Super-Massive Black Hole in the Galactic Center

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We investigate microlensing amplification of faint stars in the dense stellar cluster in the Galactic Center by the super-massive black hole, which is thought to coincide

with the radio source Sgr A*. Such amplification events would appear very close to the position of Sgr A*, and could be observed, in principle, during the monitoring of stellar proper motions in the Galactic Center. We use observations of the K-band ($2.2\,\mu$m) luminosity function in the Galactic Center and in Baade's Window, as well as stellar population synthesis computations, to construct empirical and theoretical K luminosity function models for the inner 300 pc of the Galaxy. These, together with the observed dynamical properties of the central cluster and inner bulge, are used to compute the rates of microlensing events which amplify stars with different intrinsic luminosities above specified detection thresholds. We present computations of the lensing rates as functions of the event durations, which range from several weeks to a few years, for detection thresholds ranging from $K_0 = 16 mag$ to $19 mag$. We find that events with durations shorter than a few months dominate the lensing rate because of the very high stellar densities and velocities very near the black hole, where the effective lens size is small. For the current detection limit of $K_0 = 17 mag$, the total microlensing rate is 3×10^{-3} yr^{-1}. The rate of events with durations ≥ 1 yr is 1×10^{-3} yr^{-1}. The median value of the peak amplification for short events is $\Delta K \sim 0.75 mag$ above the detection threshold, and is only weakly dependent on K_0. Long events are rarer, and are associated with more distant stars, stars at the low velocity tail of the velocity distribution, or stars that cross closer to the line-of-sight to Sgr A*. Therefore, the median peak amplifications of long events are larger and attain values $\Delta K \sim 1.5 mag$ above the threshold. Recent proper motion studies of stars in the Galactic Center have revealed the possible presence of one or two variable K-band sources very close to, or coincident with, the position of Sgr A* (Genzel et al. 1997; Ghez et al. 1998). These sources may have attained peak brightnesses of $K \approx 15 mag$, about 1.5–$2 mag$ above the observational detection limits, and appear to have varied on a timescale of ~ 1 yr. This behavior is consistent with long-duration microlensing amplification of faint stars by the central black hole. However, we estimate that the probability that a single such an event could have been detected during the course of the recent proper motion monitoring campaigns is $\sim 0.5\%$. A ten-fold improvement in the detection limit and 10 yr of monthly monitoring could increase the total detection probability to $\sim 20\%$.

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G359.87+0.18: An FR II Radio Galaxy 15 Arcminutes from Sgr A*. Implications for the Scattering Region in the Galactic Center

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G359.87+0.18 is an enigmatic object located 15′from Sgr A*. It has been variously classified as an extragalactic source, Galactic jet source, and young supernova remnant. We present new observations of G359.87+0.18 between 0.33 and 15 GHz and an H I absorption spectrum and use these to argue that this source is an Faranoff-Riley II radio galaxy. We are able to place a crude limit on its redshift of $z \gtrsim 0.1$. The source has a spectral index $\alpha < -1$ ($S \propto \nu^\alpha$), suggestive of a radio galaxy with a redshift $z \gtrsim 2$. The scattering diameters of Sgr A* and several nearby OH masers ($\approx 1''$ at 1 GHz) indicate that a region of enhanced scattering is along the line of sight to the Galactic center. If the region covers the Galactic center uniformly, the implied diameter for a background source is at least 600″at 0.33 GHz, in contrast with the observed 20″diameter of G359.87+0.18. Using the scattering diameter of a nearby OH maser OH 359.762+0.120 and the widths of two, nearby, non-thermal threads, G0.08+0.15 and G359.79+0.17, we show that a uniform scattering region should cover G359.87+0.18. We therefore conclude that the Galactic center scattering region is inhomogeneous on a scale of 5′(≈ 10 pc at a distance of 8.5 kpc). This scale is comparable to the size scale of molecular clouds in the Galactic center. The close agreement between these two lengths scales is an indication that the scattering region is linked intimately to the Galactic center molecular clouds.

