Research Training Group
Graduiertenkolleg
Models of Gravity

Spring Workshop 2020

02. – 04. March 2020

ZARM, University of Bremen

List of speakers:

- Marek Abramowicz (Göteborg)
- Torsten Asselmeyer-Maluga (Berlin)
- Matthias Bartelmann (Heidelberg)
- Leo Brunswick (Lyon)
- Pedro Cunha (Potsdam)
- Andreas Eckart (Köln)
- Shoukufe Faraji (Bremen)
- Victoria Grinberg (Tübingen)
- Hildegard Meyer-Ortmanns (Bremen)
- Anna Nelles (Erlangen)
- Gonzalo Olmo (Valencia)
- Axel Pelster (Kaiserslautern)
- Marvin Pinkwart (Bremen)
- Boris Vertmann (Oldenburg)

Abstracts:

Marek Abramowicz (Göteborg)

2 talks:

1. Title: The Fast Radio Bursts

Abstract:
I present a detailed update on a particular model for the FRBs which explains the phenomenon as collisions of Primordial Black Holes with Neutron Stars. The energy reservoir for the FRB is in the NS magnetosphere. The model explains the high event rates of FRB, their energetic, short duration, and the fact that some of the FRB repeat in the same source.

2. Title: Gravitational waves from ultra compact stars and on the EHT images of ultra compact stars and wormholes.

Torsten Asselmeyer-Maluga (Berlin)

Titel: Cosmology and 4-manifolds: a geometric/topological model of dark matter and dark energy

Abstract:
Smooth Quantum Gravity is the trial to solve some fundamental problems in physics (like dark matter/energy and/or quantum gravity) using first principles. Here, the topology of the spacetime is fixed whereas the differential topology of the spacetime is changed (also known as exotic smoothness structure). But what are the consequences of this ''small change''? In this talk, I will give an overview of the results to use differential topology in cosmology. Using deep results of exotic 4-manifolds, our cosmological model has an inflationary behaviour (in agreement with the Planck results). In particular, we are able to reproduce the Starobinsky model. As a byproduct, parameters like the number of e-folds or the energy scales are topological invariants and can be determined. Furthermore, we will get a model for all types of matter (including dark matter) so that we will obtain values for the neutrino masses.The reason for inflation is identified as decoherence process from the quantum state at the big bang to a classical 3-manifold. The impact on the formation of dark energy as cosmological constant and of dark matter is also discussed.

Matthias Bartelmann (Heidelberg)

Title: Cosmic structure formation with analytic methods

Abstract:
Kinetic field theory (KFT) has been developed in recent years to study structure formation in ensembles of classical particles in and out of equilibrium. In a straightforward manner, KFT can be specialised to cosmology, where it allows to calculate highly non-linear power spectra of cosmic density fluctuations with analytic means. I will summarize the main concepts of KFT and its cosmological applications and show how the flexibility of KFT can be used to study structure formation with large varieties of dark-matter models or generalised theories of gravity.

Leo Brunswick (Lyon)

Title: Some known effects of topology on the large scale behaviour of a spacetime

Abstract:
We introduce Buchert's scalar averaging for dust fluid orthogonal foliation in dimension N and show how the Euler characteristic (a topological invariant) plays a role in the large scale behaviour of a spacetime filled with an irrotational pressureless fluid. We also present other heuristic arguments pointing toward a dark energy like effects coming from topology.

Pedro Cunha (Potsdam)

Title: 100 years of light deflection, where we are now: EHT, scalar hair and the M87 supermassive black hole

Abstract:
Hypothetical ultralight bosonic fields will spontaneously form macroscopic bosonic halos around Kerr black holes, via superradiance, transferring part of the mass and angular momentum of the black hole into the halo. Such process, however, is only efficient if resonant: when the Compton wavelength of the field approximately matches the gravitational scale of the black hole. For a complex-valued field, the process can form a stationary, bosonic field-black hole equilibrium state - a black hole with synchronised hair. For sufficiently massive black holes, such as the one at the centre of the M87 supergiant elliptic galaxy, the hairy black hole can be robust against its own superradiant instabilities, within a Hubble time. Studying the shadows of such scalar hairy black holes, we constrain the amount of hair which is compatible with the Event Horizon Telescope (EHT) observations of the M87 supermassive black hole, assuming the hair is a condensate of ultralight scalar particles of mass ~1E−20 eV, as to be dynamically viable. We show the EHT observations set a weak constraint, in the sense that typical hairy black holes that could develop their hair dynamically, are compatible with the observations, when taking into account the EHT error bars and the black hole mass/distance uncertainty.

