The Galactic Center
Black Hole Laboratory

Instituto de Astrofísica de Andalucía (IAA-CSIC)

Granada, Nov. 19-21, 2013

Universität zu Köln
Mathematisch-Naturwissenschaftliche Fakultät
Fachgruppe Physik
I. Physikalisches Institut

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Program GC 2013, Granada

Tuesday, November 19th

09:00	Registration at IAA patio	
10:00	José M. Vílchez 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	*Coffee Break*	
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	*Coffee break*	
11:45	Anja Feldmeier ESO (Germany)	The Milky Way Nuclear Star Cluster Beyond 1 pc
12:05	Alessandra Mastrobuono-Battisti Technion-Israel Institute of Technology (Israel)	The Galactic Center: the nuclear star cluster formation and evolution
12:25	Anna Boehle UCLA (USA)	New Orbital Analysis of Stars at the Galactic Center Using Speckle Holography
12:45 - 14:00	*Lunch break*	
14:00	Jaroslav Haas Charles University in Prague (Czech Republic)	Two-body relaxation of thin stellar discs around SMBHs
14:20	**Michael Kramer** **Max Planck Institut für Radioastronomie (Germany)**	**The Galactic Center Black Hole Laboratory**

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	*Coffee break*	

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 Insitute of Astronomy, University of Cambridge (UK)	Fossil imprint of a powerful flare at the Galactic Centre along the Magellanic Stream
10:45 - 11:15	*Coffee break*	

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	*Lunch break*	
14:00	Lachezar Filipov Space and Technology Research Institute (Bulgaria)	Self-organization processes in accretion disks
14:20	Agnieszka Janiuk Center for Theoretical Physics (Poland)	Modeling black hole mergers in long gamma ray bursts

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 MPIfR (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.

Talks

Session: SgrA*

Delphine Porquet (Observatoire Astronomique de Strasbourg, France)

X-ray properties of the Galactic center

I will review the present knowledge about the X-ray properties of the Galactic center that is one of the most richest regions of the sky hosting numerous astrophysical objects such as stars, X-ray binaries, supernovae remnants, non-thermal filaments, molecular clouds and last but not least the closest supermassive black hole. Sgr A* with a mass of about 4 millions solar masses is extremely faint, though a level of activity has been revealed through the detection of flares. Therefore, SgrA* is the ideal target to investigate the accretion and ejection physics in the case of extremely low accretion rate onto a supermassive black hole where black holes are thought to spend most of their lifetime, its impact on its neighborhood, and its history over cosmic time.

Hiroshi Murakami (Department of Information Science, Faculty of Liberal Arts, Tohoku Gakuin University, Japan)

Weekly Monitoring of Sgr A with the X-ray Satellite "Suzaku"*

With Suzaku, we will carry out the X-ray monitoring of the supermassive blackhole Sgr A* in the 0.4--80 keV band. A small gas cloud, G2, is on an orbit almost straight into Sgr A* by 2014. This event gives us a rare opportunity to test the mass feeding onto the blackhole by a gas. We then try five weekly monitoring with a 20 ksec each observation in the 2013 September and 2014 Spring window. In this conference, we will present a look of the first five observations.

Thomas Boller (MPE Garching, Germany)

Predicting pictures from black holes using ray-tracing in GR and pc-GR

Einstein's General Relativity (GR) invented 100 years ago successfully describes gravitation. An algebraic extension of GR to pseudo-complex (pc) variables has been proposed, called pseudo-complex General Relativity (pc-GR). One of the important consequences of pc-GR theory is the presence of a field with repulsive properties. This has the effect that for very large masses the gravitational collapse is stopped and something what we call a “gray star” is formed instead of a black hole. When applied to the Friedmann-Lemaitre-Robertson-Walker model of the Universe, pc-GR results in a finite or vanishing acceleration of the Universe for very large times. We are currently performing ray-tracing simulations based on the pc-GR theory for Sgr A* and M87 for different accretion scenarios and viewing angles for the observer.

Banafsheh Shahzamanian (I. Physikalisches Institute, University of Cologne, Max Planck Institute for Radioastronomy, Germany)

*NIR polarization of SgrA**

We present an overview of polarized near-infrared (NIR) observations of Sagittarius A* (SgrA*) which is associated with the super massive black hole at the center of the Milky Way. The observations have been carried out using NACO adaptive optics instrument at the VLT(ESO) and CIAO NIR camera on the Subaru telescope (from 2004 to 2012). We will present several polarized flares that have been observed during these observations and for the first time will present the statistical properties of NIR polarization of SgrA*. Linear polarization at 2.2 micron and its variations can help us to constrain the physical conditions of the accretion process around this SMBH.

Kazunori Akiyama (University of Tokyo, Japan)

Long-term monitoring of Sgr A* at 43GHz with VERA and KVN+VERA

We present the results of radio monitoring observations of Sgr A* at 43 GHz with VERA, which is a VLBI array in Japan. VERA and KVN+VERA (combined array with Korean VLBI Network) provides angular resolutions on millisecond scales and enables to have a look at structure within ~100 Schwarzschild radii of Sgr A* as well as VLBA. We performed multi-epoch observations of Sgr A* in 2005 - 2008, and started to monitor it again with VERA and KVN+VERA from Jan. 2013 for tracing the current G2 encounter event. We report the results of observations in 2005-2008 (Akiyama et al. 2013, PASJ in press.), and then the preliminary results of a monitor with an interval of 3 weeks started from January 2013.

