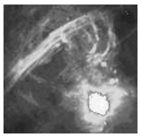
GCNEWS



The Newsletter of Galactic Center Research

Edited by Angela Cotera, Heino Falcke & Sera Markoff

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Imaging the event horizon of Sgr A*?

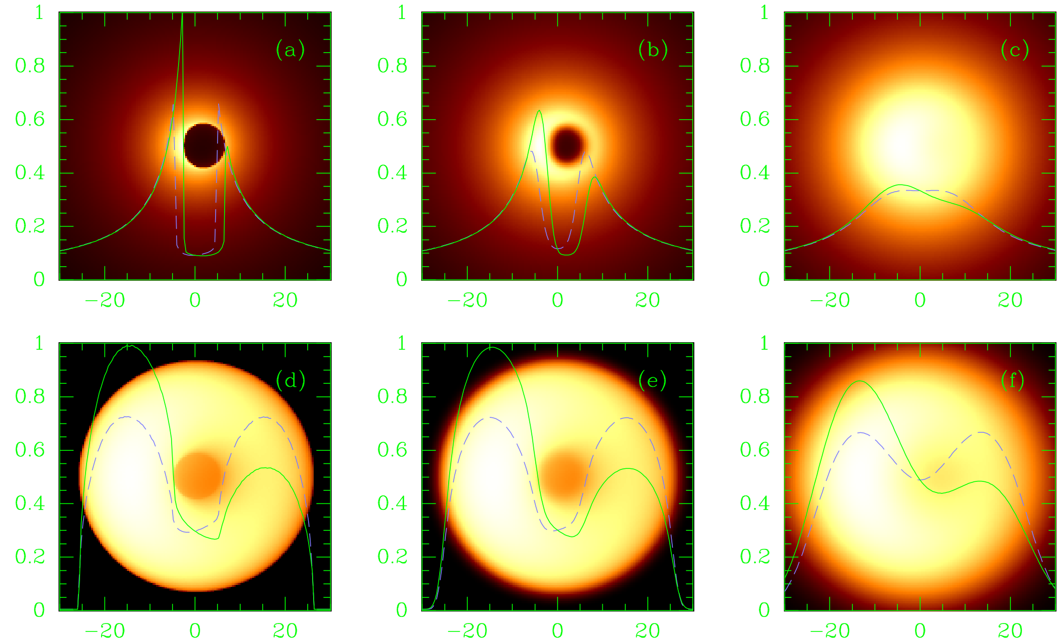

Figure 1: The black hole in the Galactic Center – if it is one – is big and close enough to image its event horizon, or 'shadow', with existing technology. This is argued in a paper by Falcke, Melia, & Agol (2000, ApJL) — see abstracts inside. The figure shows the appearance of the shadow of the black hole for Sagittarius A* against the compact radio emission. The images were calculated for the interstellar scattering and the instrumental resolution expected for upcoming sub-mm VLBI experiments (right: λ1.3mm, middle: λ0.6mm). In a second paper Agol argues that the polarization properties of Sgr A* strengthen that claim (see invited article and abstract inside).

Invited Article:

*Polarization in Sagittarius A** — Geoffrey Bower

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Editorial:

Angela Cotera & Heino Falcke

Update on GCNEWS

As our first order of business, we would like to welcome Sera Markoff to the GCNEWS editorial team. Sera finished graduate school at the University of Arizona last fall under Fulvio Melia with her dissertation *High-Energy Emission Processes in the Galactic Center*, and is currently a Humbolt Postdoctoral Fellow at MPIfR in Bonn. With three of us now working to bring you GCNEWS, we anticipate a smoother production process.

Also in this issue, we include our first contribution from colleagues in China. The number of subscribers has gone up to 275 representing at least 25 countries. Just for fun, those countries are (in no particular order): United Kingdom, Chile, United States, Italy, Mexico, Belgium, Australia, Germany, Spain, The Netherlands, Yugoslavia, Brazil, Malta, India, Canada, Israel, Switzerland, Russia, South Africa, France, Japan, Indonesia, Denmark, Sweden, Poland and China.

Next GCWorkshop?

Almost two years have passed since GC98, our last Galactic Center Workshop, and we are wondering when and where the next GC meeting is going to be? Significant progress has been made recently towards understanding numerous problems in the Galactic Center: the orbits of the stars with measured proper motions around Sgr A* are being determined, both linear and circular polarization of Sgr A* has been measured (see article in this issue), Chandra X-Ray results are soon to be officially released, and the recently commissioned Gemini is devoting one of two demonstration science programs to the GC, to name just a few. In addition, the last conference concentrated on the inner parsecs, and meanwhile significant progress has been made on the larger scale structure.

Since we know from experience that a conference takes at least a year to plan, we are sending out a "call for a meeting" to see if someone will take up the gauntlet and commit to hosting our next meeting. The GCNEWS team will help to publicize the meeting, and provide a conduit to the community. You may have noticed we have not (yet) volunteered to organize the meeting. For any of you who have organized meetings, this should come as no surprise. We are still recovering from the last one, so although we are not particularly anxious to organize the next meeting ourselves, we are happy to provide input.

So, who's it going to be? We have had a string of very good conferences: 1989 at UCLA, 1993 in Ringberg, 1996 in Chile, 1997 at Kyoto and of course 1998 in Arizona. Certainly we have not exhausted *all* the possibilities! So, we look forward to learning the date and location of the next GC conference.

GC Summer School

We point out that there will be a summer school for students "Galactic Black Hole 2001" about astrophysics and general relativity in August 2001 hosted by the German Physical Society (DPG) in Germany. It will mainly revolve around the Galactic Center and is open to international students. The scientific organization is in the hands of F.W. Hehl (University of Cologne) and H. Falcke (MPIfR Bonn), and a number of well-known GC researchers and teachers have been enlisted, as well as several scientists working on general relativity. For more information see the last side of this issue or the preliminary webpage at http://www.thp.Uni-Koeln.DE/BH2001/.

This issue – invited articles

As mentioned above, the invited article in this issue gives a brief review of the polarization properties of Sgr A*. This is a hot new topic which emerged out of the blue in the last year, after having laid dormant for almost two decades. Following the initial work by Bower et al. (presented in Vol. 10) in this issue we are featuring new results on linear polarization at even higher frequencies (Aitken et al.) and the first attempts for a theoretical interpretation (Quataert & Gruzinov; Agol).

As you know, we have solicited brief review articles on a well-defined topic or short original research articles by a GC expert for each issue of GCNEWS. So far we have been successful in providing our readers with the latest exciting results. For example, the flux and properties of the gamma-ray 'point' source at the Galactic Center were first published in GCNEWS (Vol. 4, Mattox) and the history of how GC sources got their name can only be found here (Vol. 2, Palmer & Goss). The short research articles featuring OH masers (Vol. 8, Yusef-Zadeh), the lesser-known military satellite NIR images of the GC (Vol. 5, Shipman et al.), and new VLT results on GC stars (Eckart et al., Vol. 10), have provided worthwhile reading without taking up too much of everyones valuable time. All the articles are now featured in ADS and hence are available to a wider audience. We will try to continue this tradition and may be approaching any one of our readers for the next issue: however, we are certainly open to volunteers or topic suggestions.