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Stellar positions from SiO masers in the Galactic center

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We report on the possibility of determining milliarcsecond accurate positions (relative to Sgr A*) for 43 GHz SiO masers located at the Galactic center. The SiO masers were found in OH/IR stars in a previous

Very Large Array survey. We used the Very Long Baseline Array and the phased Very Large Array in a phase-referencing scheme with a cycle time of 40 seconds. The continuum source Sgr A* is used as phase-reference source. Because of the atmospheric phase instability at 43 GHz and sensitivity considerations, only 2 sources (from 10) were detected. However, we show that reliable positions can be obtained with calculable errors, which allows one to measure the proper motion of these stars accurate to c.a. 30 km/s in 5 years.

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The Stellar Content of Obscured Galactic Giant H II Regions: I. W43

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Near infrared images of the Galactic giant H II region W43 reveal a dense stellar cluster at its center. Broad band JHK photometry of the young cluster and $K-$band spectra of three of its bright stars are presented. The 2 μm spectrum of the brightest star in the cluster is very well matched to the spectra of Wolf–Rayet stars of sub–type WN7. Two other stars are identified as O type giants or supergiants by their N III and C IV emission. The close spatial clustering of O and the hydrogen WN type stars is analogous to the intense star burst clusters R136 in the Large Magellanic Cloud and NGC 3603 in the Galaxy.

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Spectroscopy of the Pistol and Quintuplet Stars in the Galactic Centre

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We present initial results of a spectroscopic study of the Pistol and of the cocoon stars in the Quintuplet Cluster. From ISOCAM CVF 5—17μm spectroscopy of the field of the Pistol Star, we have discovered a nearly spherical shell of hot dust surrounding this star, a probable LBV. This shell is most prominent at $\lambda \gtrsim 12\mu$m, and its morphology clearly indicates that the shell is stellar ejecta. Emission line images show that most of the ionised material is along the northern border of this shell, and its morphology is very similar to that of the Pistol H II region (Yusef-Zadeh & Morris, 1987). We thus confirm that the ionisation comes from very hot stars in the core of the Quintuplet Cluster. An SWS spectrum of the Pistol Nebula indicates a harder ionising radiation than could be provided by the Pistol Star, but which is consistent with ionisation from Wolf-Rayet stars in the Quintuplet Cluster. The CVF 5—17μm spectra of the cocoon stars in the Quintuplet do not show any emission feature that could help elucidate their nature. [The full paper can be found in astro-ph9812046].

Key words: ISO, Galactic Centre, Quintuplet, Pistol, LBVs

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The jet/disk symbiosis III. What the radio cores in GRS 1915+105, NGC 4258, M81, and Sgr A tell us about accreting black holes

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We have derived simplified equations for a freely expanding, pressure driven jet model as a function of jet power and applied it successfully to the radio cores in the black hole candidates GRS 1915+105, NGC 4258, and M81 which are observationally well defined systems, and to Sgr A*. By using equipartition assumptions, the model has virtually no free parameters and can explain all sources by just scaling the jet power. In GRS 1915+105 it also naturally explains the jet velocity and the radio time delay. The jet powers we derive for the radio cores of the first three sources are comparable to their accretion disk luminosities, providing further evidence for the existence of symbiotic jet/disk systems and a common engine mechanism also in low-luminosity AGN and stellar mass black holes. With the exception of Sgr A* an advection dominated accretion flow (ADAF) does not seem to be necessary to explain any of the radio cores which span a large range in luminosity and size, as well as in black hole masses and accretion rate—from Eddington to extreme sub-Eddington. We suggest, however, that the jet model can be used to derive minimum accretion rates and thus find that Sgr A* seems to be truly radiatively deficient—even in a starved black hole model—and that a combination of jet and ADAF model may be one possible solution.

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Eprint: astro-ph/9810226
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Relativistic Effects in Proper Motions of Stars Surrounding the Galactic Center

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We simulate the astrometric observations of stars moving close to the black hole in the Galactic Center. We show, that for orbits $\leq 10^3$ AU and position measurements with the accuracy of the Keck Interferometer, the periastron motion of elliptical orbits will be measurable. The models of star trajectories neglecting the periastron motion will be easy to reject with the high confidence level. The measurement of orbital elements and the periastron motion can be effectively used as an independent estimate the distance to the Galactic Center. The effects of orbit precession may be visible in some cases. The effects of gravitational radiation are completely negligible as well as the influence of the black hole rotation on the propagation of light.

