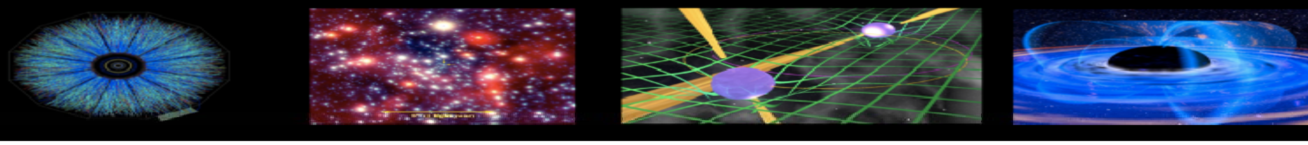


Minutes/Summary of

1ST WORKING GROUPS MEETING

June 24

- 10:30-11:00 **Welcome S. Britzen & A. Zensus** 0.02

- 11:00-11:30 **Action MP0905** S. Britzen 0.02

Organization _ Activities _ Science (three wheels working together)
Science:
There is fragmentation in topics and methods used. Brief description of different scientific topics of interest to all WGs:

(1) Quantum black holes (QBH) and the unification of forces/dimensions in the Universe
(2) Primordial black holes. Are they observable with Fermi-LAT?
(3) Stellar black holes. Pulsar timing array and gravitational waves
(4) μ-QSOs. Learning about their supermassive counterparts
(5) Galactic center. Approaching the event horizon and probing the accretion disk or orbiting blobs
(6) AGN. Triggering of activity and co-evolution with host galaxy
(7) Gravity at different scales
(8) Jets and outflows. Creation and mass content

Goal: To enhance our understanding of the BH phenomenon, in the context of the evolution of the Universe and to study the fundamental laws of nature using an interdisciplinary and multi-dimensional approach.

Special focus on:

- Gravity – Quantum Gravity
- Accretion
- Jets
- Gravitational Waves + BBH
- BH cosmological evolution (co-evolution, early Universe)

Working Groups:

WG1: Xavier Calmet
WG2: Robert Ferdman / Anthony Rushton
WG3: Andreas Eckart
WG4: Eduardo Ros

COST (general): 356 participations in 129 actions (36 countries)

COST: Black holes in a violent Universe: 19 participating countries + 1 (Australia)

The core group: WG leaders + Antxon Alberdi + STSM Coordinator (Papadakis) + Outreach Coordinator + Gender Coordinator + Management (Rottmann) & Grant Holder (Tegethoff) + Chair (Britzen)

Activities:

- Management Meetings (1/yr)
- Core group (2/yr)
- WG Meetings (next WG meeting in Valencia)
- STSMs (10/yr) (next call June 30th)
- Outreach/Gender Activities
- Liaison/Interaction
- Conferences
- Winter Schools
- Scientific Strategic Meeting
- Final Symposium
- 2011: 2 conferences + WG meeting
- 2012: 2 schools + WG meetings
- Website (including pdf files of talks) :
  - (1) public area,
  - (2) internal pages
  - (3) communication platform for female scientists
- Publications (COST acknowledgement) + for wider public

- 11:30-12:15 **Quantum Black Holes** X. Calmet 0.02

Goal: Unification of forces (creation of quantum black holes (QBH) as possible signature)

Question:
How does gravity fit with the rest of the forces?

Coupling constants dependant on energy of phenomenon
Gravity becomes important at energy 10^{19} GeV (M_p) → creation of QBH

New theories needed:

1. string theory,

2. loop quantum gravity,
3. noncommutative geometry,
4. nonperturbative quantum gravity.

Planck mass might be smaller than currently believed (could be probed in LHC and astrophysical systems)

- additional scalar field (massive) (additional particle)
- 10^33 fields needed (only gravitational interaction with standard model)

How can one test these?

- Gravity tested only up to 10^{-3} eV!
- Supernovae could constrain the scale/number of extra dimensions
- Cosmic rays can also be used as constraints

Formation of a QBH?

- Collision of high energy particles (LHC)
- If energy E is confined in space R and if R<E a small BH formed
- Thermal black holes (large entropy; $M_{BH}>>M_P$; classical physics)
- QBH (small entropy; $M_{BH}>>M_P$; decay signature different)
- QBH would decay immediately because of Hawking radiation

Important Topics:

- Model the decay of small BHs.
- Carry of QED charge, impact? (results of gluon/quark collisions)
- Is there a minimal length impact on BH solutions?
- What is the correct cross-section for QBH? Is there a minimal mass?
- No hair theorem: QBHs do not care how they were created
    - Initial info on quantum state is lost
    - QBHs are solely define by their mass, angular momentum, and QED charge
- Probe quantum gravity experimentally (primordial BHs?)

Audience Questions:

Does the fine structure constant evolve with energy/ time?

- It is possible, needs to be tested.

Conditions in extragalactic jets are extreme. Are they extreme enough for the above?

- This needs to be investigated. What are energy scales involved in jets?

Can QBHs be produced by cosmic rays?

- Depends on the energy scales (M_p) and where gravity becomes important (see above).