Polarization in Sagittarius A*

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Abstract

We summarize the current state of polarization observations of Sagittarius A*, the compact radio source and supermassive black hole candidate in the Galactic Center. These observations are providing new tools for understanding accretion disks, jets and their environments. Linear polarization observations have shown that Sgr A* is unpolarized at frequencies as high as 86 GHz. However, recent single-dish observations indicate that Sgr A* may have strong linear polarization at frequencies higher than 150 GHz. Circular polarization, which was recently discovered in Sgr A*, is detectable to frequencies as high as 43 GHz. It is strongly variable on a 10-day timescale, with the degree of variability increasing with frequency. At low frequencies, fractional circular polarization is stable over nearly 20 years. We discuss some of the possible models for the origin of the circular polarization.

Introduction

Polarization observations have been very successful in the study of active galactic nuclei (AGN). Linear polarization (LP) observations have demonstrated conclusively that synchrotron emission is the dominant mechanism in jets, that magnetic fields are present in jets, and that shocks propagate in jets leading to variability in the total and polarized intensity. Circular polarization (CP) observations, while producing less clear cut conclusions so far, have the potential for illuminating new physics. For example, on the basis of CP observations Wardle et al. (1998) have recently claimed that jets are not primarily hadronic but leptonic.

With the success of polarization observations in AGN in mind, we set out to determine the polarization characteristics of Sagittarius A*, the supermassive black hole candidate and compact radio source in the Galactic Center. Polarization observations offer the possibility to break the theoretical deadlock that exists over the nature of Sgr A*. Both advection dominated accretion flow (ADAF) models (e.g., Özel, Psaltis & Narayan 2000) and accretion-disk-powered-jet models (Falcke & Biermann 1999) can account for the spectrum from centimeter wavelengths to the X-ray, while meeting the size constraints imposed by very long baseline interferometry.

Observational methods are limited by the high galactic extinction and the hyperstrong interstellar scattering screen in the Galactic Center. Polarization observations have the potential to see through the scattering screen and determine intrinsic source characteristics. Now, new observational results are leading to new opportunities for understanding of Sgr A*.

Linear Polarization

Sgr A* has been known to show no LP since not long after its discovery (Balick & Brown 1974). However, this result had not been quantified and it was often assumed that the interstellar scattering screen depolarized the intrinsic source through beam or bandwidth depolarization. Recently, with VLA and BIMA observations, we confirmed the low LP and showed that interstellar depolarization is unimportant (Bower et al. 1999ab). We summarize in Figure 1 our continuum measurements of LP in Sgr A*. Note that the increasing value of the upper limits with frequency is a measure of the increasing difficulty of these observations.

Both bandwidth and beam depolarization are Faraday effects. The dense, magnetized plasma of the interstellar scattering screen is a potential source of these effects. Observed rotation measures (RMs) in the GC are on the order of 10^3 rad m^{-2} (Yusef-Zadeh, Wardle & Parastaran 1997) but they could potentially reach $10^4 - 10^5$ rad m^{-2} (Bower et al. 1999a). High frequency polarimetry and spectro-polarimetry are useful techniques for avoiding these effects. The first relies on the decreasing strength of the effects with frequency. The second removes the effect of large RMs through a Fourier transform method.

In the case of bandwidth depolarization, a large RM rotates the LP position angle through $\gtrsim \pi$ rad in the observing band. High frequency continuum polarimetry and spectro-polarimetry rule this effect out in Sgr A*. The RM must exceed 8×10^6 rad m^{-2} in order to depolarize any intrinsic LP at 43 GHz in the 50 MHz bandwidth of the VLA. VLA spectro-polarimetry at 4.8 and 8.4 GHz also place a lower limit of $\sim 10^7$ rad m^{-2} to an RM that depolarizes intrinsic LP.

Beam depolarization occurs when different paths of the scatter broadened image experience different RMs. This places stricter limits on the RM than bandwidth depolarization, if the scale of turbulence is sufficiently small. RM variations greater than 3×10^5 rad m^{-2} are necessary to depolarize the signal at 86 GHz. These are disallowed, however, by the known conditions of the scattering medium.

Very recently, Aitken et al. (2000) reported that with SCUBA observations at the JCMT they have detected LP in Sgr A* at frequencies greater than 150 GHz. These results are complicated by the large primary beam of the JCMT (34″ at 150 GHz) and the presence of strong free-free emission and polarized dust emission. Removing these effects, Aitken et al. find 10^{+9}_{-4}% LP at 150 GHz. This result requires confirmation with a millimeter/submillimeter interferometer. If true, they are a significant and challenging addition to our understanding of the polarization properties of Sgr A*.

The very sharp rise in LP from 86 to 150 GHz may be due to Faraday effects in the accretion region (Bower et al. 1999a). Quataert and Gruzinov (2000) have demonstrated that a high frequency detection of LP can distinguish between disparate models for Sgr A*. ADAF inflows have high electron and magnetic field densities leading to bandwidth depolarization at radii $r \lesssim 10^4 r_g$ even at frequencies greater than 100 GHz. The high frequency detection by Aitken et al. implies that the electron density and accretion rate must be much lower than in the standard ADAF case.

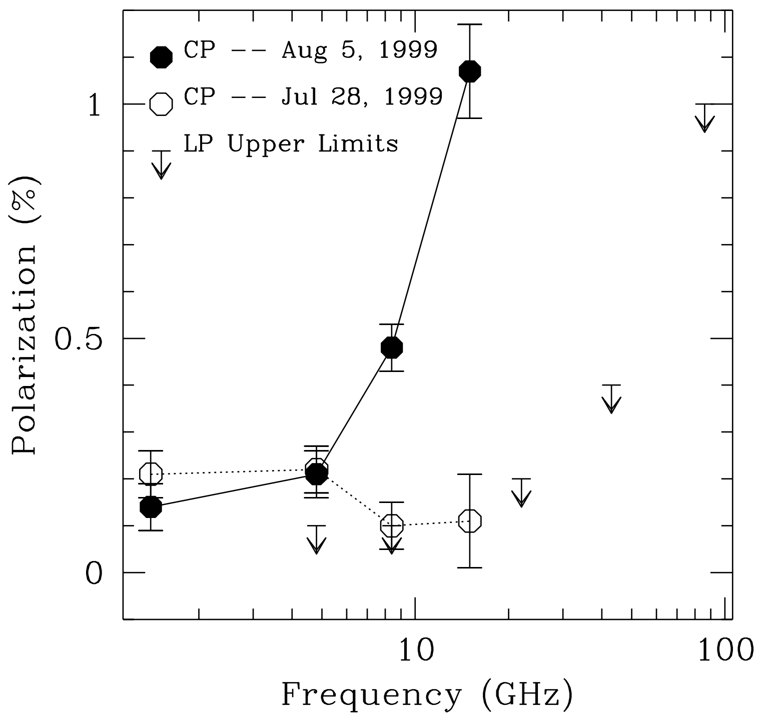

Figure 2: Linear and circular polarization in Sgr A* from 1.4 to 86 GHz. The down arrows indicate upper limits for linear polarization measurements. The open octagons are CP measurements from the VLA on July 28, 1999. The filled octagons are measurements from the VLA on August 5, 1999. The sign of CP has been flipped in this figure. Not shown is the 10^{+9}_{-4}% detection of LP at 150 GHz by Aitken et al.

Circular Polarization

In the course of discovering that Sgr A* shows no LP at centimeter wavelengths, we discovered serendipitously that Sgr A* has strong CP (Bower, Falcke & Backer 1999c). This is surprising in light of the strong limits on linear polarization. AGN typically have LP-to-CP ratios $\gg 1$ (Weiler & de Pater 1983). But for Sgr A* at 4.8 GHz, the fractional CP is ~ -0.3%, which is at least 3 times the level of LP. We have since followed up with monitoring campaigns using the VLA and the ATCA and an analysis of data from the VLA archives covering 18 years. CP measurements with the VLA are technically difficult; confirmation with ATCA observations (Sault & Macquart 1999) and at multiple frequencies over many epochs with the VLA has been crucial.

