

REPORT ON THE RADIONET3 NETWORKING ACTIVITY

TITLE: THE GALACTIC CENTRE BLACK HOLE LABORATORY

DATE: 19-21 NOVEMBER 2013 **TIME:** (WHOLE DAY)

LOCATION: GRANADA, SPAIN

MEETING WEBPAGE <http://galacticcenter.iaa.es>
<http://www.astro.uni-koeln.de/gc2013>

HOST INSTITUTE: INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA (IAA-CSIC)
(HTTP://WWW.IAA.ES)

PARTICIPANTS NO: 70-75

MAIN LEADER: ANTXON ALBERDI (IAA-CSIC)

REPORT:

1. Programme of the meeting

See attached document.

2. Scientific Summary

Sagittarius (SgrA*) at the centre of our Galaxy is a highly variable radio, near-infrared (NIR), and X-ray source which is associated with a $4 \times 10^6 M_{\text{sun}}$ super-massive central black hole (SMBH). A fast moving infrared excess source G2 which is widely interpreted as a core-less gas and dust cloud approaches Sagittarius A* (SgrA*) on a presumably elliptical orbit covering the region of the high velocity S-stars close to SgrA*. The passage of this Dusty S-cluster Objet (DSO) is expected to result in accretion phenomena, which will give an improved insight into the nature of the immediate surroundings of the SMBH SgrA*. Recent orbit determinations now expect the periape passage to occur in April/May 2014. November 2013 certainly closed the first year of an intense observing session during which the immediate vicinity of SgrA* has been monitored during the flyby of the DSO. The main goal of the conference was to focus on the new observational and theoretical results that are linked to this phenomenon and to point out possible consequences for our understanding of galactic nuclei in general. SgrA* is the closest SMBH and can be taken as a paradigm for very Low Luminosity Active Galactic Nuclei (LLAGN).

It has also been shown that the strong polarized infrared flux density excursions (often referred to as flares) from SgrA* show patterns of strong gravity as expected from in-spiralling material very close to the black hole's horizon. Therefore, it is mainly the polarization and the strong flux variability that gives us certainty that we study the immediate vicinity of a SMBH. In the following the three major topics of the conference are summarized:

1. - The Galactic Centre:

The DSO source approaching the super-massive black hole SgrA* at the centre of the Milky Way has spawned great activities in observing that region covering the entire electromagnetic spectrum from radio, via infrared to X-ray wavelengths using telescopes across the world. Efforts and first observational results were presented by Lorant Sjouwerman (NRAO, USA). He reported on monitoring observations of the interaction between SgrA* and the DSO with the Karl G. Jansky Very Large Array. The SgrA region has been observed since 2012 October on roughly a bi-monthly interval, cycling through eight observing bands. There are strengths and weaknesses of observing with the VLA. For monitoring the flux densities and in particular the radio spectral indices the short wavelength observations (<6cm) are most useful. It was pointed out that no particular flux density variation was detected. This may be linked with the fact that the newly determined periape passage did not happen in late 2013 but is now expected to happen in April/May of 2014. However, in the radio-shock frame in which variations of up to several Janskys were expected even during the pre-periape time this indicates that the medium is less dense than expected and/or that the bow-shock size i.e. the cross-section of the dust source is much smaller than assumed.

There is also profound progress in imaging and modelling the central putative accretion disk of SgrA* as well as the jet that may be associated with the source. Gas and stars within the Galactic Centre stellar cluster provide the fuel for the central super-massive black hole and hence the reason for most of the flux density variability observed from it. The stellar density close to centre is in excess of $10^5 M_{\odot}$ per cubic-parsec. This implies that in this region the evolution of stars is influenced by stellar collisions. These effects were summarized by Ross Church (Lund Observatory, Sweden). X-ray properties of the Galactic centre were reviewed by Delphine Porquet (University of Strasbourg, France). She summarized the present knowledge on the X-ray properties of the Galactic centre that is extremely faint in the X-ray bands, though a level of activity has been revealed through the detection of flares. Therefore, SgrA* is the ideal target to investigate the mass accretion and ejection physics in the case of extremely low accretion rate onto a supermassive black hole. This is actually the phase in which super-massive black holes are thought to spend most of their lifetime.

