

Scientific report for the COSPAR satellite conference
"Physics and Astrophysics of Neutron Stars and Black Holes"

July 16-17, 2010
Jacobs University Bremen

1. SUMMARY

In the past decades, compact objects have turned out to be fruitful laboratories for physics under the most extreme conditions. A full understanding of these objects requires General Relativity (space-time curvature effects near black holes and neutron stars), the physics of strong (structure of neutron stars) and weak interactions (neutrino emission and cooling of neutron stars) and solid state and atomic physics in the presence of magnetic fields (neutron star crusts and atmospheres). Moreover, radiative processes (electromagnetic signatures) and gas dynamics are required to understand how compact objects shape their environments (e.g. by energetic outflows into the ambient medium). Often black holes and neutron stars are located in dense stellar environments such as in the centers of galaxies or in globular clusters and in such an environment they can leave a strong dynamical imprint on the surrounding stars. Problems of the above type are prime examples for multi-physics challenges and therefore require intense interaction between experts of different fields for substantial scientific progress.

The aim of this conference was to bring together leading experts in different sub-disciplines for a moderate-size workshop in which intense scientific discussion is possible. We paid particular attention to span a wide range of length scales so that phenomena, say black hole outflows, can be compared from the smallest, say an X-ray binary, to the largest scales, say in a galaxy cluster. Particular emphasis was put on the interaction of scientists between different sub-fields. This was stimulated by long talks (35+5 minutes) with a substantial fraction of review material and long coffee breaks with ample time for discussion and interaction, see also "Final Programme" in Sec. 4. We had intense discussions both directly after the talks and during the coffee sessions. Several new collaborations were initiated during the meeting.

The meeting took place as a satellite meeting to 38th COSPAR assembly which facilitated bringing together world-leading experts to this well-focused meeting. It was held on July 16-17 at Jacobs University Bremen with 41 participants in total.

Organizers:

Marcus Brüggen (Jacobs University Bremen)
Stephan Rosswog (Jacobs University Bremen)

2. DESCRIPTION OF THE SCIENTIFIC CONTENT AND DISCUSSION OF THE EVENT

The workshop brought together people working on a broad range of topics, both from the observational and the theoretical/computational side, with the overarching theme of neutron stars and black holes. Speakers included, both, theorists and observers, and both young scientists, such as doctoral students (14), as well as senior scientists that are leaders in their fields. Participants came from nine different countries and a broad range of institutions, see Sec. 5. Due to the broad range of fields and the fact that many scientists had never met before, the speakers were explicitly encouraged to include a substantial review part into their talks. All speakers were given 35 minutes plus 5 minutes for questions. The introductory parts served to provide the participants with a common language and background and facilitated the subsequent discussion. Discussions also spilled into the coffee and lunch breaks and were continued during the BBQ and the conference dinner. The total number of participants, 41, seemed about right for the purposes of this conference: large enough to allow for substantial diversity, but small enough for in-depth scientific discussions. Overall, the organizers were very pleased with the level of intense scientific communication across the borders of the individual fields.

Topically, the talks can broadly be classified into the following areas which obviously are closely interconnected in various ways:

- *Accretion and the production of jets:*
This area included recent observational progress, in particular in jets launched from neutron stars. These recent findings were then backed-up and brought into the context of our current progress on the jet launch mechanisms based on first principle approaches.
- *Gamma-ray bursts:*
We had an entire afternoon session related to Gamma-ray Bursts (GRB). The two sessions were opened with a review and an update on the most recent results from the current space-based missions such as FERMI and SWIFT with a discussion of the capabilities of future space probes. The session was rounded up by an overview over the state of the art in terms of physical GRB production mechanisms and a report on recent progress in the modeling efforts of GRB central engines.
- *Compact objects as probes of the fundamental theory of gravity:*
The first session on Saturday morning was dedicated to the use of compact objects as probes of the fundamental theory of gravity. Possibilities to test for additional scalar fields, for the strong equivalence principle, for gravitational dipole radiation, for a time-dependent gravitational constant, generally alternative theories of gravity, constraints on extra-dimensions and tests of the “no-hair-theorem” were extensively discussed. One talk was entirely dedicated to the use of neutron stars

and white dwarfs, the other one focused on the use of black holes for these purposes.

- *Co-evolution of black holes, accretion disks and their surroundings:*
The remaining talks dealt with the interactions of black holes with their environments, both their feeding accretion disks and their large-scale environments such as a galaxy cluster. The talks addressed in particular how black hole spins are determined by different accretion periods and how the black hole spin feeds back on the geometries of the surrounding disks. Moreover, the role and impact of turbulence on the growth of black holes was discussed. The remaining talks dealt with questions how outflows from black holes shape the physical properties of the surrounding galaxy cluster medium. Ideas were presented on the role of the spin of the BH in controlling the growth of black holes and regulating centers of galaxy clusters. Other talks focused on the mounting evidence for the effect of AGN-powered jets on cluster centers. New observational evidence was presented that showed how AGN redistribute metals over large distances. Finally, in a number of talks detailed observations on nearby clusters were shown that revealed the history of accretion and outbursts over very long time scales.