The VLA archive data clearly indicates that the CP flux at 4.8 GHz is stable at $-0.31 \pm 0.13\%$ over 18 years, despite a factor of two change in total intensity. CP at 8.4 GHz is also apparently stable at $-0.27 \pm 0.10\%$ over 10 years. However, short-term variability around the mean value is apparent. In fact, the CP flux changes significantly on timescales as short as a few days. In Figure 1, we show the spectrum of CP from 1.4 to 15 GHz on two dates separated by a week. In this short interval, the CP has increased dramatically at frequencies greater than 5 GHz. This flare in fractional CP is coincident with a 30% flare in total intensity (Bower, Falcke, Sault & Backer 2000).

In general, the degree of CP variability increases sharply with frequency. Recently, after several epochs without detection, we have detected strong CP with an inverted spectrum at 22 and 43 GHz using the VLA. The analysis of this new result is not yet complete but the preliminary result suggests that the CP spectrum rises during flares into the millimeter regime.

Interpretation of the CP results is not yet certain. The variability suggests a two component model that includes a steep-spectrum quiescent phase and frequent inverted-spectrum flares. Under this scenario there are two distinct origins for the CP, originating in the low and high frequency components of Sgr A*. In jet models, these are more and less compact regions, respectively. In ADAF models, the high/low frequency component originates from non-relativistic/relativistic electrons in the flow.

Gyrosynchrotron radiation is a natural model for the high frequency component of the CP. It originates from non-relativistic electrons in a strong field and produces low LP-to-CP ratios. However, this is certainly not the only possible model. Synchrotron radiation can produce low LP-to-CP ratios under certain conditions. This can include the effects of linear-to-circular conversion, which is believed to be active in 3C 279 (Wardle et al. 1998). Finally, birefringent scattering, in which a magnetized region scatters LCP and RCP differentially in angle, could play role if the natural steep spectrum that it produces can be accounted for. Any model must explain the low LP-to-CP ratio, the inverted spectrum of CP and the nature of the variability. Detailed modeling of the source is probably necessary.

Outstanding observational issues for the CP in Sgr A* are the relationship between CP and total intensity fluctuations; determining the turnover frequency of CP flares; and observing potential structural changes on the AU scale that are related to CP variability.

In the future, CP and LP measurements could be very important tools for understanding accretion flows, jets and their environments. Nearby low luminosity AGN, which are often associated with ADAF systems, are the first targets for these studies. However, before that we must ground our understanding of these behaviors in the best studied and most well-known AGN, Sgr A*.

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Abstracts

Viewing the Shadow of the Black Hole at the Galactic Center

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In recent years, the evidence for the existence of an ultra-compact concentration of dark mass associated with the radio source Sgr A* in the Galactic Center has become very strong. However, an unambiguous proof that this object is indeed a black hole is still lacking. A defining characteristic of a black hole is the event horizon. To a distant observer, the event horizon casts a relatively large "shadow" with an apparent diameter of ~ 10 gravitational radii due to bending of light by the black hole, nearly independent of the black hole spin or orientation. The predicted size ($\sim 30\mu$arcseconds) of this shadow for Sgr A* approaches the resolution of current radio-interferometers. If the black hole is maximally spinning and viewed edge-on, then the shadow will be offset by ~ 8 μarcseconds from the center of mass, and will be slightly flattened on one side. Taking into account scatter-broadening of the image in the interstellar medium and the finite achievable telescope resolution, we show that the shadow of Sgr A* may be observable with very long-baseline interferometry at sub-millimeter wavelengths, assuming that the accretion flow is optically thin in this region of the spectrum. Hence, there exists a realistic expectation of imaging the event horizon of a black hole within the next few years.

Ref.: ApJ 528, L13 (Jan 1, 2000)
Email: hfalcke@mpifr-bonn.mpg.de
Eprint: astro-ph/9912263
http://www.mpifr-bonn.mpg.de/staff/hfalcke/ publications.html#bhimage

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Is Galactic Structure Compatible with Microlensing Data?

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We generalize to elliptical models the argument of Kuijken (1997), which connects the microlensing optical depth towards the Galactic bulge to the Galactic rotation curve. When applied to the latest value from the MACHO collaboration for the optical depth for microlensing of bulge sources, the argument implies that the Galactic bar cannot plausibly reconcile the measured values of the optical depth, the rotation curve and the local mass density. Either there is a problem with the interpretation of the microlensing data, or our line of sight to the Galactic centre is highly atypical in that it passes through a massive structure that wraps only a small distance around the Galactic centre.

Ref.: ApJ Letters, submitted
Email: Ortwin.Gerhard@unibas.ch
Eprint: astro-ph/0003330

The Distance to the Galactic Center

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The Optical Gravitational Lensing Experiment (OGLE) data on high-amplitude delta Scuti stars (HADS) and RR Lyrae stars have been analyzed to determine the distance to the Galactic bulge. Individual color excesses and V absorption for each individual variable star have been computed, which lead to accurate V0 magnitudes. The period-luminosity relation of the HADS is utilized to calculate distance moduli. We find that the metal-strong HADS are concentrated strongly to the bulge. The best distance modulus to the bulge from the HADS data is 14.49±0.06 mag. The dependence of M_V on period for the bulge RR Lyrae stars can be found from the reddening-free magnitude VV-I. The zero point of the M_V log P relation is set with the horizontal branches of Oosterhoff type I globular clusters. $M_V \sim 0.44$ mag (long-distance scale) in the log P interval -0.29 to -0.22 as inferred by main-sequence fitting of the clusters to local subdwarfs and utilizing short-period HADS in the clusters. The best distance modulus to the bulge from the RR Lyrae (ab) stars is 14.45 mag, which compares favorably with the distance modulus of 14.49 mag found from the HADS. We adopt the mean value 14.47 ± 0.08 mag for the bulge distance modulus. A small additive correction leads to 7.9 ± 0.3 kpc as the best distance to the Galactic center.

Ref.: PASP 112, 202-216, 2000 February
Email: PASP@io.byu.edu
http://www.journals.uchicago.edu/PASP/journal

/issues/v112n768/200037/200037.html

Detection of polarized mm and sub-mm emission from Sgr A*

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We report the detection of linear polarization from Sgr A* at 750, 850, 1350 and 2000μm which confirms the contribution of synchrotron radiation. From the lack of polarization at longer wavelengths it appears to arise in the millimetre/sub-millimetre excess. There are large position angle changes between the millimetre and sub-millimetre results and these are discussed in terms of a polarized dust contribution in the sub-millimetre and various synchrotron models. In the model which best explains the data the synchrotron radiation from the excess is self-absorbed in the millimetre region and becomes optically thin in the sub-millimetre. This implies that the excess arises in an extremely compact source $\sim$ 2 Schwarzschild radii.