The discovery of radio pulsations from a magnetar PSR J1745-2900, at only 3 arcsec from SgrA*, with the Effelsberg telescope has highlighted the great value and the efforts that are currently being

undertaken to find pulsars in the Galactic Centre (Michael Kramer, MPIfR, Bonn). If close enough, they would allow us to measure the spin and quadrupole moment of the central black hole with superb precision allowing us to test different theories of gravity. The number of pulsars in the central cluster will depend on the star formation history in the overall region. Star formation activity in the Galactic Centre was summarized by Farhad Yusef Zadeh (Northwestern University, Chicago, USA). Given the deep gravitational potential towards the very centre star cannot form in the same way they do throughout the Milky Way. However, infrared observations have shown the evidence that massive stars were formed in the hostile environment of SgrA* a few million years ago. VLA, ALMA and CARMA measurements suggest that on-going star formation is still taking place in this region during the past few times 10^5 years. A broad variety of possible star formation scenarios can be discussed. A fraction of the material associated with these phenomena may have accreted onto SgrA*. This process may in part be responsible for the origin of the -ray emitting Fermi bubbles. These Fermi bubbles may be linked to the giant magnetized outflows from the Galactic Centre as reviewed by Roland M. Crocker (Australia National University, Australia). Radio polarization observations by the Parkes radio telescope in Australia have recently led to the discovery of these giant radio lobes emanating from the Galactic nucleus. These lobes are largely coincident with the Fermi Bubbles discovered in gamma-ray domain. However, the radio outflows extend to even larger angular scales, covering about 55 to 60 degrees north and south of the Galactic plane. It is likely that the radio lobes – and the Fermi Bubbles – are the result of the concentrated star formation occurring in the Central Molecular Zone of the Milky Way rather than signatures of putative activity of the super-massive black hole.

2. - Low Luminosity Galactic Nuclei

The nucleus of our Galaxy has an extremely low luminosity. Although it also demonstrates that violent activities may take place at times. Hence, a comparison between the centre of the Milky Way and the nuclei of galaxies hosting Low Luminosity Active Galactic Nuclei (LLAGN) appears to be imperative. Santiago G. Burillo discussed the footprints of AGN feeding and feedback in LLAGN. The study of the content, distribution and kinematics of interstellar gas is a key to understand the fueling of AGN and star formation activity in galaxy disks. Current mm-interferometers provide a sharp view of the distribution and kinematics of molecular gas in the circumnuclear disks of galaxies through extensive mapping of molecular line. The use of molecular tracers specific to the dense gas phase can probe the feedback influence of activity on the chemistry and energy balance in the interstellar medium of galaxies. Modern mm-interferometers permit the study of the mechanisms responsible for fueling AGN and star formation activity in the central R<1 kpc disks of an active galaxy at 10-100 pc scale. This study has revealed streaming motions towards and away from the nuclear region that do not necessarily have to be co-phased with current AGN activity. These phenomena are directly coupled to black-hole fuelling, feedback and duty cycles as summarized by Carole Mundell (LJMU University, Liverpool, United Kingdom). The distribution of gas and stars in nearby galaxies traced by 3-D studies of molecular, neutral and ionised gas provide a unique view of the role of the multi-phase medium in triggering and fuelling nuclear activity in galactic nuclei on size scales ever closer to the central black hole. It has been suggested that the variability observed in nearby radio-quiet AGN might provide parallels to our own Galactic Centre. They also provide evidence that AGN duty cycles may be shorter than previously thought.

3. - Black Hole Laboratory Theory and Instrumentation

In addition, it is time to review the current state of theoretical efforts. Emphasis was given to the implications for our understanding of the feeding mechanism of Black Holes, the accretion phenomenon and the physical nature of the event horizon. The conference therefore also was dedicated to reviewing the most recent findings on star formation, properties of the ISM, magnetic fields, and stellar structure, kinematics, and dynamics near massive black holes. An improved link between theory and observations will be provided by new and upcoming instrumentation such as the future capability of measuring polarization in the X-ray domain and direct imaging of the event horizon region for e.g. M87 as a representative of the largest super massive black holes, and SgrA* as a representative for the so far smallest known super massive black holes.