3. ASSESSMENT OF THE RESULTS AND IMPACT OF THE EVENT ON THE FUTURE DIRECTION OF THE FIELD

The workshop showed a lot of promise for having a strong impact on the future development of the field. In particular, it brought together two groups of scientists (working on more stellar-mass scale objects and those working on AGNs and galaxy clusters) that work on apparently similar topics, but still rarely meet. The organizers learnt from several of the participants that they had met and discussed with people they knew previously only from their publications. In particular, the workshop revealed several regions of substantial overlap between the study of accretion states in neutron stars/stellar mass black holes and their much larger counterparts, the supermassive black holes in active galactic nuclei. Here a lot of common ground for future collaborations has been identified and we are very confident that several new collaborations have been started during this conference and that we will see many interesting results as an outcome of these collaborations. After the conference, the organizers received a lot of unsolicited, positive feedback in particular on the interactive character of the meeting.

Already now, it seems that the workshop has stimulated new collaborations in the following fields:

- *Accretion onto black holes:*
Intense discussions during the workshop resulted in new, well-defined projects between scientists working mainly (semi-)analytically and those working with full-fledged hydrodynamical methods (Beloborodov, Dan, King, Nixon, Rosswog). The

future will see a couple of results that have been initiated at this workshop.

- *Black holes in Galaxy clusters:*

In the field of the role of black holes on galaxy clusters, which are the largest cosmological structures, new projects between observers (Wise, McNamara, Simionescu, Kraft) and theorists (Scannapieco, King, Churazov) have been kicked off. As a result of this workshop, Ralph Kraft from Harvard University, has decided to spend a few months at the end of this year at Jacobs University to pursue ideas developed at this workshop.

4. FINAL PROGRAMME OF THE MEETING

Friday July 16, 2010

Time	Speaker	Convenor
09:30 - 10:10	Sebastian Heinz: "Jets from Neutron Stars"	Rosswog
10:10 - 10:50	Max Camenzind: "Relativistic Jets from Black Holes Systems"	
10:50 - 11:30	Coffee Break	
11:30 - 12:10	Sera Markoff: "New insights into AGN evolution from X-ray binary accretion state"	Brüggen
12:10 - 12:40	Iossif Papadakis: "X-ray variability of radio-quiet AGN"	
12:40 - 14:00	Lunch Break	
14:00 - 14:40	Chryssa Kouveliotou: "Magnetar observations in the Swift-Fermi/GBM era"	Rosswog
14:40 - 15:20	Kevin Hurley: "An overview of current gamma-ray burst experiments"	
15:20 - 16:00	Neil Gehrels: "Recent GRB results from Swift"	
16:00 - 16:30	Coffee Break	
16:30 - 17:10	Josh Grindlay: "Do short GRBs as 'standard candles' EXIST?"	Rosswog
17:10 - 17:50	Andrei Beloborodov: "Mechanism of GRBs"	
17:50 - 18:30	Luciano Rezzolla: "Towards building a self-consistent picture of sGRBs"	

19:30 BBQ on campus

Saturday July 17, 2010

Time	Speaker	Convenor
09:30 - 10:10	Michael Kramer: "Compact objects as laboratories for fundamental physics"	Rosswog
10:10 - 10:50	Dimitrios Psaltis: "Tests of strong-field gravity with neutron stars and black holes"	
10:50 - 11:30	Coffee Break	
11:30 - 12:10	Eugene Churazov: "AGN feedback and the gas hydrostatic equilibrium"	Beloborodov
12:10 - 12:40	Andrew King: "Evolution of black hole spin"	
12:40 - 14:00	Lunch break	
14:00 - 14:40	Evan Scannapieco: "The role of AGN turbulence in black hole growth"	Churazov
14:40 - 15:20	Brian McNamara: "AGN feedback and black hole spin"	
15:20 - 16:00	Michael Wise: "AGN outbursts as diagnostics of SMBH accretion and growth"	
16:00 - 16:30	Coffee Break	
16:30 - 17:10	Ralph Kraft: "Accretion and feedback in the nearest active galaxy: Centaurus A"	Brüggen
17:10 - 17:30	Aurora Simionescu: "Evidence for AGN feedback from clusters of galaxies"	

5. PARTICIPANTS

Dr.	Araya-Melo	Pablo	Jacobs University Bremen, Germany
Mr.	Bayraktar	Kutalmish	Istanbul University, Turkey
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