Heino Falcke (Radboud University Nijmegen (NL)/ASTRON (NL)/MPIfRA Bonn (DE), The Netherlands)

Is Sgr A jet-lagged?*

Sgr A* in the Galactic Center is by now the best constrained supermassive black hole candidate we know, yet there is still some debate where its radio emission actually originates. Does it come from a relativistic outflow or from the accretion flow? Here we present the first ever joint ALMA (Cycle 0) + VLA observations of Sgr A*, which can address this particular question. One concrete predictions of the jet model is that flares should travel from high to low frequencies, since higher frequencies are generated closer to the black hole. Earlier VLA observations had already found that there is a time lag of ~20 minutes between flares observed at 43 and 22 GHz, consistent with an outflow. We have now observed Sgr A* for one 8 hr track quasi-simulatenously at up to 9 frequency bands between 18 and 350 GHz, thereby frequently switching between frequencies. As expected, the average spectrum of Sgr A* is inverted with a turnover to optically thin emission around 300 GHz. Although Sgr A* only showed a weak flare during the observing period, we are able to trace this flare from 100 GHz down to 18 GHz with a frequency-dependent lag up to one hour between 100 GHz and 18 GHz. The lag-frequency relation, combined with VLBI sizes, is indeed nicely consistent with a relativistic outflow and confirms the previously established 42-22 GHz lag. A trend towards mild acceleration is also present in the data, but needs further confirmation. Spectrum and lags are readily explained by a moderately relativistic jet, such as those seen in recent GRMHD simulations of Sgr A*. In addition we also present the first 100 GHz ALMA image of Sgr A West, which, however, holds no major surprises.

Gunther Witzel (UCLA, California, USA)

NIR variability of SgrA*

We discuss recent synchronous observations of Sgr A* with NIRC2@KECKII and OSIRIS@KECKI in L'-band and H-band, respectively. These observations represent the first truly synchronous high cadence dataset to test for time variability of the spectral index within the near infrared. We discovered a time-variable time lag between both bands. Furthermore, these high cadence data show effects on time scales as short as 20 seconds. We discuss the significance of both findings in the framework of a rigorous statistical model of the variability and explore possible physical explanations.

Iván Agudo (Joint Institute for VLBI in Europe, The Netherlands)

Tracing changes in Sgr A*'s accretion flow through Faraday rotation measures at 1mm with the IRAM 30m Telescope

During the first semester of 2012, we performed an intense 1mm monitoring program of the polarimetric, and total flux, evolution of Sgr A* and its surrounding swith the IRAM 30m Millimeter Radio Telescope. To cover the predicted interaction of the G2 gas cloud with Sgr A*, we restarted our monitoring program from June 2013 to observe also at 3mm and with a time sampling of one week. Our observing set-up builds on the dual sideband (with ~20 GHz separation) feature of the EMIR receiver set and the capability of the VESPA auto-correlator to be split in two sections in polarimetry mode. Therefore, our monitoring program allows us to perform a high-sensitivity study of the time dependent changes of the Faraday rotation in the vicinity of Sgr A* both between our two different spectral windows (at about 1 and 3mm), and within each one of them (on sub-bands separated ~20GHz each other). Changes of Faraday rotation reflect changes in the electron content and magnetic field intensity and orientation on the line of sight from the source. This is expected if a dense cloud of gas would cross the line of sight on its closest approach to Sgr A*. In this talk we will summarize the observing results obtained from our monitoring program so far.

Monika Moscibrodzka (Radboud University Nijmegen, The Netherlands)

A coupled jet-disk model for Sgr A: explaining the flat-spectrum radio core with GRMHD simulations of jets*

The supermassive black hole in the center of the Milky Way, Sgr A*, displays a nearly flat radio spectrum which is typical for jets in Active Galactic Nuclei. Indeed, time-dependent, magnetized models of radiatively inefficient accretion flows, which are commonly used to explain the millimeter, near-infrared, and X-ray emission of Sgr A* also often produce jet-like outflows. However, the emission from these models so far has failed to reproduce the flat radio spectrum. We show that current GRMHD simulations can naturally reproduce the flat spectrum, when using a two-temperature plasma in the disk and a constant electron temperature plasma in the jet. This assumption is consistent with current state-of-the art simulations, in which the electron temperature evolution is not explicitly modeled. Stronger magnetization and stronger shearing seen in the jet sheath could possibly explain the difference in electron heating between jet and disk.

Grischa Karssen (Physikalisches Institut der Universität zu Köln, Germany), Grischa Karssen (1), Michal Bursa (2), Andreas Eckart (1,3), Monica Valencia-S. (1), Michal Dovciak (2), and Vladimir Karas (2)

1. I.Physikalisches Institut, Universitaet zu Koeln; 2. Astronomical Institute, Czech Academy of Sciences; 3. Max-Planck-Institut fuer Radioastronomie

Modeling the variable near-infrared emission from SgrA* with an orbiting hotspot

The near-infrared (NIR) emission of Sagittarius A* (Sgr A*), the source associated with the supermassive black hole at the center of our galaxy, is polarized and highly variable. Correlations between intensity and polarimetric parameters of the observed light curves compared with the predicted ones for different configurations, allow us to extract information about the geometry of the radiating region. We assume that the flux variation in the light curves is produced by overdense regions orbiting close to the marginal stable orbit, and use numerical simulations to trace the emission from the disk to the observer in a Kerr spacetime. Here I present a report on the progress of the numerical code. In particular, I compare the predicted polarization signatures from hot spots with and without taking secondary and tertiary photons into account."