Picture of the Conference:



Participants: They were coming from many European and American institutions (see attendance list). Around 30% of the participants were women. There was a significant number of talks given by PhD students or young Post-docs (e.g. Monica Moscibrodzka, Naden Sabha, Anja Feldmeier, Anna Boehle, Ralph Eatough, Devaky Kunneriath, between others).

3. Attendance list (incl. participant names, affiliation and country) signed by the participants and confirmed by the organizer

See attached document.

4. Financial Report / RadioNet3 contribution

The Galactic Centre Black Hole Laboratory in Granada, Nov. 19-22, 2013 has been organized by the COST Action MP0905 "Black Holes in a Violent Universe". The conference has also been supported by and linked to the COST Action MP1104 - "Polarization as a tool to study the Solar System and Beyond", the FP7 action "Probing Strong Gravity by Black Holes Across the Range of Masses", and the collaborative research centre SFB956 "Conditions and Impact of Star Formation -Astrophysics, Instrumentation and Laboratory Research".

The conference has also been supported by **RadioNet3**. We have received 1000 Euros and we have used them to cover part of the cost of the conference dinner (it was held on Thursday, November 21, 2013).

5. Conference Proceedings and Web page

It is our intention to include the presentations (for those ones whose permission has been given by the speaker) in our web page <http://galacticcenter.iaa.es>.

List of participants

Iván Agudo	Joint Institute for VLBI in Europe (Netherlands)	agudo@jive.nl
Danor Aharon	Technion - Israel Institute of Technology (Israel)	danor@tx.technion.ac.il
Kazunori Akiyama	University of Tokyo (Japan)	kazunori.akiyama@nao.ac.jp
Antxon Alberdi	IAA-CSIC (Spain)	antxon@iaa.es
Sonia Anton	SIM-FCUL (Portugal)	santon@fc.ul.pt
Miguel Batista	Physics Department-Roraima Federal University (Brazil)	campos@on.br
Anna Boehle	UCLA (USA)	aboehle@astro.ucla.edu
Thomas Boller	MPE Garching (Germany)	bol@mpe.mpg.de
Abhijeet Borkar	I. Physikalisches Institut, Universität zu Köln (Germany)	borkar@ph1.uni-koeln.de
Silke Britzen	Max-Planck-Institut für Radioastronomie (Germany)	sbritzen@mpifr.de
Xavier Calmet	University of Sussex (UK)	x.calmet@sussex.ac.uk
Miguel Campos	Physics Department-Roraima Federal University (Brazil)	campos@on.br
Ross Church	Dept. Astronomy and Theoretical Physics, Lund University (Sweden)	ross@astro.lu.se
Francesco Costagliola	IAA-CSIC (Spain)	costagli@iaa.es
Roland Crocker	Australian National University (Australia)	rcrocker@fastmail.fm
Michał Dovciak	Astronomical Institute, Academy of Sciences (Czech Republic)	dovciak@asu.cas.cz
Ralph Eatough	Max-Planck-Institut für Radioastronomie (Germany)	reatough@mpifr-bonn.mpg.de
Andreas Eckart	I. Physikalisches Institut, Universität zu Köln (Germany)	eckart@ph1.uni-koeln.de
Heino Falcke	Radboud University Nijmegen (NL) / ASTRON (NL) / MPFR Bonn (DE)	h.falcke@astro.ru.nl
Anja Feldmeier	ESO (Germany)	afeldmei@eso.org
Lachezar Filipov	Space and Technology Research Institute (Bulgaria)	lfilipov@space.bas.bg
Raquel Fraga-Encinas	Radboud University Nijmegen (Netherlands)	r.fraga@astro.ru.nl
Santiago García-Burillo	Observatorio Astronómico Nacional (Spain)	s.gburillo@oaan.es
Arne Grenzebach	ZARM, University of Bremen (Germany)	arne.grenzebach@zarm.uni-bremen.de
Nicolas Grossos	Observatoire Astronomique de Strasbourg (France)	nicolas.grosso@astro.unistra.fr
Jaroslav Haas	Charles University in Prague (Czech Republic)	haas@sirrah.troja.mff.cuni.cz
Rubén Herrero-Illana	IAA-CSIC (Spain)	herrero@iaa.es
Murat Hüdaverdi	Yildiz Technical University (Turkey)	murat.hudaverdi@gmail.com
Behrang Jalali	I. Physikalisches Institut, Universität zu Köln (Germany)	bjalali@ph1.uni-koeln.de
Agnieszka Janiuk	Center for Theoretical Physics, Polish Academy of Sciences (Poland)	agnes@cfi.edu.pl
Jens Juel Jensen	Dark Cosmology Centre, University of Copenhagen (Denmark)	juel@dark-cosmology.dk
Vladimir Karas	Astrophysical Institute, Academy of Sciences (Czech Republic)	vladimir.karas@cuni.cz
Grischa KarsSEN	I. Physikalisches Institut, Universität zu Köln (Germany)	gkarssen@ph1.uni-koeln.de
Laurens Katgerman	DC Rapporteur (Netherlands)	l.katgerman@tudelft.nl
Claus Kiefer	University of Cologne (Germany)	kiefer@thp.uni-koeln.de
Michael Kramer	Max-Planck-Institut für Radioastronomie (Germany)	mkramer@mpifr.de