- 12:15-12:45 **Stellar Black Holes** A. Rushton 0.02

Interesting Topics:

- Accretion on to Stellar-mass black hole (SBH)
- Pulsar timing in the orbit of a SBH

Synergies:

(1) Pulsar timing array,
(2) μQSO to QSO connection and scaling relations,
(3) intermediate mass BHs.

Introduction to binary systems:
Compact object + companion star

- High-mass companion:
  - Mass transfer via stellar wind
  - Short lifetimes
- Low-mass companion:
  - Mass-transfer via a Lagrangian point
  - Longer lifetimes

Compact object: white dwarf, neutron star, or SBH (determines accretion mode)

- Complex X-ray spectrum
- Variable in X-rays
- Strong radio jets
- Advection-dominated accretion
- Difference of last surface
  - event horizon
  - solid surface

Multiwavelength field:

- Radio emission (outflow jet)
- Sub-mm (base of the jet)
- NIR/optical (companion star)
- X-ray/Gamma (accretion)

Different states of XRBs → different accretion modes

Correlation between bolometric luminosity and synchrotron luminosity (accretion vs. jet emission) → fundamental property of all black holes!

Pulsars:

- Extremely precise clocks
- Objects of extreme matter
- Period measured to extreme accuracy
- Pulsar binary system: orbit reduced → gravitational waves evidence!
- Pulsar - black hole system: ultimate test for gravity
- Pulsars timing array → require around 30 pulsars
  - Constraints for some of the exotic theories
  - Complementary to other GW detectors

Audience Questions:
Topology of XRBs between states: are magnetic fields important for the launching of jets?

- Magnetic fields are crucial!! Energy density of magnetic field comparable or even more important than the energy of particles

What is the origin of γ-ray emission in μQSO?

- Jet is emitting it (pair production) and possible cascading of particles coming from accretion disk / corona.

Why is pulsar-BH more important than pulsar-pulsar binary?

- The metric is different, and therefore it provides different test for general relativity.

What are μQSO jetσ made off?

- Probably leptons (electrons)

Which components are included in XRBs simulations? Is the jet indeed flat-spectrum? What is the importance of the jet opening angle?

- The probed scale of the jet is important (e.g., Poyntix flux dominated jet = not flat spectrum!)

- 14:00-14:45 Galactic **Centre Black Holes** A. Eckart 0.02

<u>Complex structure:</u>

- arched filaments (star formation, magnetic fields),
- arches + quintuplet (star clusters),
- SgrA west (mini spiral, black hole)
- XRBs in the central 40x40pc, density higher towards the center

<u>IRS13E:</u>

- apparently a small stellar cluster
- proper motions measured
- upper limit to the intermediate BH mass (10^3-$10^4 M_{sol}$)
- unlikely that a BH is there (if so, it must be highly under-luminous)

<u>Central stellar cluster:</u>

- proper motions + radial velocities
- distance (8.3 kpc)
- mass ($4x10^6 M_{sol}$)

<u>Simultaneous NIR/Xray Flares:</u>

- investigation of the low and high flare states in multiwavelength campaigns
- flare timescale ~100 mins → Xrays (1/day) , K band flare (4-6/day)
- time lags between NIR and Xrays consistent with 0 minutes
- scattering efficiency for Xrays smaller than NIR
    - differentially rotating accretion disk or axisymmetric wave oscillation
- radio flares show signature of single synchrotron component adiabatic expansion
- very low expansion velocities (v=0.006c)
- 1.5-2 hours lag between NIR and sub-mm (APEX and VLT instruments)

<u>Polarization:</u>

High polarization for SgrA* (non-thermal emission)

NIR polarization implies high spin for the BH (>0.4-1)

<u>Orbiting hot spot:</u>

- orbiting around the BH, gravitational effects on polarized emission (EVPA swings)
- mm-radio size smaller than anticipated from radio→ orbiting hot spot or foot point of the jet observed?
- hot spot predicts correlation between flux changes, polarization, and polarization angle → seen in the data

Interaction between XRBs and BH implied:
- High-speed ejected stars
- Be stars observed around BH → could not have formed there (too short-lived)

Wind ejected from SgrA* (accretion wind?):
- Mini-cavity
- cometary-like structure of some stars

Alternative scenarios:
- neutrino ball scenario (supported by degeneracy pressure)
  - excluded for SgrA*
- boson star scenario (supported by Heisenberg uncertainty principle)
  - unlikely to form a stable configuration at the galactic center

Synergies: JWST, VLBI, ALMA, VLT, LBT, Spitzer spectroscopy, E-ELT

Audience Questions:
Could the X-ray emission be a superposition of the XRBs instead of SgrA*?
- No, enough angular resolution to resolve the emission structure.

How about the eternal collapsing structure scenario?
Are the SgrA* mass and the bulge mass correlated?
- They follows the known correlation, although not exactly.

Why we don't have normal accretion on SgrA*?
- Same problem as in XRBs. Angular momentum extraction and advection dominated accretion make accretion less efficient
  - poor understanding of the phenomenon

Could you detect a change in the inclination angle of the disk?
- Probably not. There are too many parameters to account for, large errors and uncertainties. Higher precision measurements needed.