Shogo Nishiyama (National Astronomical Observatory of Japan, Japan)

Large Scale Magnetic Field Configuration in the Galactic Center

We present a large-scale view of the magnetic field (MF) in the central 3deg x 2deg region of our Galaxy. The polarization of point sources has been measured in the J, H, and Ks bands using the near-infrared polarimetric camera SIRPOL on the 1.4 m Infrared Survey Facility telescope. Comparing the Stokes parameters between high extinction stars and relatively low extinction ones, we obtain polarization originating from magnetically aligned dust grains in the central few hundred parsecs of our Galaxy. We find that near the Galactic plane, the MF is almost parallel to the Galactic plane (i.e., toroidal configuration), but at high Galactic latitudes (| b | > 0.4deg) the field is nearly perpendicular to the plane (i.e., poloidal configuration). This is the first detection of a smooth transition of the large-scale MF configuration in this region.

Tsuru Takeshi Go (Cosmic Ray Group, Physics, Kyoto Unversity, Japan)

*X-ray Study of 3-D View of the Galactic Center Region and 1000-yr Activity History of Sagittarius A**

The diffuse X-ray emission from the Galactic center region is characterized by helium like iron K emission line (6.7-keV line) originated in high temperature plasmas and neutral iron K emission line (6.4-keV line) from the giant molecular clouds (GMCs) such as Sgr B2. The distribution of the 6.4-keV line is clumpy and generally traces the distribution of molecular clouds. The 6.4-keV line shows the large equivalent width of ~1 keV and time variability. These results suggest photo-ionization process in GMCs irradiated by external X-ray sources. No source bright enough to power the 6.4-keV line is found. Sgr A* is the only capable source. Thus, the 6.4-keV line emission observed at present in the GMCs is the reflection of the past activities of Sgr A*. On the other hand, the 6.7-keV line emission has few distinctive structures, suggesting that the high temperature plasmas have smooth distribution in the Galactic center region. Assuming a GMC is located on the near side of the Galactic center region in the line of sight, it absorbs a significant part of the soft X-ray emission from the high temperature plasmas on the far side. On the other hand, a GMC on the far side has small affect on the plasma emission. Thus, absorption structures of the X-ray spectrum of the high temperature plasmas allow us to determine the line of sight postion of GMCs. Applying this method, we successfully determined the 3-D positions of GMCs in the Sgr B, C, D and E regions. From the 3-D positions and masses of the GMCs and their luminosities of 6.4-keV line emission, we obtained the light curves of Sgr A* for the last 50-600 years. The X-ray luminosity was estimated to be 1-3 x10^39 ergs/s.

Session: G2/DSO

Lorant Sjouwerman (National Radio Astronomy Observatory (NRAO), USA)

NRAO VLA monitoring of the interaction of Sgr A and the gas cloud*

We report on an ongoing community service observing program to follow the expected encounter of the G2 cloud with the black hole Sgr A* in 2013. The NRAO Karl G. Jansky Very Large Array (VLA) has been observing the Sgr A region since 2012 October on roughly a bi-monthly interval, each for two hours, cycling through eight observing bands at their default continuum frequencies, using 2 GHz of bandwidth. We will discuss the strengths and weaknesses of observing with the VLA, the data reduction, and the latest results. The data from the monitoring program are publicly available through the NRAO data archive immediately after observing has completed, and the flux densities are published by NRAO staff as soon as the data are reduced. The cumulative results of the monitoring effort are posted on the service observing web page https://science.nrao.edu/science/service-observing.

Andreas Eckart (I. Physikalisches Institut, University of Cologne, Germany)

*The DSO and other dusty objects close to SgrA**

A fast moving infrared excess source (G2) which is widely interpreted as a core-less gas and dust cloud approaches SgrA* on a presumably elliptical orbit.

Here we present NIR K- and L-band observations of this source and put it into context with other dusty sources at the Galactic Center. The K'-band data for G2 result in clear continuum identifications and proper motions of this ~19m dusty S-cluster object (DSO). In 2002-2007 it is confused with star S63, but free of confusion again since 2007. Its NIR colors and a comparison to other sources in the field imply that it could rather be an IR excess star with photospheric continuum emission at 2 microns than a core-less gas and dust cloud. Also we find very compact L'-band emission (<0.1") contrasted by the reported extended ($\sim$0.2") Brγ emission. The presence of a star will change the expected accretion phenomena, since a stellar Roche lobe may retain much of the material during and after the peri-bothron passage.

In addition we will report on our VLT, APEX monitoring results of SgrA* in 2013.

Michal Zajaček (Charles University in Prague, Astronomical Institute of the Academy of Sciences of the Czech Republic)

Encounter of a dust cloud with supermassive black hole: Predictions for high-eccentricity passages near galactic nuclei

Supermassive black holes reside in galactic cores, where they are surrounded by a nuclear star cluster and clumpy tori with a significant dust content. Mutual collisions can set some of the dust clumps on a highly eccentric plunging trajectories towards the black hole.

We model the outcome of the pericenter passage of a dust cloud, as it is tidally destroyed and partially accreted. We confine our attention on the dust component of the in-falling clouds and develop a simplified scheme to treat the cloud interaction with the supermassive black hole and its diluted gaseous environment. We also discuss the differences between core-less clouds and those hosting a star inside. To this end we employ the modification of the Swift code.

We determine the fraction of dust mass that is accreted on the first and the second passages through the pericenter and we find that, for realistic values of the model parameters, more than 90% is torn away from the star during the first passage. During subsequent passages, the mass bound to the star remains approximately constant inside the Roche lobe unless there is an efficient mechanism of dust supply.

We give examples of the cloud evolution for which we employ the orbital parameters of the current G2/DSO object in the Galactic Center.

Session: GC environment stellar

Farhad Yusef-Zadeh (Northwestern University, USA)

Star Formation Activity in the Galactic center

Infrared observations show compelling evidence that massive stars were formed in the hostile environment of Sgr A* a few million years ago. I will present VLA, ALMA and CARMA measurements also suggest that on-going star formation near Sgr A* and the circumnuclear molecular ring in the last 10^5 years. I will then discuss how stars are formed near Sgr A* in the context of the passage of a giant molecular cloud interacting with Sgr A*. A fraction of the material associated with the gaseous disk will accrete onto Sgr A* and may be responsible for the origin of the gamma-ray Fermi bubbles.