Ref.: ApJ Letters, accepted 23 Mar. 2000
Email: acc@star.herts.ac.uk
Eprint: astro-ph/0003379
http://star.herts.ac.uk/ acc/pubs.html

Deep X-Ray Observations of Supernova Remnants G 359.1−0.5 and G 359.0−0.9 with ASCA

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We present the results of deep ASCA observations of two shell-like radio supernova remnants (SNRs) located in the direction to the Galactic center (GC) region. Unlike the radio morphology, G 359.1−0.5 shows center-filled X-rays with prominent Kα lines of He-like silicon and H-like sulfur. The plasma requires at least two temperature components: a silicon-dominated cool plasma of 0.6 keV temperature and a sulfur-dominated higher temperature plasma of 4.4 keV. Because the absorption column is $\sim 6\times10^{22}$ H cm^{-2}, this SNR would be near to the GC. The spherical plasma is attributable to supernova ejecta with the total mass of Si and S being about 0.1 $M_\odot$ and 0.3 $M_\odot$, respectively. X-rays from G 359.0−0.9 trace the partial shell structure of the radio emission. The spectrum is well fitted to a single-temperature plasma of 0.4 keV with a non-solar abundance of magnesium or iron. Because the absorption column is not very large, $\sim 1.8\times10^{22}$ H cm^{-2}, G 359.0−0.9 would be in front of the GC region. The total supernova energy, interstellar density near to the X-ray emitting shell and age of the SNR are estimated to be 1.2×10^{51} erg, 0.5 cm^{-3}, and 1.8×10^4 yr, respectively. We also discuss possible implications on the origin of the large-scale hot plasma surrounding the GC.

Ref.: PASJ, April 2000, in press
Email: bamba@cr.scphys.kyoto-u.ac.jp
Eprint: astro-ph/0003057

The Composition and Distribution of Dust Along the Line of Sight Towards the Galactic Center

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We discuss the composition of dust and ice along the line of sight to the Galactic Center (GC) based on analysis of mid-infrared spectra (2.4–13 μm) from the Short Wavelength Spectrometer on the Infrared Space Observatory (ISO). We have analyzed dust absorption features arising in the molecular cloud material and the diffuse interstellar medium along the lines of sight toward Sagittarius A* and the Quintuplet sources, GCS3 and GCS4. It is evident from the depth of the 3.0 μm H_2O and the 4.27 μm CO_2 ice features that there is more molecular cloud material along the line of sight toward Sgr A* than GCS3 and 4. In fact, Sgr A* has a rich infrared ice spectrum with evidence for the presence of solid Methane, NH_3, and possibly HCOOH. Hydrocarbon dust in the diffuse interstellar medium along the line of sight to the GC is characterized by absorption features centered at 3.4 μm, 6.85 μm, and 7.25 μm. Ground-based studies have identified the 3.4 μm feature with aliphatic hydrocarbons, and ISO has given us the first meaningful observations of the corresponding modes at longer wavelengths. The integrated strengths of these three features suggest that hydrogenated amorphous carbon is their carrier. We attribute an absorption feature centered at 3.28 μm in the GCS3 spectrum to the C-H stretch in aromatic hydrocarbons. This feature is not detected, and its C-C stretch counterpart appears to be weaker, in the

Sgr A* spectrum. One of the key questions which now arises is whether aromatics are a widespread component of the diffuse interstellar medium, analogous to aliphatic hydrocarbons.

Ref.: ApJ, July 2000, in press
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http://arXiv.org/abs/astro-ph/0002421

A supermassive scalar star at the Galactic Center?

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We explore whether supermassive non-baryonic stars (in particular boson, mini-boson and non-topological soliton stars) might be at the center of some galaxies, with special attention to the Milky Way. We analyze, from a dynamical point of view, what current observational data show, concluding that they are compatible with a single supermassive object without requiring it to be a black hole. Particularly, we show that scalar stars fit very well into these dynamical requirements. The parameters of different models of scalar stars necessary to reproduce the inferred central mass are derived, and the possible existence of boson particles with the adequate range of masses is commented. Accretion to boson stars is also analyzed, and a comparison with another non-baryonic candidate, a massive neutrino ball, which is also claimed as an alternative to the central black hole, is given. Both models are capable to explain the nature of the object in Sgr A* without invoking the presence of a singularity. One difficult issue is why the accreted materials will not finally produce, in a sufficiently long time, a black hole. We provide an answer based on stellar disruption in the case of boson stars, and comment several suggestions for its possible solution in neutrino ball scenarios. Finally, we discuss the prospects for the observational detection of these supermassive scalar objects, using the new generation of X-ray and radio interferometry satellites.

Ref.: ApJ, submitted
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Eprint: astro-ph/0004064

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2 μm Spectroscopy within 0$''$.3 of Sgr A*

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We present moderate (R $\approx$ 2,700) and high resolution (R $\approx$ 22,000) 2.0–2.4 μm spectroscopy of the central 0.1 square arcseconds of the Galaxy obtained with NIRSPEC, the facility near-infrared spectrometer for the Keck II telescope. The composite spectra do not have any features attributable to the brightest stars in the central cluster, i.e. after background subtraction, $W_{^{12}CO(2-0)} < 2$ Å. This stringent limit leads us to conclude that the majority, if not all, of the stars are hotter than typical red giants. Coupled with previously reported photometry, we conclude that the sources are likely OB main sequence stars. In addition, the continuum slope in the composite spectrum is bluer than that of a red giant and is similar to that of the nearby hot star, IRS16NW. It is unlikely that they are late-type giants stripped of their outer envelopes because such sources would be much fainter than those observed. Given their inferred youth ($\tau_{\rm age} < 20$ Myr), we suggest the possibility that the stars have formed within 0.1 pc of the supermassive black hole. We find a newly-identified broad-line component ($V_{\rm FWHM} \approx 1{,}000$ km $s^{-}1$) to the 2.2178 μm [Fe III] line located within a few arcseconds of Sgr A*. A similar component is not seen in the Br-γ emission.

Ref.: ApJ Letters, April 10th Issue
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Hybrid Thermal-Nonthermal Synchrotron Emission from Hot Accretion Flows

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We investigate the effect of a hybrid electron population, consisting of both thermal and non-thermal particles, on the synchrotron spectrum, image size, and image shape of a hot accretion flow onto a supermassive black hole. We find two universal features in the emitted synchrotron spectrum: (i) a prominent shoulder at low ($\lesssim 10^{11}$ Hz) frequencies that is weakly dependent on the shape of the electron energy distribution, and (ii) an extended tail of emission at high ($\gtrsim 10^{13}$ Hz) frequencies whose spectral slope depends on the slope of the power-law energy distribution of the electrons. In the low-frequency shoulder, the luminosity can be up to two orders of magnitude greater than with a purely thermal plasma even if

only a small fraction ($< 1\%$) of the steady-state electron energy is in the non-thermal electrons. We apply the hybrid model to the Galactic center source, Sgr A*. The observed radio and IR spectra imply that at most 1% of the steady-state electron energy is present in a power-law tail in this source. This corresponds to no more than 10% of the electron energy injected into the non-thermal electrons and hence 90% into the thermal electrons. We show that such a hybrid distribution can be sustained in the flow because thermalization via Coulomb collisions and synchrotron self-absorption are both inefficient. The presence of non-thermal electrons enlarges the size of the radio image at low frequencies and alters the frequency dependence of the brightness temperature. A purely thermal electron distributions produces a sharp-edged image while a hybrid distribution causes strong limb brightening. These effects can be seen up to frequencies $\sim 10^{11}$ Hz and are accessible to radio interferometers.