Devaky Kunneriath	Astronomical Institute, Academy of Sciences (Czech Republic)	devaky@astro.cas.cz
Greg Madsen	Institute of Astronomy, University of Cambridge (UK)	gmadsen@ast.cam.ac.uk
Minnie Mao	National Radio Astronomy Observatory (USA)	mmao@nrao.edu
Isabel Márquez	IAA-CSIC (Spain)	isabel@iaa.es
Josefa Masegosa	IAA-CSIC (Spain)	pepa@iaa.es
Alessandra Mastrobuono-Battisti	Technion - Israel Institute of Technology (Israel)	amastrobuono@physics.technion.ac.il
Lucio Mayer	University of Zurich (Czech Republic)	lucio@phys.ethz.ch
Ivan Milic	Astronomical Observatory Belgrade (Serbia) / Lagrange Laboratory (France)	milic@aob.rs
Monika Moscibrodzka	Radboud University Nijmegen (Netherlands)	m.moscibrodzka@astro.ru.nl
Emmanuelle Mossoux	Observatoire Astronomique de Strasbourg (France)	emmanuelle.mossoux@astro.unistra.fr
Carole Mundell	ARI, Liverpool John Moores University (UK)	cgm@astro.livjm.ac.uk
Hiroshi Murakami	Tohoku Gakuin University (Japan)	hiro_m@izcc.tohoku-gakuin.ac.jp
Shogo Nishiyama	National Astronomical Observatory of Japan (Japan)	shogo.nishiyama@nao.ac.jp
Volker Perlick	ZARM, University of Bremen (Germany)	perlick@zarm.uni-bremen.de
Luka Popovic	Astronomical Observatory Belgrade (Serbia)	lpopovic@aob.rs
Delphine Porquet	Observatoire Astronomique de Strasbourg (France)	delphine.porquet@astro.unistra.fr
Mónica Rodríguez	IAA-CSIC (Spain)	mrm@iaa.es
Eduardo Ros Ibarra	Max-Planck-Institut für Radioastronomie (Germany)	ros@mpifr-bonn.mpg.de
Anthony Rushton	University of Oxford & Southampton (UK)	anthony.rushton@soton.ac.uk
Nadeen Sabha	I. Physikalisches Institut, Universität zu Köln & MPIfR Bonn (Germany)	sabha@ph1.uni-koeln.de
Jimit Sanghvi	University of Turku (Finland)	alone26287@gmail.com
Banafsheh Shahzamanian	I. Physikalisches Institut, Universität zu Köln & MPIfR Bonn (Germany)	shahzaman@ph1.uni-koeln.de
Lorant Sjouwerman	National Radio Astronomy Observatory (USA)	lsjouwer@nrao.edu
Lyuba Slavcheva-Mihova	Institute of Astronomy and National Astronomical Observatory (Bulgaria)	lslav@astro.bas.bg
Paolo Sofitta	IAPS/INAF (Italy)	pao.lo.soffita@iaps.inaf.it
Marko Stalevski	Astronomical Observatory of Belgrade (Serbia)	mstalevski@aob.rs
Zdenek Stuchlik	Silesian University at Opava (Czech Republic)	zdenek.stuchlik@fpf.slu.cz
Petra Suková	Center for Theoretical Physics, Polish Academy of Sciences (Poland)	psukova@cft.edu.pl
Takeshi Tsuru	Cosmic Ray Group, Physics, Kyoto University (Japan)	tsuru@cr.scphys.kyoto-u.ac.jp
Ulf Torkelsson	Department of Physics, University of Gothenburg (Sweden)	torkel@physics.gu.se
Merja Tornikoski	Aalto University Metsähovi Radio Observatory (Finland)	merja.tornikoski@aalto.fi
Marianne Vestergaard	Dark Cosmology Centre, University of Copenhagen (Denmark)	vester@dark-cosmology.dk
Gunther Witzel	UCLA (USA)	witzel@astro.ucla.edu
Farhad Yusef-Zadeh	Northwestern University (USA)	zadeh@northwestern.edu
Michal Zajáček	Charles University in Prague (Czech Republic)	michal_zajacek@yahoo.com
Kastytis Zubovas	Centre for Physical Sciences and Technology (Lithuania)	kastytis.zubovas@ftmc.lt