Nadeen Sabha (I. Physikalisches Institut, University of Cologne & MPIfR Bonn, Germany)

The central stellar cluster in the infrared

In this talk I will summarize our recent results on the S-star cluster. We investigate the distribution of the diffuse background emission and the stellar number density counts around the central black hole. This allows us to determine the stellar light and mass contribution that can be expected from the faint members of the cluster. We then use post-Newtonian Nbody techniques to investigate the effect of stellar perturbations on the motion of S2, as a means of detecting the number and masses of the perturbers. In addition, I will discuss our recent finding of an MIR convex-like feature at a distance of ~0.68 pc from the center where the supermassive black hole, Sgr A*, lies. This feature resembles a stellar bowshock with a symmetry axis pointing to the center of the cluster.

Vladimir Karas (Astronomical Institute, Academy of Sciences, Czech Republic) and Ladislav Subr (Charles University Prague, Czech Republic)

The orbital interaction between stars and a SMBH surrounded by an accretion disc

We report an update of our modelling work on a self-gravitating accretion disc or a torus around a supermassive black hole. Our main objective is to demonstrate that interaction of nuclear stars with the gaseous/dusty disk can increase the rate of gradual orbital decay of stellar trajectories by setting some stars on eccentric trajectories. Cooperation between the gravitational field of the disc and the dissipative environment can provide a mechanism explaining the origin of stars that become bound tightly to the central black hole. We examine this process as a function of the black hole mass and conclude that it is most efficient at the lower end of SMBH mass interval. Members of the cluster experience the stage of orbital decay via collisions with the accretion disc and by other dissipative processes, such as tidal effects, dynamical friction and the emission of gravitational waves. Mutual interaction between stars and the surrounding environment establishes a non-spherical shape and anisotropy of the nuclear cluster. In some cases, the stellar sub-system acquires a ring-type geometry. Stars of the nuclear cluster undergo a tidal disruption event as they plunge below the tidal radius of the supermassive black hole.

Ross Church (Dept. Astronomy and Theoretical Physics, Lund University, Sweden)

Stellar Collisions at the Galactic Centre

Observations of the stars at the Galactic Centre show that there is a lack of red giants within about 0.5 pc of the super-massive black hole. The very high stellar number densities this close to the SMBH imply that the giants-- or their progenitors -- may have been destroyed by stellar collisions. I will review the expected rates of collisions between different types of stars at the Galactic Centre and their likely effects, and attempt to quantify how large a contribution stellar collisions could make to the puzzle of the missing red giants.

Anja Feldmeier (ESO, Germany)

The Milky Way Nuclear Star Cluster Beyond 1 pc

Within the central 10pc of our Galaxy lies a dense cluster of stars, the nuclear star cluster, forming a distinct component of our Galaxy. Nuclear star clusters are common objects and are detected in 75% of nearby galaxies. It is, however, not fully understood how nuclear clusters form. Because the Milky Way nuclear star cluster is at a distance of only 8 kpc, we can spatially resolve its stellar populations and kinematics much better than in external galaxies. This makes the Milky Way nuclear star cluster a reference object for understanding the structure and assembly history of all nuclear star clusters.

We have obtained an unparalleled data set using the near-infrared long-slit spectrograph ISAAC (VLT) in a novel drift-scan technique to construct an integral-field spectroscopic map of the central 10x8 pc of our Galaxy. To complement our data set we also observed fields out to a distance of 19 pc along the Galactic plane to disentangle the influence of the nuclear stellar disk. From this data set we extract a stellar kinematic map using the CO bandheads and an emission line kinematic map using H2 emission lines. Using the stellar kinematics, we set up a kinematic model for the Milky Way nuclear star cluster to derive its mass and constrain the central Galactic potential. Because the black hole mass in the Milky Way is precisely known, this kinematic data set will also serve as a benchmark for testing black hole mass modelling techniques used in external galaxies.

Alessandra Mastrobuono-Battisti (Technion-Israel Institute of Technology, Israel)

The Galactic Center: the nuclear star cluster formation and evolution

Nuclear stellar clusters (NSCs) are known to exist around massive black holes (MBHs) in galactic nuclei. NSCs are thought to have formed through the infall of multiple globular clusters (GCs), and/or through in-situ star formation, following gas inflow to the nucleus of the galaxy. Here we study the infall scenario by means of fully self-consistent direct N-body simulations. In particular, we present models set up with data from the Milky Way bulge, Globular Cluster System and central MBH. We run several high precision simulations and study both the infall of regular GCs, as well as the possibility of GCs hosting intermediate-mass black holes (IMBHs). The GCs are initially on circular orbits with galactocentric radius of 20pc. Due to dynamical friction, the GCs decay one after the other toward the Galactic center, where they merge and form the NSC. We then follow the relaxation of the newly formed NSC. We find that the formed NSC exhibits many of the observed features of the Milky Way Nuclear Star Cluster. Moreover, we show that this formation mechanism produces observational signatures in the form of age segregation, in which the typical ages of stars in the NSCs are dependent on their distance from the MBH. We also discuss the implications of our results and role of the NSC structure in affecting the build-up of MBHs as well as the inspiral rate of IMBHs onto the MBH, leading to extreme mass ratio gravitational wave sources and fast relaxation.