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Email: fozel@cfa.harvard.edu
Eprint: astro-ph/0004195

The role of the outer boundary condition in accretion disk models: theory and application

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In a previous paper (Yuan 1999, hereafter Paper I), we find that the outer boundary conditions(OBCs) of an optically thin accretion flow play an important role in determining the structure of the flow. Here in this paper, we further investigate the influence of OBC on the dynamics and radiation of the accretion flow on a more detailed level. Bremsstrahlung and synchrotron radiations amplified by Comptonization are taken into account and two-temperature plasma assumption is adopted. The three OBCs we adopted are the temperatures of the electrons and ions and the specific angular momentum of the accretion flow at a certain outer boundary. We investigate the individual role of each of the three OBCs on the dynamical structure and the emergent spectrum. We find that when the general parameters such as the mass accretion rate $\dot{M}$ and the viscous parameter α are fixed, the peak flux at various bands such as radio, IR and X-ray, can differ by as large as several orders of magnitude under different OBCs in our example. Our results indicate that OBC is both dynamically and radiatively important therefore should be regarded as a new "parameter" in accretion disk models. As an illustrative example, we further apply the above results to the compact radio source Sgr A* located at the center of our Galaxy. Advection-dominated accretion flow (ADAF) model has been turned out to be a great success to explain its luminosity and spectrum. However, there exists a discrepancy between the mass accretion rate favored by ADAF models in the literature and that favored by the three dimensional hydrodynamical simulation, with the former being 10-20 times smaller than the latter. By seriously considering the outer boundary condition of the accretion flow, we find that due to the low specific angular momentum of the accretion gas, the accretion in Sgr A* should belong to a new accretion pattern, which is characterized by possessing a very large sonic radius. This accretion pattern can significantly reduce the discrepancy between the mass accretion rate. We argue that the accretion occurred in some detached binary systems, the core of nearby elliptical galaxies and active galactic nuclei(AGNs) very possibly belongs to this accretion pattern.

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Possible evidence for the disk origin for the powering of jets in Sgr A* and nearby elliptical galaxies

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Recent VLBA observation indicates the existence of an elongated (jet) structure in the compact radio source Sgr A*. This is hard to explain in the context of advection-dominated accretion flow (ADAF) model for this source. On the other hand, the mass accretion rate favored by ADAF is 10-20 times smaller than that favored by the hydrodynamical simulation based on Bondi capture. If the latter were adopted, the predicted radio flux would significantly exceed the observation by about two orders of magnitude. A similar situation exists in the case of nearby giant ellipticals, where the canonical ADAF model – the widely assumed standard model for these sources – also significantly overpredict the radio flux. Based on these facts, in this paper we propose a truncated ADAF model for Sgr A* and three ellipticals M87, NGC 4649 and NGC 4636. We assume that the accretion disk is truncated at a certain radius $R_{\rm tr}$ within which the jet forms by extracting the energy of the disk. The radio flux is greatly suppressed due to the radiative truncation of the disk and the fits to the observational data are excellent. For example,

for Sgr A*, the model fits the observational spectrum very well from radio including the "excess" below the break frequency to hard X-ray under a high accretion rate near the simulation value, and the predicted size-frequency relationship is also in excellent agreement with the observation; for M87, the predicted upper limit of the jet location is $24R_{\rm g}$, in excellent agreement with the observational result that the jet is formed on scales smaller than $30R_{\rm g}$, and the $\approx 20\%$ variability at ~ 1 Kev – which is hard to explain in another model trying to explain the low radio flux of M87 – is also marginally interpreted. The success of the model supplies a possible piece of evidence for the disk rather than the hole origin for the powering of jets.

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A Cluster of Black Holes at the Galactic Center

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If the stellar population of the bulge contains black holes formed in the final core collapse of ordinary stars with $M \gtrsim 30M_\odot$, then about 25,000 stellar mass black holes should have migrated by dynamical friction into the central parsec of the Milky Way, forming a black hole cluster around the central supermassive black hole. These black holes can be captured by the central black hole when they randomly reach a highly eccentric orbit due to relaxation, either by direct capture (when their Newtonian peribothron is less than 4 Schwarzschild radii), or after losing orbital energy through gravitational waves. The overall depletion timescale is ~ 30 Gyr, so most of the 25,000 black holes remain in the central cluster today. The presence of this black hole cluster would have several observable consequences. First, the low-mass, old stellar population should have been expelled from the region occupied by the black hole cluster due to relaxation, implying a core in the profile of solar-mass red giants with a radius of ~ 2 pc (i.e., $1'$). The observed central density cusp (which has a core radius of only a few arc seconds) should be composed primarily of young ($\lesssim 1\,$Gyr) stars. Second, flares from stars being captured by supermassive black holes in other galaxies should be rarer than usually expected because the older stars will have been expelled from the central regions by the black hole clusters of those galaxies. Third, the young ($\lesssim 2$ Gyr) stars found at distances $\sim 3-10$ pc from the Galactic center should be preferentially on highly eccentric orbits. Fourth, if future high-resolution K-band images reveal sources microlensed by the Milky Way's central black hole, then the cluster black holes could give rise to secondary ("planet-like") perturbations on the main event.

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Stellar Dynamics in the Galactic centre: Proper Motions and Anisotropy

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We report a new analysis of the stellar dynamics in the Galactic centre, based on improved sky and line-of-sight velocities for more than one hundred stars in the central few arcseconds from the black hole candidate SgrA*. The main results are: • Overall the stellar motions do not deviate strongly from isotropy. For those 32 stars with a determination of all three velocity components the absolute, line of sight and sky velocities are in good agreement, consistent with a spherical star cluster. Likewise the sky-projected radial and tangential velocities of all 104 proper motion stars in our sample are also consistent with overall isotropy. • However, the sky-projected velocity components of the young, early type stars in our sample indicate significant deviations from isotropy, with a strong radial dependence. Most of the bright HeI emission line stars at separations from 1" to 10" from SgrA* are on tangential orbits. This tangential anisotropy of the HeI stars and most of the brighter members of the IRS16 complex is largely caused by a clockwise (on the sky) and counter-rotating (line of sight, compared to the Galaxy), coherent rotation pattern. The overall rotation of the young star cluster probably is a remnant of the original angular momentum pattern in the interstellar cloud from which these stars were formed. • The fainter, fast moving stars within $\approx 1''$ from SgrA* appear to be largely moving on radial or very elliptical orbits. We have so far not detected deviations from linear motion (i.e. acceleration) for any of them. Most of the SgrA* cluster members also are on clockwise orbits. Spectroscopy indicates that they are early type stars. We propose that the SgrA* cluster stars are those members of the early type cluster that happen to have small angular momentum and thus can plunge to the immediate vicinity of SgrA*. • We derive an anisotropy-independent estimate of the Sun-Galactic centre distance between 7.8 and 8.2 kpc, with a formal statistical uncertainty of ± 0.9 kpc. • We explicitly include velocity anisotropy in estimating the central mass distribution. We show how Leonard-Merritt and Bahcall-Tremaine mass estimates give systematic offsets in the inferred mass of the central object when applied to finite concentric rings for power law clusters. Corrected Leonard-Merritt projected mass estimators and Jeans equation modelling confirm previous conclusions (from isotropic models) that a compact central mass concentration (central density $\geq 10^{12.6} M_\odot$ pc $^{-3}$) is present and dominates the potential between 0.01 and 1 pc. Depending on the modelling method used the derived central mass ranges between 2.6 and $3.3 \times 10^{6} M_\odot$ for $R_\odot = 8.0$ kpc.