- 14:45-15:30 **Supermassive Black Holes** E. Ros 0.02

Working group dynamics:
(1) forming, (2) storming, (3) norming, (4) performing, and potentially (5) re-forming

Introduction to Einstein's principle and general relativity

Energy and mass can be extracted from the ergosphere of a rotating BH

Supermassive Black Holes:

- compact objects with mass over $10^6 M_{sol}$ (upper limit $10^{10} M_{sol}$)
- observational evidence from optical and radio
- created by the collapse of supergiant stars / formation by high density of matter in the early Universe
- short time-scale variations imply very compact region
- formation of intermediate BH (100-1000 M_{sol})?

<u>Observation for SMBH:</u>

- resolve the influence radius in optical (e.g., for SgrA*)
- HST (e.g., M87),
- VLBI H2O masers (e.g., NGC 4258),
- ASCA Fe Ka measurements (MCG-6-30-15),
- reverberation mapping,
- gas & stellar dynamics
- jets (in AGN; e.g., 3C 296)

<u>Active galaxies:</u>

- 20-25% over-luminous (different from normal galaxies both in their luminosity and the type of radiation)
- different types of activity (non-stellar light):
    - accretion (AGN)
    - star-formation (starburst)
- different classes:
    - Seyferts (complex spectra),
    - radio galaxies (big lobes perpendicular to the galaxy plane),
    - quasars (very far away, most luminous objects in the universe)
- flux variability: rapid variation → compact emitting region
- many AGN show signs of interaction with other galaxies
- standard picture of AGN:
    - SMBH (billions M_{sol})
    - accretion disk
    - jet (ultra-relativistic speeds)

<u>Open Questions:</u>

- the SMBH itself,
- accretion disks,
- merging of BH,
- jet issues
- dynamo effect in the accretion disk?
- how to trigger an AGN jet?
- M-sigma relation → co-evolution of SMBH and host galaxy

<u>Binary black holes (result of merging of galaxies):</u>

- could explain effects like:
    - twists in the jets,
    - recurrent outbursts (periodicity)

- coalescence of these BBH would produce a signal observable by LISA

Telescope + observational facilities overview

Marscher model for quasar jet:

- different scales of the jet emit in different wavelength regimes:
  - X-rays (accretion disk + kpc-scale jets)
  - UV (accretion disk)
  - Gamma-ray (jet ?)
  - mm+IR (jet, accretion disk, torus)
  - optical (jet, accretion disk)

Define condition around SMBH.
Simulations (HD, RHD, RMHD, etc.)

Audience Questions:
What will be the output of the WGs, refereed publications or a book?
Integration of new people into the groups! Keeping a record. Needs to be discussed in the WGs.

- 16:00-18:00 WGs meetings (***WG4 E. Ros 0.02***)

WG4 consistency:

- ~30 participants (biggest WG)
- more radio astronomers
- a few theoreticians
- a few high-energy astronomers

Check the deliverables for COST (WG meetings, schools, conferences)

Britzen:

- book, i.e., something to give to students (final product)
- collaboration with other WGs, i.e., synergies

Keppens:

- Prepare the basis for a next bigger proposal (e.g., Marie Curie).

Eduardo:

- Organize school about high-resolution observation techniques.
- Check what others schools are planned.
- Plan together and collaborate with other networks.

Anton:

- connecting science and industry/instrumentation (as in the case of FP7)
  - e.g.,instrument GRAVITY (VLT) → relevant for broad line region science

Keppens: RH and MHD models (jet propagation + deceleration)

Analytic + numerical simulations

Fanaroff – Riley classification (FR I, e.g., 3C31; FR II, e.g., Cygnus A)

- intrinsic difference for the way energy is transported and diffused along the jet
- Classification dependent on ambient medium properties

How to decelerate highly energetic flows?

- external medium influence
- study with axisymmetric HD jet models

Jet launching models?

- transverse stratification
- liability to relativistic Rayleigh-Taylor mode
- transition from Class I to II?

Model parameters:

- kinetic energy,
- Lorentz factor,
- ratio between jet/IGM inertia,
- opening angle,
- density discontinuities for external medium

Inevitably: boundaries created:

- FRII → FRI transition possible for large density contrast for the external medium discontinuity
- internal stratification of jet (spine/sheath morphology)
- outer disk jet launched magnetocentrifugally
- inner jet launched by efficient extraction of angular momentum from the BH
    - fast rotating inner jet
    - radially layered jet
- internal stratification eventually leads to mixing and deceleration of the jet

Depending on the initial distribution of energy for the two components (outer/inner) (whether the jet is liable to the instability) one gets a division for the resulting Lorentz factor: fast and slow

Audience Questions:

Ultimate result should be comparable with observations. Can they produce emissivity maps?

- Working on that currently.

Are there helical instabilities?

- Perturbations are indeed seen in 3D realizations of the model.
- Helical structures are seen for the inner jet, not the outer

What is the mass load of the jet?

- Inner jet is more like electron-positron. Outer jet is electron-proton plasma.