Anna Boehle (UCLA, USA)

New Orbital Analysis of Stars at the Galactic Center Using Speckle Holography

We present initial results of a study that has more than doubled the time baseline for astrometric measurements of faint stars orbiting the supermassive black hole (SMBH) at the Galactic Center. The advent of Adaptive Optics has enabled stars as faint as K~19 mag to be tracked at 50 mas resolution for the last decade. While similar resolution images exist from the prior decade, they were obtained from speckle imaging data analyzed with the technique of shift-and-add, which limited detections to stars brighter than K~16 mag. By improving the speckle data analysis technique with speckle holography and using prior orbital knowledge, we are now able to track stars as faint as ~18 mag at 50 mas resolution through the early Keck speckle data sets (1995-2005). This methodology has already led to the detection of two short-period stars never previously seen in speckle images, such that our data now spans their full orbits. We can now better constrain the orbital parameters of all stars in the intriguing "S-star cluster," which will ultimately give us insight into the origin of these stars and be used to probe the curvature of space-time in the unexplored regime near a SMBH.

Jaroslav Haas (Charles University in Prague, Faculty of Mathematics and Physics, Astronomical Institute, Czech Republic)

Two-body relaxation of thin stellar discs around SMBHs

Two-body relaxation of central mass dominated, initially thin stellar discs is an open topic of the current astrophysics. We investigate this phenomenon by means of direct numerical N-body integration. In addition to the central potential and the mutual gravitational interaction of the stars within the disc, we also include the perturbative influence of an extended spherically symmetric star cluster. Our calculations show that the radial density profile of the disc undergoes a significant evolution. In particular, we find that, for a variety of initial configurations, the disc evolves a broken power-law surface density profile. Considering the young stellar disc observed in the Sgr A* region, it thus appears that the single power-law surface density profile ~R^{-2} reported by various authors for this structure does not match theoretical expectations.

Michael Kramer (MPI für Radioastronomie, Germany)

The Galactic Center Black Hole Laboratory

The Galactic Center is the closest super-massive black hole near Earth and hence offers us the opportunity to study gravity under extreme conditions. One way of achieving this is to find pulsars orbiting Sgr A* which would allow us to measure the spin and quadrupole moment of the central black hole with superb precision. The prospects and implications for tests of theories of gravity are discussed and the needed experiment explained. The required search for pulsars in the centre reason is difficult but received an unexpected boost by the recent discovery of radio pulsations from a magnetar with the Effelsberg telescope as presented by Eatough et al. during this conference.

Ralph Eatough (Max-Planck-Institut für Radioastronomie, Germany)

Radio observations of PSR J1745-2900, a magnetar in the Galactic Centre

PSR J1745-2900 is a magnetar, ~3"" offset from Sgr A*, discovered at X-ray wavelengths with the NASA Swift and NuSTAR telescopes. Follow-up observations with the Max Planck Institute for Radio Astronomy (MPIfR) Effelsberg 100-m telescope, and a number of other radio telescopes, have detected pulsations which allow limits to be placed on the strength of the magnetic field in the immediate vicinity of the black hole; a quantity important in understanding the accretion process. The magnetar also provides a unique opportunity to probe interstellar scattering toward the Galactic Centre (GC). Measurements of both the angular and temporal broadening caused by scattering have enabled us to place the first constraints on the location of the scattering medium toward the GC. Our measurements of scattering also imply either a dearth of pulsars in the GC or a population still hidden by a more complex scattering environment. New searches for pulsars even closer to Sgr A* are already underway. The superb tests of General Relativity possible using such pulsars will also be discussed.

Danor Aharon (Technion - Israel Institute of Technology, Israel)

The evolution of stellar populations in galactic nuclei

Most galactic nuclei contain massive black holes (MBHs) hosted by dense nuclear stellar clusters (NSCs). Relaxed NSCs with a single population of stars are expected to have a steep power-law number density distribution ($n \sim r^{-7/4}$). Realistic nuclei such as our own Galactic center (GC), are known to host multiple stellar populations with a wide age distribution. Here we model such realistic nuclei by including the effect of star formation on the structure and the evolution of the NSC. We model the interaction between an old background stellar population and several young stellar populations arising from star formation. We find that the presence and dynamics of young populations reduce the time at which the old population reaches steady state, and affect the processes in the inner parsecs of galactic nuclei.

Behrang Jalali (University of Cologne, Germany)

Star Formation close to Sgr A*

The formation of stars close to black holes at the centre of galaxies is often considered implausible. It is assumed that the strong gravitational field of a massive black hole disrupts the parent molecular cloud and prevents star formation. Surprisingly, young stars have been observed across the entire nuclear star cluster including the region close (< 0.5~pc) to the Milky Way's central black hole, Sgr~A*.

In this work we focus particularly on small groups of young stars such as IRS~13N, 0.1~pc away from Sgr~A*, which is suggested to contain about five embedded massive young stellar objects. We perform hydrodynamical simulations to follow the evolution of molecular clumps orbiting about a 4 million solar mass black hole, to constrain the formation and the physical conditions of such groups.

In our simulations of clumps evolving on a highly eccentric orbit, the strong compression due to the black hole along the orbital radius vector of the clump causes the gas densities to increase to values required for star formation. This suggests that the tidal compression from the black hole could not only facilitate but also support star formation.

Additionally, we speculate that the infrared excess source G2/DSO approaching Sgr~A* on a highly eccentric orbit could be associated with a dust enshrouded star that may have been formed recently through the mechanism supported by our models.

Session: BH Physics

Xavier Calmet (University of Sussex, UK)

Self-healing of Higgs inflation model

I review the issue associated with perturbative unitarity of the Higgs inflation model and describe how to resolve it. I explain that no new physics beyond the standard model and general relativity is needed to account for our current understanding of the universe.