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The Effelsberg Search for Pulsars in the Galactic Centre

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We report the status of a search for pulsars in the Galactic Centre, using a completely revised and improved high-sensitivity double-horn system at 4.85-GHz. We also present calculations about the success rate of periodicity searches for such a survey, showing that in contrast to conclusions in recent literature pulsars can be indeed detected at the chosen search frequency.

Ref.: PASP, IAU Colloq. 177, Pulsar-Astronomy – 2000 and Beyond, eds. M.Kramer, N.Wex, R.Wielebinski
Email: mkramer@jb.man.ac.uk
Eprint: astro-ph/0002117

Non-equilibrium H_2 ortho-to-para ratio in two molecular clouds of the Galactic Center

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We present ISO observations of the S(0), S(1), S(2), and S(3) rotational lines of molecular hydrogen from two molecular clouds near the Galactic Center (GC). We have also measured continuum dust emission at infrared wavelengths with ISO and the rotational radio lines J=1–0 of ^{13}CO and C^{18}O and J=2–1 of C^{18}O with the IRAM-30m telescope. Using the dust continuum spectra and the CO lines we derive a total visual extinction of $\sim$ 15-20 magnitudes toward these GC clouds. After correcting the H_2 data for extinction, the gas temperatures are ~ 250 K and the column densities of warm gas are $\sim 2\times10^{21}$ cm^{-2}. This is the first direct measure of the H_2 column densities of the warm component; with this, we estimate an NH_3 abundance in the warm gas of $\sim 2\ 10^{-7}$. The column density of warm gas is, at least, a factor of 100 larger than the corresponding column densities derived from the warm dust. The observed ortho-to-para ratio (OTPR) is ~ 1, clearly below the local thermodynamical equilibrium (LTE) OTPR for gas at 250 K of ~ 3. Low velocity shocks (~ 10 km s^{-1}) are the most likely explanation for the column densities of warm gas and dust and the non-LTE H_2 OTPR.

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Eprint: astro-ph/0002478

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150 GHz NOBA observations of the Galactic Center Arc

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We have used the seven beam 150 GHz bolometer NOBA installed at the Nobeyama 45-m telescope to map the central section of the Galactic Center Arc. In addition we mapped Sgr A, which shows Sgr A* and the thermal spiral structure. The results agree with previous mm-observations. South of the thermal "sickle" feature (G0.18-0.04) we observe three regions of enhanced emission along the Arc, which are located slightly offset relative to the most intense vertical filaments seen at low frequencies. This 150 GHz emission is observed at the apparent interacting areas of dense molecular material with the Arc. Another structure is seen south of the molecular cloud, where the Arc's vertical filaments apparently cross a weak filamentary structure running orthogonally in the direction of Sgr A. The 150 GHz results are unexpected in view of previous 32 GHz and 43 GHz results, which indicate a fading of the Arc towards higher frequencies. Cold dust can be ruled out as the origin of the 150 GHz emission. Synchrotron emission from quasi-monoenergetic electrons or an electron distribution with a low energy cut-off seems compatible with the available data. The coincidence of enhanced emission with regions of interacting molecular gas strongly suggests that high energetic electrons are accelerated in those places where the magnetic field is compressed and subsequently enter and illuminate the Arc.

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Email: p098wre@mpifr-bonn.mpg.de

Cloud Collision-Induced Star Formation in Sagittarius B2. I. Large-Scale Kinematics

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We present maps of a ∼14 pc × 20 pc region covering the Sgr B2 molecular cloud complex in the ^{13}CO (1 – 0) and CS (1 – 0) lines with high angular resolution. A more restricted central area was also mapped in the C^{18}O (1 – 0) line. The ^{13}CO cloud consists of two components: a compact core of ∼3 pc in diameter roughly centered on Sgr B2 (M) and an extended plateau of ∼17 pc × 7.5 pc area containing the maser sources and most of the HII regions. Compact, massive (∼3×10^5 $M_\odot$) C^{18}O cores are associated with Sgr B2(M) and Sgr B2(N). The obtained intensity distributions are compared with those of molecular masers and compact HII regions reported in the literature. Low-velocity (40 – 65 km s^{-1}) masers, with positions roughly aligned in the north–south line connecting the three major compact HII region complexes, are located near the eastern margin of a large hole in the low-velocity molecular cloud. In contrast, most of the high-velocity (65 – 80 km s^{-1}) masers are distributed near the center of a compact molecular cloud at higher velocity, where a shock seems to have occurred. These results provide further evidence supporting the cloud–cloud collision hypothesis based on limited ^{13}CO (1 – 0) data (Hasegawa et al. 1994). In addition, this hypothesis appears to be consistent with a wide range of new observations that have appeared in the literature.

Ref.: ApJ 534, No.2, May 10, 2000, in press
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Bipolar-Hyper-Shell Galactic Center Starburst Model: Further Evidence from ROSAT Data and New Radio and X-ray Simulations

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Using the all-sky ROSAT soft X-ray and 408-MHz radio continuum data, we show that the North Polar Spur and its western and southern counter-spurs draw a giant dumbbell-shape necked at the galactic plane. We interpret these features as due to a shock front originating from a starburst 15 million years ago with a total energy of the order of $\sim 10^{56}$ ergs or 10^5 type II supernovae. We simulate all-sky distributions of radio continuum and soft X-ray intensities based on the bipolar-hyper-shell galactic center starburst model. The simulations can well reproduce the radio NPS and related spurs, as well as radio spurs in the tangential directions of spiral arms. Simulated X-ray maps in 0.25, 0.75 and 1.5 keV bands reproduce the ROSAT X-ray NPS, its western and southern counter-spurs, and the absorption layer along the galactic plane. We propose to use the ROSAT all-sky maps to probe the physics of gas in the halo-intergalactic interface, and to directly date and measure the energy of a recent Galactic Center starburst.

Ref.: ApJ, in press
Email: sofue@mtk.ioa.s.u-tokyo.ac.jp

Stellar Iron Abundances at the Galactic Center

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We present measurements of [Fe/H] for six M supergiant stars and three giant stars within 0.5 pc of the Galactic Center (GC) and one M supergiant star within 30 pc of the GC. The results are based on high-resolution ($\lambda/\Delta\lambda = 40{,}000$) $K-$band spectra, taken with CSHELL at the NASA Infrared Telescope Facility. We determine the iron abundance by detailed abundance analysis, performed with the spectral synthesis program MOOG. The mean [Fe/H] of the GC stars is determined to be near solar, [Fe/H] $= +0.12 \pm 0.22$. Our analysis is a *differential* analysis, as we have observed and applied the same analysis technique to eleven cool, luminous stars in the solar neighborhood with similar temperatures and luminosities as the GC stars. The mean [Fe/H] of the solar neighborhood comparison stars, [Fe/H] $=$ $+0.03 \pm 0.16$, is similar to that of the GC stars. The width of the GC [Fe/H] distribution is found to be narrower than the width of the [Fe/H] distribution of Baade's Window in the bulge but consistent with the width of the [Fe/H] distribution of giant and supergiant stars in the solar neighborhood.