Program GC 2013, Granada

Tuesday, November 19th

09:00	Registration at IAA patio	
10:00	José M. Vilchez IAA director	Welcome
10:05	Antxon Alberdi, Andreas Eckart	Opening remarks
		Sgr A*
10:10	Delphine Porquet Observatoire Astronomique de Strasbourg (France)	X-ray properties of the Galactic center
10:45	Hiroshi Murakami Tohoku Gakuin University (Japan)	Weekly Monitoring of Sgr A* with the X-ray Satellite "Suzaku"
11:05	Thomas Boller MPE Garching (Germany)	Predicting pictures from black holes using ray-tracing in GR and pc-GR
11:25 - 11:45	<i>Coffee Break</i>	
11:45	Banafsheh Shahzamanian I. Physikalisches Institut (Germany)	NIR polarization of SgrA*
12:05	Kazunori Akiyama University of Tokyo (Japan)	Long-term monitoring of Sgr A* at 43GHz with VERA and KVN+VERA
12:25	Heino Falcke Radboud University Nijmegen (NL), ASTRON (NL), MPIfR Bonn (DE)	Is Sgr A* jet-lagged?

12:45	Gunther Witzel UCLA (USA)	NIR variability of SgrA*
13:05 - 14:15	Lunch break	
14:15	Iván Agudo Joint Institute for VLBI in Europe (Netherlands)	Tracing changes in Sgr A*'s accretion flow through Faraday rotation measures at 1mm with the IRAM 30m Telescope
14:35	Monika Moscibrodzka Radboud University Nijmegen (Netherlands)	A coupled jet-disk model for Sgr A*: explaining the flat-spectrum radio core with GRMHD simulations of jets
14:55	Grischa KarsSEN I. Physikalisches Institut (Germany)	Modeling the variable near-infrared emission from SgrA* with an orbiting hotspot
15:15	Shogo Nishiyama NAOJ (Japan)	Large Scale Magnetic Field Configuration in the Galactic Center
15:35	Tsuru Takeshi Go Department of Physics, Kyoto University (Japan)	X-ray Study of 3-D View of the Galactic Center Region and 1000-yr Activity History of Sagittarius A*
15:55 - 16:15	Coffee break	G2/DSO
16:15	Lorant Sjouwerman NRAO (USA)	NRAO VLA monitoring of the interaction of SgrA* and the gas cloud
16:50	Andreas Eckart I. Physikalisches Institut (Germany)	The DSO and other dusty objects close to SgrA*
17:10	Michal Zajaček Charles University in Prague (Czech Republic)	Encounter of a dust cloud with supermassive black hole: Predictions for high-eccentricity passages near galactic nuclei