Claus Kiefer (University of Cologne, Germany)

Black holes as open quantum systems

The quantum behaviour of black holes can only be fully understood if they are treated as open systems. I show that the thermal nature of Hawking radiation is consistent with unitary evolution if the process of decoherence is taken into account. In this sense, no information-loss problem occurs, at least not at the semiclassical level where this investigation is performed. I also discuss the role of the quasi-normal modes and speculate on the recovery of the Bekenstein-Hawking entropy in this context.

Petra Suková (Center for Theoretical Physics of the Polish Academy of Sciences, Poland)

Chaos in geodesic flow in black-hole-disc system: computation of FLI and MEGNO

Inspired by models of accreting astrophysical black holes, we consider a simple, static and axisymmetric exact configuration of a black hole surrounded by a concentric thin disc or ring. Due to the presence of the additional source, the geodesic dynamics -- originally completely integrable in the Schwarzschild field -- generally becomes chaotic. Using the method of measuring the deviation vector proposed by Wu et all. in 2006 we compute the Fast Lyapunov Indicator (FLI) in the two--particle approach and employing the result of Mestre at al. 2011 we obtain the Mean Exponential Growth Factor of Nerby Orbits (MEGNO) and show the onset of chaos with increasing strength of perturbation. We compare our results with those obtained by different methods for finding chaos. In our approximation we also model the motion of stars near Galactic center endowed by a supermassive black hole, an accretion disc and circumnuclear ring.

Devaky Kunneriath (Astronomical Institute, Prague, Czech Republic)

Inducing the activity of the Galactic centre by repetitive accretion episodes

Gas clouds are present in the Galactic centre, where they orbit around the supermassive black hole. Collisions between these clumps reduce their angular momentum, and as a result some of the clumps are set on a plunging trajectory. Constraints can be imposed on the nature of past accretion events based on the currently observed X-ray reflection from the molecular clouds surrounding the Galactic centre. We discuss accretion of clouds in the context of enhanced activity of Sagittarius A* during the past few hundred years. We put forward a scenario according to which gas clouds bring material close to the horizon of the black hole on 0.1 parsec scale.

Session: GC environment non-stellar

Roland Crocker (Australian National University, Australia)

The Giant Magnetized Outflows from the Galactic Centre

Radio polarization observations by the Parkes radio telescope in Australia have recently led to the discovery of giant radio lobes emanating from the Galactic nucleus. These lobes are largely coincident with the Fermi Bubbles discovered in gamma-ray data but actually extend to even larger angular scales, ~55-60 degrees north and south of the Galactic plane. The lobes extend more than half way across the sky as seen from Australia. I will explain why we believe the radio lobes -- and the Fermi Bubbles -- are likely the result of the concentrated star formation occurring in the Central Molecular Zone rather than signatures of putative activity of the super-massive black hole. In fact, I will argue that these giant outflow phenomena are consequences of processes that tend to keep the black hole rather quiescent.

Kastytis Zubovas (Centre for Physical Sciences and Technology, Vilnius, Lithuania)

Sgr A* activity shapes the Central Molecular Zone

Although Sgr A* is currently quiescent, there are indications that it was not always the case. Rings of young stars in the central parsec and the Fermi bubbles seemingly emanating from the Galactic centre both suggest that Sgr A* experienced a brief AGN phase some 6 Myr ago. During this episode, Sgr A* launched an outflow which significantly perturbed its surroundings.

I will present results of SPH simulations of Sgr A* outflow interacting with the dense gas of the Central Molecular Zone. Even starting with an idealized gas distribution - a smooth thick rotationally supported disc - the gas is perturbed enough to become gravitationally unstable. Once the AGN switches off, the CMZ develops an asymmetric structure with spiral density waves and massive clumps of star-forming gas. The clumps formed in the CMZ have slightly elliptical orbits and masses comparable to the young stellar clusters and star forming regions observed in the Galactic centre. The results suggest that Sgr A* may have had an important role in forming the current structure of the CMZ.

Greg Madsen (Institute of Astronomy, University of Cambridge, UK)

Fossil imprint of a powerful flare at the Galactic Centre along the Magellanic Stream

The Fermi satellite discovery of the gamma-ray emitting bubbles extending 50 (10 kpc) from the Galactic center has revitalized earlier claims that our Galaxy has undergone an explosive episode in the recent past. We report on new evidence for such activity based on Hα observations of the Magellanic Stream, a large gaseous tidal structure at a distance of 50-100 kpc that trails the Magellanic Clouds. The Hα surface brightness of the Stream is a factor of five brighter than what is expected from UV radiation escaping the Galactic disk. A nuclear starburst origin for the Hα emission is ruled out by the low star formation rates across the inner Galaxy and the lack of starburst ionization cones in external galaxies extending more than a few kpc. Time-dependent models of Stream clouds exposed to a flare in ionizing photon flux show that the gas must recombine and cool for a time interval of ≈ 2 Myr before the emitted Hα surface brightness fades to the observed level. We argue that the Stream Hα emission arose from a "Seyfert flare" that was active 1–3 Myr ago, consistent with the cosmic ray lifetime in the Fermi bubbles. The rapid change over a huge dynamic range in ionizing luminosity argues for a compact UV source with an extremely efficient (presumably MHD) "drip line" onto the accretion disk.

Session: Extragalactic

Santiago García-Burillo (Observatorio Astronomico Nacional (OAN), Spain)

The Footprints of AGN Feeding and Feedback in LLAGNs

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 CO line mapping. On the other hand, the use of specific molecular tracers specific to the dense gas phase can probe the feedback influence of activity on the chemistry and energy balance/redistribution in the interstellar medium of galaxies. Radiative and mechanical feedback is often invoked as a mechanism of self-regulation in galaxy evolution. A detailed study of nearby AGNs is essential if we are to understand if and how accretion can self-regulate. We used the high-resolution (<1") interferometer CO maps obtained with the IRAM array in the context of the NUclei of GAlaxies (NUGA) survey to study the mechanisms responsible to fuel AGN and Star Formation activity in the central R<1 kpc disks of a sample of 25 active galaxies at 10-100 pc scale. More recently we have used the ALMA interferometer to image the distribution of molecular gas in the circumnuclear disks of a subset of nearby Seyferts. In two of these sources, NGC1068 and NGC1433, we report the discovery of two massive molecular outflows.