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Email: solange@astronomy.ohio-state.edu
Eprint: astro-ph/0002062

Tidal spin-up of stars in dense stellar cusps around massive black holes

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We show that main-sequence stars in dense stellar cusps around massive black holes are likely to rotate at a significant fraction of the centrifugal breakup velocity due to spin-up by hyperbolic tidal encounters. We use realistic stellar structure models to calculate analytically the tidal spin-up in soft encounters, and extrapolate these results to close and penetrating collisions using smoothed particle hydrodynamics simulations. We find that the spin-up falls off only slowly with distance from the black hole because the increased tidal coupling in slower collisions at larger distances compensates for the decrease in the stellar density. We apply our results to the stars near the massive black hole in the Galactic Center. Over their lifetime, $\sim 1M_{\odot}$ main sequence stars in the inner 0.3 pc of the Galactic Center are spun-up on average to $\sim 10\% - 30\%$ of the centrifugal breakup limit. Such rotation is $\sim 20 - 60$ times higher than is usual for such stars and may affect their subsequent evolution and their observed properties.

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Eprint: astro-ph/0004240

A Second Luminous Blue Variable in the Quintuplet Cluster

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H and K band moderate resolution and 4 microns high resolution spectra have been obtained for FMM362, a bright star in the Quintuplet Cluster near the Galactic Center. The spectral features in these bands closely match those of the Pistol Star, a luminous blue variable and one of the most luminous stars known. The new spectra and previously-obtained photometry imply a very high luminosity for FMM362, L $\geq$ $10^6 L_{\odot}$, and a temperature of 10,000 – 13,000 K. Based on its luminosity, temperature, photometric variability, and similarities to the Pistol Star, we conclude that FMM362 is a luminous blue variable.

Ref.: ApJL 530, L97
Email: tgeballe@noao.edu

A correlation between the SiO and the Fe 6.4 keV line emission from the Galactic center

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One of the most interesting results of the X-ray observations with the ASCA satellite of the Galactic center (GC) is the spatial distribution and the intensity of the Fe line at 6.4 keV. Up to now the morphology and the intensity of this line have been a puzzle. In this letter we present a map of the GC in the 1-0 line of SiO covering the same region than the ASCA observations. The SiO emission is restricted to molecular clouds with radial velocity between 10 and 60 km s^{-1} in the Sgr A and Sgr B complexes. We find a correlation between the SiO morphology and the spatial distribution of the Fe 6.4 keV line, on the large scale and also within Sgr A and Sgr B. The SiO abundance increases by a factor of $\gtrsim$20 in the regions with strong Fe 6.4 keV line. This indicates that the Fe 6.4 keV line mainly arises from molecular clouds with large gas phase abundance of refractory elements. We discuss the implications of the correlation on the origin of the hard X-rays, and the heating and the chemistry of the molecular clouds in the GC.

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Email: vicente@cay.oan.es
Eprint: astro-ph/0003063
http://www.oan.es/preprints/

Studies of Galactic Nuclei with Darwin

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This paper describes a number of potential observing programs for Darwin in the area of galactic nuclei. Observations of our Galactic centre at the shorter wavelengths (5 μm) covered by Darwin will detect large numbers of stars. Extrapolation of the existing K band counts to the flux levels expected to be reached by Darwin in 1 hour suggests $\sim$ 5,000 detectable stars (arc sec)$^{-2}$ around the compact radio source Sgr A*, which is commonly believed to be associated with a black hole of mass 2.6 million M$_{\odot}$. Over its lifetime, Darwin will be capable of exquisitely accurate measurements of stellar proper motions, including the ability to follow entire stellar orbits around the hole for stars with orbital radii $\sim 10^{-3}$ pc. It may also be able to observe the general relativistic advance of the pericenter of stellar orbits somewhat closer to the hole. Stars behind the hole will be gravitationally lensed by it. It appears that the probability of observing a lensing event at any given time is of order unity at Darwin's resolution and sensitivity, so this should be a rich area of research. Darwin will measure the infrared spectrum of Sgr A* with a gain of $\sim$ 4 orders of magnitude of sensitivity over present upper limits, easily detecting

the source if it conforms to the predictions of current ADAF models. Stars which approach too close to the black hole will be tidally disrupted by it, and Darwin's resolution is sufficiently good to spatially separate such a tidally disrupted red giant or supergiant from the black hole itself. However, the event rate is almost certainly too low for such a disruption to be seen in the mission lifetime. Dust shells around stars in the vicinity of the Galactic centre will be promising candidates for study. Darwin will be able to study the stellar luminosity function and stellar proper motions in the nucleus of M31. The possibility of using the stellar proper motions to estimate the mass of the nuclear black hole is discussed. Potential investigations of the distributions of warm dust and gas in the nuclei of nearby active galaxies are described. Darwin should be able to image the dusty accretion disks in Seyfert galaxies, compact starbursts around active nuclei and, depending on the available spectral resolution, study the stratification of different ionic species through observations of fine structure lines. It may be possible to resolve the broad line region if the wavelength coverage extends to short enough wavelengths. Darwin's nulling mode will be valuable for blocking the bright, compact light of quasars and investigating the kinematics of the surrounding gas. Whether stars, gas or dust are observed, galactic nuclei present densely-populated, bright fields, so the primary technical requirement for good imaging fidelity is very extensive coverage of the uv plane.

Ref.: in "Darwin and Astronomy: The Infrared Space Interferometer", European Space Agency Publication Division, ESA SP-451 (2000)
Email: wilson@astro.umd.edu

The Galactic Center: An Interacting System of Unusual Sources

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The region bounded by the inner tens of light years at the center of the Milky Way contains five principal components that coexist within the central deep gravitational potential well. These constituents are a black hole candidate (Sgr A*) with a mass equivalent to $2.6 \pm 0.2 \times 10^6$ suns, a surrounding cluster of evolved stars, a complex of young stars, molecular and ionized gas clouds, and a powerful supernova-like remnant. The interaction of these components is responsible for many of the phenomena occurring in this complex and unique portion of the Galaxy. Developing a consistent picture of the primary interactions between the components at the Galactic Center will improve our understanding of the nature of galactic nuclei in general, and will provide with a better defined set of characteristics of black holes. For example, the accretion of stellar winds by Sgr A* appears to produce far less radiation than indicated by estimates based on models of galactic nuclei.

Ref.: Science 2000, Vol. 287, p. 85
Email: zadeh@oort.astro.nwu.edu
http://www.sciencemag.org/cgi/content/abstract/287/5450/85

The Population of Faint Transients in the Galactic Centre

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BeppoSAX has detected a population of faint transient X–ray sources in the Galactic Centre. I show that a simple irradiated–disc picture gives a consistent fit to the properties of this population, and that it probably consists of low–mass X–ray binaries which have evolved beyond their minimum orbital periods ~ 80 min. Since all post–minimum systems are transient, and neutron–star LMXBs are more common than black–hole LMXBs in the Galaxy, the majority of these systems should contain neutron stars, as observed. This picture predicts that the Galactic Centre transients should have orbital periods in the range $\sim 80 - 120$ minutes, and that most of them should repeat in the next few years. In this case, the total number of post–minimum transients in the Galaxy would be considerably smaller than the usual estimates of its total LMXB population. I discuss possible reasons for this.

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Email: ark@star.le.ac.uk
Eprint: astro-ph/0004277

Constraining the Accretion Rate Onto Sagittarius A* Using Linear Polarization

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Two possible explanations for the low luminosity of the supermassive black hole at the center of our galaxy are (1) an accretion rate of order the canonical Bondi value, but a very low radiative efficiency for the accreting gas or (2) an accretion rate much less than the Bondi rate. Both models can explain the broad-band spectrum of the Galactic Center. We show that they can be distinguished using the linear polarization of synchrotron radiation. Accretion at the Bondi rate predicts no linear polarization at any frequency due to Faraday depolarization. Low accretion rate models, on the other hand, have much lower gas densities and magnetic field strengths close to the black hole; polarization is therefore observable at high frequencies. If confirmed, a recent detection of linear polarization from Sgr A* at $\gtrsim 150$ GHz argues for an accretion rate $\sim 10^{-8} M_{\odot}$/yr, much less than the Bondi rate. This test can be applied to other low-luminosity galactic nuclei.