Niedzwiecki: X/Gamma-ray studies of the central engine

Accretion onto black holes:

- gravitational potential energy released mostly within 100Rs

Spectral states of BH binaries (correlated changes, e.g., in jet activity!):

- Seyfert galaxies – similar to hard spectral state
- higher accretion rate objects (NLS1) → similar to soft states

Xray reflection spectrum:

- line shape distorted by special and general relativistic and geometric effects (e.g., Fe Ka line)
- both Fe Ka and La lines found to be equally distorted
  - most energy radiated within a few Rs
  - in most objects that truncation of the disk is at R>10Rg, for many R>50Rg

Audience Questions:

Conclusion is that most BHs rotate fast?

- It indeed appears that most SMBH should be rapidly rotating.
- Observationally, there are not enough data to constrain the spin of BHs. Nandra paper data do not have enough SNR to determine the spin.

Truncation of disks at this R?

- Depends on interpretation: truncation, ionization, bad data

Kadler: Observing BH at high energies

Current X-ray observatories:

- Chandra (imaging),
- XMM (spectroscopy),
- Suzaku (spectroscopy, hard x-rays),
- INTEGRAL (hard x-rays),
- RXTE (hard x-rays, monitoring),
- Swift (rapid response, broadband spectra)

X-ray spectrum of AGN = power-law

- Hard X-ray produced by comptonization from the electrons in the hot disk corona ($T \sim 10^8$K)
- MGC-6-30-15 the only good example to constrain the spin of the black hole (high spin!)

Blazar spectrum:

- 2 humps (synchrotron + IC (leptonic or hadronic))
- blazar sequence (lower luminosity → spectrum shifted towards higher energies)
- Gamma-ray emission coming from AGN → very variable
- Multiwavelength BH observations (e.g., connection gamma to radio)

Audience Questions:

Are there correlations between gamma and other wavelength?

- There are plenty! Most intriguing is whether gamma-ray flares are associated with changes in the VLBI jet. Optical and gamma → IC! More data needed

Popovic: AGN spectral lines & SMBH

Optical spectroscopy:

- spin of BH,
- presence of AGN,
- mass of black hole,
- accretion rate

Difference between Kerr and Schwarschild radius:

- last stable orbit at smaller radius for Kerr metric

Introducing a hot spot in the accretion disk can affect the resulting optical spectral lines:

- depending on the position of the hotspot, the effect on the line is different

Measure of the mass of the black hole using broad-line region geometry and kinematics:

- geometry can be very complex
- effect of the torus (part of the BLR might be obscured)
- size of the BLR (different sizes of emitting regions)
- estimate kinematics
- approaching or receding jets can affect measurements.
- connection between BLR geometry + physics with radio/gamma/xray properties
- different spectral characteristics for BLAGN with FWHM<3000 km/s with other emission properties

Audience Questions:

Are there other lines that could be used?

- Iron line is the most luminous line. Other lines exist but with low SNR.

Why only some AGN have this iron line?

- Often iron line is very narrow and can not be observed. Also, torus could obscure the line. Inclined disk would also hide the line.

Anton: GAIA and Quasars

GAIA:

- optical mission,
- multi-epoch,
- astrometry,
- 3D map of Milky Way,
- photometry + spectroscopy,
- for 5 years,
- mag limit 20
- 500000 AGN should be detected

GAIA will provide a catalog:

- no imaging, just point sources
- variability
- color & contrast
- counterparts for ulta high energy cosmic rays (from Auger)

Variability would affect the photocenter of the point source (especially for sources with ejected new components, shocks, variable BLR)

Cosmic rays, Auger catalog correlates with AGN that do not have jets (only CygA).

- Where are these UHECR created and coming from?

Audience Questions:
What will be the time sampling of GAIA?

- Each object will be observed once per week!

Is someone working on the connection of radio and optical reference frames?

- Yes! In Bordeaux

Lobanov: Probing the vicinity of SMBH

Concerning SMBHs:

- Go beyond post-Newtonian tests of GR (provided by pulsars)
- Consider carefully all “Exotic” alternatives to BH
- Strive for a full 3D GRMHD + Poynting flux + thermal particles description of BH vicinity
- Look for means to 2D image the black holes
- Important to determine the true physical nature of BH
- Be realistic → find the most efficient way to go about these points!

VLBI:

- only technique to offer 10^{-4} arcsecond resolution
- also space-VLBI: 10 mas
- high-frequency VLBI (mmVLBI): up to 20 mas
- spatial dynamic range of >500 is required!
- filling the uv-space for mmVLBI → imaging of the event horizon

Strong evidence for:

- collimation on linear scales of 10^3 R_g
- strong acceleration on parsec scales (10^5-10^6 R_g)

Distinguishing between BH and other scenarios:

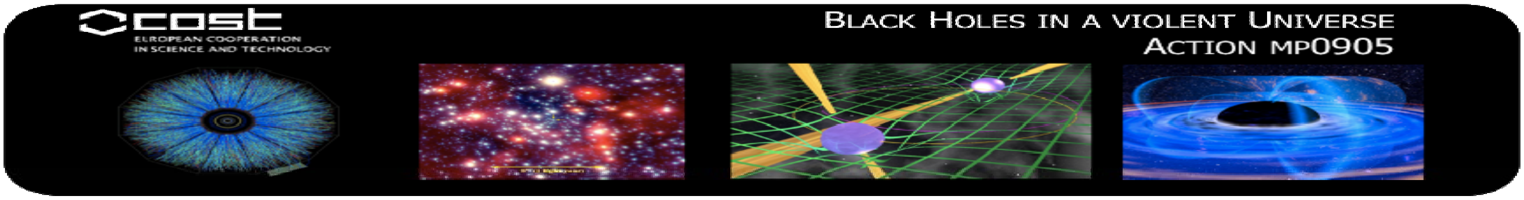
- stellar orbits (neutrino condensates)
- radiation spectrum (boson stars + eternal collapsing objects; low freq needed!)
- gravitation waves (anything)
- VLBI (eternal collapsing objects; magnetic fields/2D images)

Jets may have an EM component created in the immediate vicinity of the BH that affects their formation and propagation

High sensitivity VLBI (space or mm) is one of the primary (and affordable) tools for studies of BH and relativistic jets.

Audience Questions:
The event-horizon telescope, using closure phases, can calculate the orbital period of hot spots on the accretion disk?

- Mass of the black hole and spin can then be determined:
  - for SgrA* (but low sensitivity, too short timescales 90 minutes)
  - for M87 (timescales of days/week)



June 25 (top)

- 09:00-10:30 WGs meetings (***WG4 E. Ros 0.02***)

Caramete: BH candidates in the nearby Universe

Cosmic rays to BHs:
- UHECR possible originating in extragalactic objects (AGN jets)
- UHECR events linked to sources on the sky
- distinguish between different source populations
    - important: BH mass

Sample from 2MASS catalog:
- old stellar population
    - well correlated to BH mass
- using a redshift and flux limit
- first sample = 10000 objects

Use Hubble type:
- scaling relation of flux/distance
    - catalog of SMBH (~6000)
- Data missing in FIR/radio/optical colors
- formula for mass works better for ellipticals

Three methods to test distributions:
- Importance
- Rejection
- monte carlo sampling method
    - Monte-carlo works best
    - can reproduce well the distribution of redshifts

Simple scaling relation to get a big catalog of BH

Goal: multi-dimensional simulation of different values (redshift, luminosity, BH mass)

www.science-side.com → news on science (popular science)

Audience Questions:
Can we link the popular science site to the COST site and people from COST can contribute?
- Yes!

How do you estimate the BH mass?

- Proportional to 2μm flux and inverse proportional to distance squared. Best for ellipticals

Can you have deflection of CR from magnetic field of galaxy?

- Yes, of the order of 10 degrees (from simulations) but most UHECR come from a few sources. Statistical analysis can account for this effect.

If UHECR are produced in jets, why include spiral galaxies?

- AGN jets are usually found in elliptical hosts. No noise introduced due to the statistical analysis, especially for the most luminous sources.

Gergely: Supermassive Black Hole Binaries

Bardeen accretion spins up BH:

- mass increase by a factor of 3 → from maximally counter-rotating to maximally rotating BH

Corrections to accretion rate from:

- photon capture
- open and closed magnetic fields
- truncation of disk because of jet
    - spin limit reduced (efficiency reduced to 25% -35%)

Most BH spinning fast, mergers (unless wet) reduce the spin (?)

<u>No gravitational wave detection for some years yet:</u>

- Noise and signal of the same order
- Ground-based gravitational interferometers: very sensitive to noise (e.g., earthquakes, storms, train passing, etc.)

<u>X-shaped galaxies:</u>

- spin-flip model?
- un-equal mass BBH systems (typical 1:10)
- orbital angular momentum shrinks
- spin changes direction
- re-orientation of the jets! (usually happens during the inspiral phase)

<u>LISA will not detect SMBH binaries</u>

Audience Questions:

Is LISA not correctly designed for SMBH binaries?

- No! But pulsar timing array will be ideal for that.

Do BH rotate rapidly?

- Yes! See last day talks. But most AGN do not have jets.

This 3 times increase of mass factor is unlikely, especially for a single event.

Accretion could happen in different directions?

- Re-orient spin!

Stratification of optical lines (reverberation mapping) + galactic center observations support rotating BHs (apart from jets)

Roland: Determining properties of BBH from VLBI

Inner VLBI jet is never straight:
- precession
- can be explained by a BBH system
- precession of the accretion disk

Three perturbation:
- precession of accretion disk
- motion of BH ejecting the jet around BBH gravity center
- motion of the BBH around the gravity center of the galaxy

Both BH can have accretion disks

Two families of trajectories (different Omega=angle to plane of orbit):
- Offset of the origin of the VLBI ejection from VLBI core
- measure of the radius of the BBH

From trajectory/kinematics of component:
- inclination angle and bulk Lorentz factor
- we find families of solutions (usually not unique solution)

1823+568 two fast moving components:
- both components belong to the same family of trajectories
    - all geometrical parameters the same offset between VLBI ejection and VLBI core ~70-90 mas
- best fit 80 mas for the separation of the BBH system
- at precision of <10mas most sources will appear double
    - problem for GAIA?