Carole Mundell (ARI, Liverpool John Moores University, UK)

Black-hole fuelling, feedback and duty cycles

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.

Although technically challenging such studies are now evolving to include comparative study of gaseous and stellar dynamics in active and quiescent galaxies.

I will review 3D studies at optical, radio and mm wavelengths and highlight the importance of studying the inner kiloparsec, where activity and dynamical timescales become comparable, including a new IFU-imaging spectroscopic comparative study of the distribution and kinematics of ionised gas in a carefully matched sample of Seyfert and quiescent galaxies, selected from the SDSS, that takes 3D studies to higher redshift.

I will show that variability in nearby radio-quiet AGN may provide parallels to our own Galactic Centre and that AGN duty cycles may be shorter than previously thought.

Isabel Marquez (IAA-CSIC, Spain)

X-ray Variability of LINERs

One of the most important features in active galactic nuclei (AGN) is the variability of their emission. Variability has been discovered at X-ray, UV, and radio frequencies on time scales from hours to years. Among the AGN family and according to theoretical studies, Low-Ionization Nuclear Emission Line Region (LINER) nuclei would be variable objects on long time scales. Our purpose is to investigate spectral X-ray variability in LINERs and to understand the nature of this kind of objects, as well as their accretion mechanism. Chandra and XMM-Newton public archives were used to compile X-ray spectra of LINER nuclei at different epochs with time scales of years. To search for variability we fit all the spectra from the same object with a set of models, in order to identify the parameters responsible for the variability pattern. We also analyzed the light curves in order to search for short time scale (from hours to days) variability. Whenever possible, UV variability was also studied. We found that long term spectral variability is very common, with variations mostly related to hard energies (2-10 keV). These variations are due to changes in the soft excess, and/or changes in the absorber, and/or intrinsic variations of the source. Short time scale variations during individual observations were not found.

Lachezar Filipov (Space and Technology Research Institute, Bulgaria)

Self-organization processes in accretion disks

Agnieszka Janiuk (Center for Theoretical Physics, Polish Academy of Sciences, Poland)

Modeling black hole mergers in long gamma ray bursts

We consider a scenario for the longest duration gamma ray bursts, resulting from the collapse of a massive rotating star in a close binary system with a companion black hole. The primary black hole born during the core collapse is first being spun up and increases its mass during the fallback of the stellar envelope just after its birth. As the companion black hole enters the outer envelope, it provides an additional angular momentum to the gas. After the infall and spiral-in towards the primary, the two black holes merge inside the circumbinary disk. The second episode of mass accretion and high final spin of the post-merger black hole prolongs the gamma ray burst central engine activity. The observed events should have two distinct peaks in the electromagnetic signal, separated by the gravitational wave emission. The gravitational recoil of the burst engine is also possible.

Luka Popovic (Astronomical Observatory Belgrade, Serbia)

Super-massive black hole estimates using spectro-polarimetric observations

Here we discuss a method for super-massive black hole estimates using spectro-polarimetric observations. Using the fact that the polarization angle in the case of equatorial polarization depends only on the velocity field in the region around a super-massive black hole, we find that this can be used for confirmation of the Keplerian emission gas motion, and consequently for the super-black hole mass estimate.

Session: Instrumentation

Paolo Soffitta (IAPS/INAF, Italy)

*X-ray polarimetry as diagnostic tool of the past activity of Sgr A**

The present X-ray brightness of some molecular clouds surrounding the Galactic Center could be due to the reflection of radiation emitted from Sgr A* in the past. If this is so few hundred years ago Sgr A* was as bright as a faint AGN. Such hypothesis can be demonstrated by X-ray polarimetry of molecular clouds like Sgr B2 and Sgr C because scattering polarizes the observed radiation. The polarization angle should pinpoint Sgr A* and the degree of polarization fixes their real distance to Sgr A*. We show in this talk how such measurement can be accomplished with modern X-ray imaging photoelectric polarimeters either by a small pathfinder mission like XIPE and by an L-ESA class mission like Athena+.

Eduardo Ros (MPI für Radioastronomie, Germany)

Black hole high-resolution science with phased ALMA

The Atacama Large Millimetre/submillimetre Array, presently starting operations in Chile, will be capable of observing jointly with other antennas at millimetre and sub-millimetre wavelengths. This will be possible once a beamformer to aggregate the entire collecting area into a single, ery large aperture telescope, is completed. The ALMA Phasing Project is an international consortium which now has formed to implement this phasing capability. The use of ALMA as a phased array acting as a single large aperture will have a large impact in different scientific topics, among them, the accretion outflows processes around BH in AGN or tests of general relativity near close BH and pulsar science. The SMBHs in the Galactic Centre and in M87 are the primary candidates among other suitable targets. I will describe the general outline of the ALMA Phasing Project and some of its applications to Black Hole Science.