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Email: mj@mimas.astrouw.edu.pl
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Observations of the Galactic Center Region with Beppo-Sax

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We are performing a survey of the Galactic Center region (Sidoli et al., 1998a) with the BeppoSAX satellite. Several known point sources are visible (including one at the position of SgrA*), as well as newly discovered sources and diffuse emission. Here we report the preliminary results of the on–going analysis of both the point sources and the diffuse X–ray emission.

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Sgr A* "Visual Binaries": A Direct Measurement of the Galactocentric Distance

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We present a new geometrical method for measuring the distance to the Galactic center (r_0) by solving for the Keplerian orbit of individual stars bound to the black hole associated with the Sgr A* from radial velocity and proper motion measurements. We identify three stars to which the method may be applied, and show that 1-5% accuracy of r_0 can be expected after 15 years of observing, and 0.5-2% after 30 years of observing, depending on what the orbital parameters of these three stars turn out to be. Combining the measurements of the three stars with favorable orbital parameters leads to even more precise values. In the example that we present, such combined solution yields 4% accuracy already by the year 2002. All these estimates assume that annual position measurements will continue to be made with the $\sigma_\rho = 2$ mas precision recently reported by Ghez et al. The precision of the distance measurement is relatively insensitive to the radial velocity errors, provided that the latter are less than $50\,\mathrm{km\ s^{-1}}$. Besides potentially giving an estimate of r_0 that is better than any currently in use, the greatest advantage of this method is that it is free from systematic errors.

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The Hot Gas and the Cold Dust in the Galactic Center Clouds as Seen by ISO

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We present the first results of the LWS and SWS ISO observations of 18 molecular clouds in the Galactic center (GC) region. H_2 emission from several rotational lines in the ground vibrational state has been detected toward all molecular clouds. The rotational temperatures derived from these lines are between 150 and 500 K. Remarkably, the derived column densities of the hot H_2, $\sim 2\ 10^{22}$ cm^{-2}, are similar to those obtained for the cold gas. the From the non-detection of the S(3) line at 9.7 μm, we find that the hot gas must be located behind more than 30 mag of visual extinction of cold gas and dust. The LWS continuum spectra indicate that the cold dust has temperatures of 25-35 K and column densities similar to those required to explain the extinction of the H_2 emission. Observations of the J=2-1 and J=1-0 lines of $C^{18}O$ (J=2-1/J=1-0 line ratios of 0.7-1.4) seem to sample only the cold gas located in front of the hot gas. This indicates that the low J transitions of $C^{18}O$ does not trace the total molecular gas in the GC. The LWS continuum spectra impose stringent limits (≤ 1 per cent) to the hot dust associated to the hot H_2. Toward most of the clouds we also detected emission from the fine structure lines of ionized species such as SIII and NeII, and in some cases lines from NeIII and OIII. In contrast with the previous idea that the heating of the GC clouds is dominated by shocks, our data suggest that photoelectric heating by UV radiation can be the dominat mechanism. The effective temperature of the ionization radiation derived from the NeIII/NeII ratio is 35.000 K (typical of an O7 star). Our ISO data when combined with the upper limits to the intensities of the recombination lines measured at millimeter wavelengths indicate that the UV radiation is very diluted. Cavities with sizes larger than 2 pc surrounding the ionizing star(s) are required to explain the dilution. The origin of the ionized cavities and the implications of these findings on the heating of the molecular clouds in the GC are briefly discussed.