Discussion of the WG
- Text book on SMBH
- Basis for deeper networking (further proposals)
- Training schools
- Sci. Workshops
- Public Outreach (see Caramete's talk + public talks)
- Synergy with parallel efforts (e.g., GAIA QSO WG)
- Development of joint efforts with industry (e.g., GRAVITY)
- Multiwavelength view on AGN (e.g., VLBI + spectroscopy, IR)
- Book on all different scales of BH
    - Would that be useful?
    - Could we use a web-interface for something like that?
- Market for fundamental physics of BH school (hands-on for young scientists)

Synergies:

Theory

- Simulations of relativistic flows (rescalable)(WG2)
- Intermediate BHs
- BH formation + evolution (WG1+WG2+WG3)
- Mergers + Accretion (WG1+WG2+WG3)
- Fundamental Physics

Observations
- μQSO + QSO (multiwavelength)(WG2)
- Pulsar timing array (BBH)(WG2)
- SMBH and galactic center (WG3)
- Multiwavelength and multi-messenger studies of BH (WG2+WG3)

- 11:00-13:00 Forum Synergy S. Britzen 0.02

Kiefer: Quantum Gravity

Why quantum gravity?
- unification of all interactions
  (2) Absence of viable alternatives (so far)
- singularity theorems (black holes, big bang)
- problem of time
  - Quantum theory uses absolute time (external, non-dynamical)
  - General relativity uses dynamical time (internal, time-space)

Planck Units: length (10^{-33} cm), time (10^{-44} s), mass (10^{19} GeV/c^2)

A(g) (fine structure constant) ~10^{-39} (m_{proton}/m_{planck})
- relevant only for very small scales (e.g., black holes, big bang)
- (known) Interaction of micro- and macroscopic systems with an external gravitational field
- (somehow understood) Quantum field on curved backgrounds
- (unknown) Quantum gravity

Hawking radiation:
- BH radiate with temperature proportional to Planck constant
- temperature of radiation T~$10^{-8}(M_{sol}/M_{BH})$ → very small!
- Important for small BHs
  - stellar BH would need 10^{65} years to become so small

BHs have entropy: $10^{77}k_B(M/M_{sol})^2$ (entropy of sun ~ 10^{55})

Accelerated particles observed in Minkowski vacuum experiences thermal radiation with temperature similar to Hawking radiation temperature (equivalence principal)

Quantum general relativity:
- covariant approaches (perturbation theory, path integrals,…)

- canonical approaches (geometrodynamics, connection dynamics, loops dynamics,…)

String theory:
- can not distinguish between different interactions, unified theory from start
- only deal with separate interactions for special cases, e.g., low energy

Covariant Quantum Gravity:
- $g_{\mu\nu}=G_{\mu\nu} + f_{\mu\nu}$ ($f_{\mu\nu}$=small perturbation)
- particle of quantum gravity: graviton (massless spin-2 particle)
- concrete predictions possible at low energies
- quantum gravity correction term too small to be tested at this point

Asymptotic Safety:
- Effective gravitational constant vanishes for high energies
- Increases with distance (Dark matter?)
- Small positive cosmological constant as an nfrared effect (dark energy?)
- Space-time looks 2D in sufficiently small scales

Eucledian 4D space-time:
- (Hawking-Hartle proposal) → no boundary to the Universe (like the South Pole)
- Dynamical triangulation (Lorentzian path integrals, numerical calculations)
- Dimension number coming out ~3
- At small scales space looks 2D
- Positive cosmological constant

Canonical quantum gravity:
- Central equation are constraints ($H\Psi=0$ → no time)
- Time (and therefore space-time) have disappeared from the formalism
  - (no time problem)
- For cosmological situations, the degrees of freedom are constrained drastically.
  - In the end, one can use quantum theory in 2D. Singularities can be avoided.
- Extremal or near-extremal balck holes (exotic charge) predicted by string theory
- Primordial black holes of $M\sim10^{14}$gr would evaporate today
  - typical spectrum for gamma-rays (Fermi)
- CERN : only possible for more than 4 dimensions

Audience Questions:
Is MOND similar to quantum expansion of general relativity?
- MOND has more a priori assumptions (ad hoc).

How about loop quantum gravity?
- Canonical approach, but some weak points: problems with semi-classical situations

Which one is the better theory?
- Difficult to say! String theory might be in a dead-end situation

Can gravity remain classical?
- Conceptually it would be possible, but so far no such theory has been successful.

Synergies – Working Leaders Reports

WG 1

Topics Discussed:

Quantum gravity, formation of BH in particle collisions, modeling black hole decays (QCD effects important), BH information problem (get rid of singularities), minimal length in BH solutions (LHC phenomenology), LHC QBH are safe, LHC doing well, interesting event (could be BH or something else),

Synergies:

- primordial BHs

Format of Meeting:

- too many talks in this case
- more time to discuss within the WG and common sessions
- talks for all (common) in very simple language (no jargon), so that everyone gets the point
- worked well, more time would be desirable
- Smaller groups? Private discussions (3-4 people)?