Posters

SgrA*

Abhijeet Borkar (I Physikalisches Institut, Universität zu Köln, Germany)

*Monitoring the Flyby of the dusty source around Sgr A**

The center of our Milky Way galaxy hosts a highly variable radio, NIR & X-ray source, Sagittarius A* (Sgr A*), which is associated with a 4 million solar mass super massive black hole which is known to have a flaring activity occurring from a few hours to few days. This suggests that Sgr A* undergoes accretion events sporadically. Recently, Gillessen et. al. (2012) reported a dusty object (DSO/G2) approaching Sgr A* with its pericenter passage in mid-September 2013. The fly-by of this object could result in the enhanced accretion and hence could lead to an elevated flux and variability of Sgr A*. We report the results of our recent observations of the Galactic Center with the Australian Telescope Compact Array taken from June to September 2013.

Michal Dovciak (Astronomical Institute AS CR, Czech Republic), Marin F, Goosmann R W, Karas V, Matt G

X-ray polarization in the lamp-post model of non-smooth black-hole accretion discs

According to theoretical computations, the X-ray continuum emission reprocessed by the accretion discs of Active Galactic Nuclei (AGN) is expected to be significantly polarised.In the reflection scenario, polarisation is mainly produced by Compton scattering of the primary, power-law, coronal radiation incident onto the disc. Polarisation being sensitive to the geometry of the scatterer, we decided to re-visit the lamp-post scheme, investigating how much the polarisation properties change if the geometry of scattering is not an ideal smooth disc. To do so, we assume that the disc surface has random irregularities, so that the final result is averaged over a range of scattering geometries. Preliminary results indicate that non-smooth surfaces may lower the polarisation by 20% for irregularities of up to 30° roughness and by 60% for very large irregularities of 60°. The associated polarisation angle changes by 10° at maximum even for heavily irregular discs.

GC environment stellar

Devaky Kunneriath (Astronomical Institute, Prague, Czech Republic)

Structure of the NSC of the Milky Way Galaxy

The Nuclear Stellar Cluster (NSC) which surrounds Sgr A*, the SMBH at the centre of our galaxy, is the nearest nuclear cluster to us, and can be resolved to scales of milliparsecs. The strong and highly variably extinction towards the Galactic centre makes it very hard to infer the intrinsic properties of the NSC (structure and size). We attempt a new way to infer its properties by using Spitzer MIR images in a wavelength regime (3--8 um) where the extinction is at a minimum, and the NSC clearly stands out as a separate structure. We present results from our analysis, including extinction-corrected images and surface brightness profiles of the central few hundred parsecs of the Milky Way.

GC environment non-stellar

Sonia Anton (Universidade de Lisboa, Portugal)

Pinpointing AGN in red, massive and bulgeless SDSS-DR7 galaxies

We present the results of a study that aimed at finding extra activity among low-z bulgeless red sequence galaxies. We have found seven objects that are quenched massive galaxies, have no prominent bulge and show signs of extra activity in their nuclei, five of them being central in their halo. Even if rare, the number of discovered systems has been increasing, showing that a massive bulge might not be mandatory for the presence of a SMBH.

BH Physics

Miguel Campos (Physics Department-Roraima Federal University, Brazil)

The influence of the vacuum energy in the gravitational collapse

To explain the accelerated expansion of the universe, models with interacting dark components has been considered in the literature. Generally, the dark energy component is physically interpreted as the vacuum energy. However, as the other side of the same coin, the influence of the vacuum energy in the gravitational collapse is a topic of scientific interest. Based in a simple assumption on the collapsed rate of the matter fluid density that is altered by the inclusion of a vacuum energy component that interacts with the matter fluid, we study the final fate of the collapse process.

Miguel Batista (Physics Department-Roraima Federal University, Brazil)

Higher dimensional cosmic censorship for a star fluid with an interacting vacuum energy

We discuss the influence of the vacuum energy in the collapse process taking into account a higher dimensional spacetime, generalizing and our previous work for the usual four-dimensional spacetime. We display the consequences for the cosmic censorship conjecture, and finish the work dicussing the effective mass of the black hole formed.

On the other hand, if we have the formation of a naked singularity we can infer that the number of relativistic images and Einstein rings are more separated from the each other that in case of black holes. Besides, the thermodynamic and electromagnetic features of accretion disks are different for these two classes of objects, furnishing a clear-cut signature that could distinguish black holes from naked singularities.

Zdenek Stuchlik (Insitute of Physics, Faculty of Philosophy and Science, Silesian University at Opava, Czech Republic)

Astrophysical processes in the field of Kerr superspinars and their observational aspects

Primordial Kerr superspinars, extremely compact objects with exterior described by the Kerr naked-singularity geometry, are indicated by String Theory. Accretion converts them to near-extreme Kerr black holes, but they can survive to the era of high-redshift quasars.

In the final stages of the conversion process the near-extreme Kerr superspinars provide extraordinary physical phenomena. Efficiency of the accretion process can go up to 157.7% in the field of near-extreme Kerr superspinars with dimensionless spin very close to a=1, exceeding thus substantially the maximal efficiency that can be obtained in the field of Kerr black holes (42.3%).

The astrophysical phenomena and related optical effects occuring in the field of Kerr superspinars can give signatures that enable clear distinguishing of superspinars from black holes. Among such phenomena oscillations of Keplerian discs and toroidal structures belong; the radial profiles of the frequencies of the oscillations differ substantially from those occuring around Kerr black holes and can give rise to unexpected phenomena related to stability of the accretion discs. The most profound distinction of the Kerr superspinars and black holes can be related to spectral profiled lines created in the innermost parts of the accretion discs.

In close vicinity of the near-extreme Kerr superspinars, ultra-high-energy processes can be obtained with no fine tuning of the motion constants of the colliding particles and the products of the collisions can escape to infinity with both directional and energetical efficiency significantly larger than in the case of collisions near the horizon of near-extreme black holes.

The extraordinary phenomena related to the primordial Kerr superspinars could be observed by the prepared satellite observatories as LOFT or ATHENA, giving thus observational support for ideas of String Theory.