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Email: eliot@ias.edu
Eprint: astro-ph/0004286

Sgr A* Polarization: No ADAF, Low Accretion Rate, and Non-Thermal Synchrotron Emission

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The recent detection of polarized radiation from Sgr A* requires a non-thermal electron distribution for the emitting plasma. The Faraday rotation measure must be small, placing strong limits on the density and magnetic field strength. We show that these constraints rule out advection-dominated accretion flow models. We construct a simple two-component model which can reproduce both the radio to mm spectrum and the polarization. This model predicts that the polarization should rise to nearly 100% at shorter wavelengths. The first component, possibly a black-hole powered jet, is compact, low density, and self-absorbed near 1 mm with ordered magnetic field, relativistic Alfvén speed, and a non-thermal electron distribution. The second component is poorly constrained, but may be a convection-dominated accretion flow with $\dot{M} \sim 10^{-9} M_{\odot}$/yr, in which feedback from accretion onto the black hole suppresses the accretion rate at large radii. The black hole shadow should be detectable with sub-mm VLBI.

Ref.: ApJ Letters, submitted
Email: agol@pha.jhu.edu
Eprint: astro-ph/0005051

Announcements

Release of the INES Archive: The International Ultraviolet Explorer (IUE) Archives were delivered to the world scientific community on the 21st of March. ESA, in collaboration with the Spanish Laboratory of Space Astrophysics and Theoretical Physics (LAEFF) belonging to INTA (National Institute of Air and Space Technology), has developed and set up the INES system to access IUE Data.

INES (IUE Newly Extracted Spectra) is a complete astronomical archive and data-distribution system. Its release to the community represents the final activity by ESA in the context of the IUE project. From now LAEFF, on behalf of the international astronomical community, will be responsible of maintaining INES, making it available and providing world-wide support to scientists using IUE data.

The IUE Archive contains more than 110,000 spectra of more that 11,000 astronomical objects. All data are fully reduced and calibrated. The INES archive consists of:

- an access catalog containing the parameters required to query the archive and evaluate the observations,
- a publications catalog which links each spectrum to the publications in which it has been used via the ADS,
- the data themselves (low dispersion spectra, high dispersion spectra rebinned to the low resolution wavelength step, full high dispersion concatenated spectra, and bi-dimensional low dispersion images).

The INES Archive can be accessed at http://ines.vilspa.esa.es. Users can consult the catalogue, preview the spectra and download the data with a standard browser from the Principal Centre at LAEFF, its Mirror Centre located at the Canadian Astronomical Data Centre or any of the National Centres spread in all continents. This distributed system guarantees the availability and efficient access to the data.

Questions about the INES archive can be directed to the INES Help Desk at ineshelpiuearc.vilspa.esa.es or at http://iuearc.vilspa.esa.es/ines_jb/HelpDesk/.

ALMA Scientific Advisory Committee: The Atacama Large Millimeter Array (ALMA) project has formed a new committee to provide scientific advice to the project and outreach to the wider community. We hold monthly telecons and hold other meetings at regular intervals. The minutes of the telecons and reports from the meetings are placed on the following web site:

http://www.alma.nrao.edu/committees/ASAC/index.html

A list of the committee members can also be found on this web site. Comments or questions can be addressed directly to the individual committee members or to the committee by email via the website. In addition, we are all willing to give colloquia or other presentations on the ALMA project.

Second Large Incremental Data Release from the 2-μ All-Sky Survey (2MASS): The Two Micron All Sky Survey (2MASS) Second Incremental Data Release is now available for public access. This Release includes data from the northern and southern 2MASS facilities, covering 47% of the sky, including the Galactic Center region. The Release data products consist of a Point Source Catalog containing positions and photometry for over 162 million objects, an Extended Source Catalog containing positions, photometry and basic shape information for over 585,000 resolved sources, approximately 1.9 million compressed 512x1024 pixel (1"/pixel) images in the three Survey bandpasses, and non-compressed "postage-stamp" images for all of the Extended Source Catalog objects.

The release data products can be accessed on-line from the IPAC/2MASS Web site at:

http://www.ipac.caltech.edu/2mass/ or directly from the NASA/Infrared

Science Archive site at http://irsa.ipac.caltech.edu/. In the near future, the release Catalogs will be available via ftp download, and on a limited distribution DVD-ROM. Access to the 2MASS Atlas Images is currently possible only via the on-line services.

The 2MASS/IPAC webpage contains general information about this data release, including an on-line Explanatory Supplement (http://www.ipac.caltech.edu/2mass/releases/second/doc/explsup.html), sky coverage maps, images of interesting objects in the release, catalog characteristics, etc. A tool for determining whether a specified position is included in the release area is available on the NASA/Infrared Science Archive webpage. Questions about the release can be directed to the 2MASS Help Desk at 2massipac.caltech.edu.

We encourage you to notify us (at 2massipac.caltech.edu) about any refereed publications or conference proceedings (even in preprint form) which make use of these or earlier 2MASS Release data products. We will gladly provide links to your papers from the 2MASS website. Thank you very much in advance.

The Two Micron All Sky Survey is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology. Funding for the survey has been provided by the National Aeronautics and Space Administration and the National Science Foundation.

DPG School for Physics "Galactic Black Hole 2001" — 26-31 August 2001: This is a Summer school on Astrophysics and Gravity for advanced students, graduate students, postdocs, and researchers of physics/astronomy/applied mathematics. The school will mainly revolve around the supermassive black hole in the center of our Galaxy. A preliminary web page can be found at http://www.thp.Uni-Koeln.DE/BH2001/. The scientific organizers are F.W. Hehl (hehl@thp.uni-koeln.de) and H. Falcke (hfalcke@mpifr-bonn.mpg.de).

The current list of teachers includes: Alexander, Tal (IAS Princeton); Eckart, Andreas (Cologne University); Falcke, Heino (MPIfR Bonn); Frolov, Valeri P. (University of Alberta, Edmonton) Hehl, Friedrich W. (Cologne University); Hüttemeister, Susanne (University of Bonn); Kiefer, Claus (University of Freiburg i.Br.); Mashhoon, Bahram (University of Missouri-Columbia); Melia, Fulvio (University of Arizona, Tucson); Menten, Karl (MPIfR Bonn); Morris, Mark (UCLA); Neugebauer, Gernot (Jena University).

Every year, the German Physical Society (DPG) is organizing two courses during the summer holidays for advanced students on certain subjects of physics. During one week at the Physics Center, which can house about 70 people, about 10 to 15 lecturers teach the students the subject under consideration. The school is supported by the (non-profit) WE-Heraeus Foundation, Hanau, see http://www.physik.uni-wuerzburg.de/we-heraeus-stiftung/. Students usually pay about Euro 150 for accomodation and meals, but some reductions are possible. The language of this school is English. Whereas basically the course is addressed to the members of the DPG, other students are welcome.

Milky Way in "Science": In case you missed it: the journal *Science* dedicated its first issue of the new Millenium (no discussions about the last statement please) to the Milky Way (Jan. 7, 2000, Vol. 287, #5450), featuring a number of review and news articles also about the Galactic Center (e.g. Yusef-Zadeh, Melia, & Wardle. – see abstracts).

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