WG3

Format of Meeting:

- Brainstorming, no talks
- More synergy session in the future!! Get to know the other WGs
- Summary session in the end
- WG meet in pairs to maximize the interaction
- In one meeting an overview is devised inside the WG and presented in the next Meeting in the cross-pairing between WGs → translation + common language
- Sufficient time for WG!
- All 4 WGs together makes formation of synergies more difficult! Cross-pairing more efficient

To Do:

- Assess a possible communication problem?
- Translation: Finding a common language between WGs!
- Matter gets closer in than ISCO (modeling required)
- H-K spectral index derivation from flare statistics
- Get X-ray flare statistics to compare to NIR statistics (statistical approach rather than individual flares)

Synergies:

- QPO from X-ray binaries (WG2)
- Angular momentum problem: winds for stars? Disk creation? Mass accreted vs. mass ejected. (WG2)

WG4

Format of Meeting:

- Majority of radio astronomers in the room
- WG4 might need more time for the WG itself → activity off-line between meetings and then more time available for synergy

- Slightly longer time for the WG

To Do:
- Define major scientific and operative areas of activity
- Converge on goals and deliverables
- Converge on a WG core covering all areas
- Explore contact to industry
- Prepare program for 2. WG meeting

Discussion

<u>Can BH be formed by cosmic rays?</u>
- An Austrian group is doing this.
- cosmic rays provide the same bounds as a collider
  - higher energy than colliders but less parameters known/constrained

<u>OJ287:</u>
- test of the no-hair theorem (independent of the size/scale)
- conceptual questions, since experiments (in synergy with WG1) are currently impossible

<u>Any environment with really extreme conditions:</u>
- very high energies
- identify these systems
- find a signature for the effect we're looking for

<u>Cosmic rays have very high energy:</u>
- but one needs many events
- in the end the resulting bounds are similar to colliders

<u>Jet physics:</u>
- energies higher than LHC
- connection of particle physics on Earth and in AGN jet
  - particle interactions
  - gamma-ray production in the jets? (radiation processes)
- opacity mechanisms in jets (very energetic)
  - radiative transfer problem

<u>Connection of SgrA* with WG1?</u>
- Far off from relativistic effects, only connection with the blob in disk model.
- Currently limited by observational instruments.
  - GRAVITY would provide insight (high positional accuracy)
    - instrument should be in place in 3-4 years
    - Cologne group already involved
- Looking whether the blobs move, the core, components in a jet?

Is new physics/exotic physics needed for the interpretation of SgrA*?

- Probably not! So far everything looks fine with classical physics.
- Peri-astron shifts of stars around SgrA*
  - most stars too far away, one would need a long time (2-3 orbits) to determine that
  - even then, probably other pertubors are there → more important

Crucial to find stars closer to SgrA* (within a few mas):

- more orbits, but the closer you get
  - less volume
  - interaction with SgrA*
  - stellar scattering?
- transition point between stars and gas?
- maybe the stars we see now are the last around SgrA*
- tidal forces are only important for giant stars
- other stars are scatter/ejected out of the central region

Investigate other alternatives to BH?

- Objects with solid surface instead of BHs?
  - XRBs point towards a black hole rather than something else

GRBs and formation of BH?

- Not well understood.
- Goes under the question of evolution of BH (accretion?merger?collapse?)
- Evolution from primordial – stellar – intermediate – supermassive ?

Evolution of AGN: mergers, star-formation, cluster dynamics, AGN feedback

Simulations for outflows or accretion flows: very basic and concern all WG.

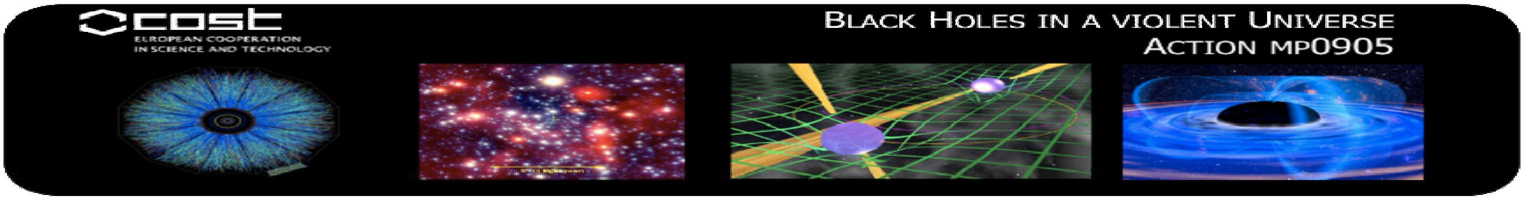
Organization:

- Focused topics, one for each meeting? In this way not everything gets crammed together.
  - First topic: primordial black holes?
- Instead of talks from WG leaders, there should be talks from people concerning the synergy-related topics.