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Hot Expanding Shells in the Envelope of the Sagittarius B2 Molecular Cloud

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We present high resolution images of the warm gas in the envelope of the Sagittarius B2 (Sgr B2) molecular cloud. These images reveal that the morphology of the Sgr B2 molecular envelope is dominated by several shells and incomplete shells expanding at low velocities $\sim$10 km s^{-1}. The sizes of the shells are between 1 and 2.6 pc and their thicknesses are between 0.2 and 0.4 pc . The shells are hot with kinetic temperatures, T_k, of 40 - 150 K. The large number of masers in H_2CO, CH_3OH and the newly detected (3,3) NH_3 masers are correlated with the hot molecular shells. Associated with the shells, we have also detected new hot cores, suggesting that massive star formation has taken place very recently in the molecular envelope of Sgr B2. Wind-blown bubbles, driven by typical galactic Wolf-Rayet stars, could account for the kinetic energies and the momenta observed in the hot NH_3 shells. Shocks associated with the expanding bubbles provide the chemistry required to explain the large number of masers, and the heating of the molecular gas in the envelope of Sgr B2.

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Luminous variables in the Quintuplet cluster

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We report observations of variability amongst the stars of the "Quintuplet" cluster located about 30 pc in projection from the centre of the Galaxy. Two of the five cocoon star members, which may be protostars or peculiar Wolf-Rayets, are seen to vary slowly with moderate amplitude (0.4–0.5 mag). The bright star within the "Pistol" HII region, suspected of being a Luminous Blue Variable (LBV), has in fact been found to show variability, confirming its tentative classification. A second nearby presumed LBV also varies. One of the apparent Quintuplet members is likely to be a Mira variable along the same line of sight.

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Deep SIGMA observations of the central square degree of the Galaxy

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The Center of the Milky Way emits radiation through all the electromagnetic spectrum due to the presence of several astrophysical phenomena. Various scientifical questions remain unsolved in the picture that emerge from observations, the main one being the presence and activity of a supermassive black hole at the Galactic Center. Also in the X-ray band a strong diffuse emission is detected up to 22 keV, it has been suggested that its origin is linked to past high energy activity of the Galactic Center. The French SIGMA soft gamma ray telescope on board the Russian Granat satellite observed the Galactic Center (GC) for about $9 * 10^6$ seconds from 1990 to the end of 1997. Its unique imaging capabilities coupled with the unprecedented exposure already allowed us to set preliminary constraints on the persistent high energy emission from Sgr A*. Here we present a new analysis of the complete set of observations of this region taking into account the possible presence of diffuse emission in the low energy channels. This allows us both to test current advection models of high energy emission from SgrA* and to investigate on past high energy activity.

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The Linear Polarization of Sagittarius A* I. VLA Spectro-polarimetry at 4.8 and 8.4 GHz

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Synchrotron radiation from active galactic nuclei (AGN) is often highly polarized. We present a search for linear polarization with the Very Large Array (VLA) at 4.8 GHz and 8.4 GHz from the nearest AGN, Sagittarius A*. As a part of this study we used spectro-polarimetric data that were sensitive to a rotation measure (RM) as large as 3.5×10^6 rad m^{-2} at 4.8 GHz and 1.5×10^7 rad m^{-2} at 8.4 GHz. The upper limit to the linear polarization of Sgr A* over a broad range of RM is 0.2% at both frequencies. We also present continuum observations with the VLA at 4.8 GHz which give an upper limit of 0.1% for RMs less than 10^4 rad m^{-2}. We conclude that depolarization is unlikely to occur in the Galacter Center scattering medium. However, it is possible for depolarization to occur in the accretion region of Sgr A* if the outer scale of turbulence is small enough. We also consider the implications of a very low intrinsic polarization for Sgr A*.

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The stream-stream collision after the tidal disruption of a star around a massive black hole

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A star can be tidally disrupted around a massive black hole. It has been known that the debris forms a precessing stream, which may collide with itself. The stream collision is a key process determining the subsequent evolution of the stellar debris: if the orbital energy is efficiently dissipated, the debris will eventually form a circular disk (or torus). In this paper, we have numerically studied such stream collision resulting from the encounter between a $10^6\,M_\odot$ black hole and a $1\,M_\odot$ normal star with a pericenter radius of 100 $R_\odot$. A simple treatment for radiative cooling has been adopted for both optically thick and thin regions. We have found that approximately 10 to 15% of the initial kinetic energy of the streams is converted into thermal energy during the collision. The spread in angular momentum of the incoming stream is increased by a factor of 2 to 3, and such increase, together with the decrease in kinetic energy, significantly helps the circularization process. Initial luminosity burst due to the collision may reach as high as $10^{41}\,\mathrm{erg\,sec^{-1}}$ in 10^4 sec, after which the luminosity increases again (but slowly this time) to a steady value of a few $10^{40}\,\mathrm{erg\,sec^{-1}}$ in a few times of 10^5 sec. The radiation from the system is expected to be close to Planckian with effective temperature of $\sim 10^5$ K.