Wednesday, November 20th

GC environment stellar

09:30	Farhad Yusef-Zadeh Northwestern University (USA)	Star Formation Activity in the the Galactic Center
10:05	Nadeen Sabha I. Physikalisches Institut (Germany)	The central stellar cluster in the infrared
10:25	Vladimir Karas Astronomical Institute, Academy of Sciences (Czech Republic)	The orbital interaction between stars and a SMBH surrounded by a massive accretion torus
10:45	Ross Church Lund University (Sweden)	Stellar Collisions at the Galactic Centre
11:20 - 11:45	<i>Coffee break</i>	The Milky Way Nuclear Star Cluster Beyond 1 pc
11:45	Anja Feldmeier ESO (Germany)	The Galactic Center: the nuclear star cluster formation and evolution
12:05	Alessandra Mastrobuono-Battisti Technion-Israel Institute of Technology (Israel)	New Orbital Analysis of Stars at the Galactic Center Using Speckle Holography
12:25	Anna Boehle UCLA (USA)	
12:45 - 14:00	<i>Lunch break</i>	Two-body relaxation of thin stellar discs around SMBHs
14:00	Jaroslav Haas Charles University in Prague (Czech Republic)	The Galactic Center Black Hole Laboratory
14:20	Michael Kramer Max Planck Institut für Radioastronomie (Germany)	

14:55	Ralph Eatough Max Planck Institut für Radioastronomie (Germany)	Radio observations of PSR J1745-2900, a magnetar in the Galactic Centre.
15:15	Danor Aharon Technion-Israel Institute of Technology (Israel)	The evolution of stellar populations in galactic nuclei
15:35	Behrang Jalali University of Cologne (Germany)	Star Formation Close to Sgr A*
15:55 - 16:15	<i>Coffee break</i>	
		BH Physics
16:15	Xavier Calmet University of Sussex (UK)	Self-healing of Higgs inflation model
16:35	Claus Kiefer University of Cologne (Germany)	Black holes as open quantum systems
16:55	Petra Sukova Center for Theoretical Physics (Poland)	Chaos in geodesic flow in black-hole-disc system: computation of FLI and MEGNO
17:15	Devaky Kunneriath Astronomical Institute, Academy of Sciences (Czech Republic)	Inducing the activity of the Galactic centre by repetitive accretion episodes

Thursday, November 21st

GC environment non-stellar

09:30	Roland Crocker Australian National University (Australia)	The Giant Magnetized Outflows from the Galactic Centre
10:05	Kastytis Zubovas Centre for Physical Sciences and Technology (Lithuania)	Sgr A* activity shapes the Central Molecular Zone
10:25	Greg Madsen Institute of Astronomy, University of Cambridge (UK)	Fossil imprint of a powerful flare at the Galactic Centre along the Magellanic Stream
10:45 - 11:15	<i>Coffee break</i>	Extragalactic
11:15	Santiago García-Burillo Observatorio Astronómico Nacional (Spain)	The Footprints of AGN Feeding and Feedback in LLAGNs
11:50	Carole Mundell ARI, Liverpool John Moores University (UK)	Black-hole fuelling, feedback and duty cycles
12:25	Isabel Márquez Instituto de Astrofísica de Andalucía - CSIC (Spain)	X-ray Variability of LINERs
12:45 - 14:00	<i>Lunch break</i>	Self-organization processes in accretion disks
14:00	Lachezar Filipov Space and Technology Research Institute (Bulgaria)	Modeling black hole mergers in long gamma ray bursts
14:20	Agnieszka Janiuk Center for Theoretical Physics (Poland)	

14:40 Luka Popovic
Astronomical Observatory Belgrade (Serbia)
Super-massive black hole estimates using spectro-polarimetric observations

Instrumentation

15:00 Paolo Soffitta
IAPS/INAF (Italy)
X-ray polarimetry as diagnostic tool of the past activity of Sgr A*

15:20 Eduardo Ros
Max Planck Institut für Radioastronomie (Germany)
Black hole high-resolution science with phased ALMA

15:40 - 16:00 *Coffee break*

16:00 Conference Summary

18:30 *Live video cast of talk by Sir Roger Penrose
from MPfIR (Germany)*
**Are we Seeing Signals from Before the Big Bang?
Recent results from WMAP and Planck**

21:00 *Conference dinner*
Restaurante El Claustro; Hotel AC Santa Paula
Gran Vía de Colón, Granada.