- 14:00-15:00 Organizational issues I.Rottmann&V.Tegethoff

STSM info

Reimbursement info



Participant's List: A B C D E F G H I J K L M N O P Q R S T U V W X Y Z (top)

Aharonian	Felix	DIAS,Dublin	WG4
Alberdi	Antxon	IAA-CSIC	WG4
Angelakis	Emmanouil	MPIfR	WG4
Anton	Sonia	CICGE-Univ.Porto & SIM-Univ. Lisbon	WG4
The role of GAIA for QSO studies (optical astrometry)			
Bremer	Marcus	I. Physikalisches Institut, Universität zu Köln	WG3
Britzen	Silke	MPIfR, Bonn	WG4
Action MP0905; Forum Synergy			
Buchholz	Rainer	I. Physikalisches Institut, Universität zu Köln	WG3
Calmet	Xavier	University of Sussex	WG1
Quantum Black Holes; WG1 Session Summary			
Casanova	Sabrina	MPIK	WG3
Chang	Chin-Shin	Max-Planck-Institut fuer Radioastronomie	WG4
D'Eath	Peter	DAMTP, Univ of Cambridge	WG4
Duschl	Wolfgang J.	ITAP Uni Kiel	WG3
Eckart	Andreas	I. Physik Uni Koeln	WG3
Galactic Centre Black Hole; WG3 Session Summary			
Fischer	Sebastian	I. Physikalisches Institut, Universität zu Köln	WG4
Gabanyi	Krisztina Eva	Research Group for Physical Geodesy and Geodynamic	WG4
Garcia-Marin	Macarena	I Physik. Institut, Universitaet zu Koeln	WG3
Gergely	Laszlo	University of Szeged	WG4
Supermassive black hole binaries			
Hossenfelder	Sabine	NORDITA	WG1
Ilic	Dragana	Department of Astronomy, Faculty of Mathematics, U	WG4

Janiuk	Agnieszka	Copernicus Astronomical Center	WG1
Karouzos	Marios	MPIfR	WG4
Keppens	Rony	Centre for Plasma-Astrophysics, K.U.Leuven	WG4
RH and MHD models for AGN jet propagation and deceleration			
Kiefer	Claus	University of Cologne	WG1
Quantum Gravity			
Kostic	Uros	University of Ljubljana	WG3
Krichbaum	Thomas	MPIfR, Bonn	WG3
Kunert-Bajraszewska	Magdalena	Torun Centre for Astronomy, Poland	WG4
Kunneriath	Devaky	Univerity of Cologne	WG3
Laurentiu Ioan	Caramete	Institute for Space Sciences	WG4
Black hole candidates in the nearby universe			
Lendermann	Victor	University of Heidelberg	WG1
Lobanov	Andrei	MPIfR, Bonn	WG3
Probing the vicinity of supermassive black holes with radio interferometry (radio)			
Mack	Karl-Heinz	Istituto di Radioastronomia - INAF	WG4
Mantovani	Franco	Istituto di Radioastronomia - INAF	WG4
Marquez	Isabel	IAA-CSIC	WG4
Marti-Vidal	Ivan	Max-Planck-Institut fuer Radioastronomie	WG4
Masegosa	Josefa	IAA-CSIC	WG4
Meliani	Zakaria	Centre for Plasma-Astrophysics, K.U.Leuven	WG4
Mezcua	Mar	Max Planck Institute for Radioastronomy (Bonn)	WG4
Micu	Octavian	TU Dortmund	WG1
Moultaka	Jihane	Observatoire Midi-Pyrénées	WG3
Nicolini	Piero	J.W.Goethe University, Frankfurt, Germany	WG1
Niedzwiecki	Andrzej	University of Lodz, Poland	WG4
X/gamma-ray studies of the central engine			
Panessa	Francesca	IASF - Rome (INAF)	WG3

Papadakis	Iossif	University of Crete	WG4
Perez Ramirez	Dolores	Univ. de Jaen - Spain	WG3
Popovic	Luka	Astronomical Observatory, Belgrade	WG4
AGN Spectral Lines and SMBH (X-rays & optical)			
Roland	Jacques	IAP Paris	WG4
Determination of the characteristics of the BBH system using VLBI observations			
Romano	Patrizia	INAF/IASF Palermo	WG4
Ros	Eduardo	Univ. Valencia	WG4
Supermassive Black Holes; WG4 Session Kick-off; WG4 Session Summary			
Rottmann	Izabela	MPIfR	WG1
Rushton	Anthony	ESO	WG2
Stellar Black Holes			
Savolainen	Tuomas	MPIfR	WG4
Subr	Ladislav	Charles University in Prague	WG3
Tegethoff	Viola	MPI für Radioastronomie	WG4
Torkelsson	Ulf	University of Gothenburg, Department of Physics	WG4
Valencia-S.	Monica	I. Physicalisches Institute - Universitaet zu Koel	WG3
Vercellone	Stefano	INAF/IASF Palermo	WG4
Vestergaard	Marianne	Dark Cosmology Centre, Niels Bohr Institute, Denma	WG4
Winstanley	Elizabeth	University of Sheffield	WG1
Witzel	Gunther	I. Physikalisches Institut der Universität zu Köln	WG3
Zensus	Anton	Max-Planck-Institut für Radioastronomie	WG3
Zuther	Jens	University of Cologne	WG4