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The Zoo of X–ray sources in the Galactic Center Region: Observations with *BeppoSAX*

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We report the results of a survey of the Galactic Center region ($|\ l\ |< 2\,\mathrm{deg}$, $|\ b\ |< 0.5\,\mathrm{deg}$) performed with the *BeppoSAX* satellite. The flux from the center of our Galaxy corresponds to a luminosity of $\sim$3 10^{35} erg s^{-1} in the 2–10 keV range. Due to the limited angular resolution ($\gtrsim 1'$) only part of it is supposed to come from Sagittarius A*, the non–thermal radio source which is believed to mark the dynamical center of the Galaxy. In addition to the diffuse emission, several bright ($L_X \gtrsim 10^{36}$ ergs s^{-1}) point sources have been observed, both persistent (A 1742–294, SLX 1744–299, SLX 1744–300, 1E 1743.1–2843, 1E 1740.7–2942) and transient (XTE J1748–288, SAX J1747.0–2853 and KS 1741–293). The Low Mass X–ray Binary AX J1745.6–2901, discovered with ASCA at only 1.3$'$ from SgrA* was detected in a low luminosity state in August 1997. The 1–150 keV spectrum of the hard X–ray source 1E 1740.7–2942 is well described by a Comptonization model, typical of black hole candidates in their low/hard state, with no evidence for strong Fe lines. The detection of a type I burst shows that the transient source SAX J1747.0–2853 (probably the same as the 1976 transient GX 0.2–0.2) is a LMXRB containing a neutron star. The transient black hole candidate XTE J1748–288 was detected at a luminosity ($\sim 10^{36}$ ergs s^{-1}) consistent with the extrapolation of the exponential decay of the outburst observed with the XTE All Sky Monitor. Two fainter sources are very likely associated with young neutron stars: the (possibly diffuse) X–ray source at the center of the composite supernova remnant G0.9+0.1, and the "head" of the axially symmetric radio source G359.23–0.92. The latter has been detected above $\sim$ 6 keV, supporting a non–thermal emission mechanism.

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And finally ... !

What you say and what they hear

As mentioned in the editorial our innocent transcribers had a hard time understanding the gibberish spoken at the recent Galactic Center conference in Tucson. If you think you speak clearly and in simple terms, think twice. Below is a short dictionary of words that appeared in the transcripts and their actual meaning:

what the transcriber heard		what the scientist said
"point oh 2"	=	0.02
"flux dance"	=	flux density
"one milligantz"	=	one milli-Jansky
"several milligenskis"	=	several mJy
"microchancies"	=	μJy
"Schwartzendragers"	=	Schwarzschild radius
"giga-arcs"	=	GHz
"Heil"	=	Well (attributed to a German speaker)*
"jet lag feature"	=	jet-like feature
"low frequency stir"	=	low frequency (radio) spur
"nometer range"	=	millimeter (wavelength) range
"radio inflorates"	=	radial inflow rates
"Reinhart"	=	the name for all speakers with German accent
"Beagleman"	=	Begelman
"[India]"	=	Narayan
"Schotz"	=	"Charles" (Townes)
"Rozack"	=	ROSAT

Finally, here is a sample of the interaction between two speakers, to give you a sample of the intelligibility of some of the transcripts (of course "Reinhart" was not really Reinhard):

Man?: Was this a flea-flique?
Reinhart: Flea-Flique, correct.

(We are assuming the actual discussion was about free-free emission!)

*Needless to say that at least one of us was not very amused.

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