Shoukufe Faraji (Bremen)

Title: Thin Accretion disk around a distorted static black hole

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Victoria Grinberg (Tübingen)

Title: X-ray binaries as observational probes for black hole physics

Abstract:
X-ray binaries, i.e., binary stellar systems consisting of a neutron star or a black hole that accretes matter from a normal star companion, are among the brightest sources in the X-ray sky. These X-ray binaries are highly dynamic, with variability scales ranging from millisecond quasiperiodic oscillations and hour- and day-long orbital periods to year-long activity cycles. They change not merely in brightness, but in the very physical processes that cause the X-ray emission. I will show that X-ray binaries are among the most important objects of today's astrophysics and particularly address how we can use observations of X-ray binaries with X-ray and gamma-ray telescopes to probe the physics under the conditions of extreme gravity in the very vicinity of black holes.

Hildegard Meyer-Ortmanns (Bremen)

Title: The Physics of Complex Systems and the Search for Universal Mechanisms

Abstract:
What makes a complex system complex? We start with a summary of features which make dynamical systems complex, followed by a short overview of typical complex systems. Specific for the approach from physics is the search for overarching or even universal mechanisms in the huge variety of dynamical phenomena, ranging from the micro- to the macro-scale. What deserves to be termed laws on the scale of fundamental interactions like gravity will be replaced by principles or mechanisms on the meso- and macro-scale. With examples from winnerless competition, critical phenomena and some other fields of research, we illustrate universal behavior that is indeed striking in view of the quite different physical realizations of the respective systems sharing such properties. We also indicate which mathematical frameworks are suited to capture universal aspects.

Anna Nelles (Erlangen)

Title: Radio Detection of Neutrinos

Abstract:
Multi-messenger Astronomy is opening new windows in our universe. For example, the combination

of high energy neutrinos with gamma rays hints at exciting sources of ultra-high energy cosmic rays. The golden event would be the combination of neutrinos, gamma rays and gravitational waves. However, to fully explore this, both more neutrinos and neutrinos of even higher energies are needed, and to this end, better detectors.

I will review the radio detection of neutrinos as tool to measure cosmic neutrinos above PeV up to tens of EeV energies. Such a detection will have implications for astrophysics, as well as for fundamental physics.

Gonzalo Olmo (Valencia)

2 talks

1 Title: Particle creation by wormholes? A toy model.

Abstract:
Wormholes are regarded as exotic solutions of gravitational theories which could represent an alternative to compact objects such as black holes. Given that quantum states are defined globally, the nontrivial topological structure of wormholes must necessarily influence the properties of the vacuum state, which is the basic element on which particle states are built in a Fock quantization. Therefore, in analogy with the case of black holes, one may wonder whether wormholes could lead to particle production. Will the vacuum state perceived by an observer on one side of the wormhole coincide with the vacuum state on the other side? If they do not coincide, what effects (number of particles, radiation fluxes, …) will be felt by an observer going through the hole? In this talk these basic questions will be addressed in a quantitative manner considering a simplified wormhole model in 1+1 dimensions.

2 Title: Visibility and impact of your research

Abstract:
The number of research papers published every day in gr-qc, hep-th, and astro-ph, averaged over 80 papers per day in 2019 and those numbers are growing. What makes your paper more interesting than the others? How can you increase the visibility and impact of your research? How do you measure that "impact"? Institutions and selection committees care about publication in prestigious outlets but also want their staff to become well-known and well-regarded in their fields. How can you build a reputation in your field? I will talk about the social dimension of science and its relevance for a successful scientific career in the XXI century. I will introduce some useful tools and tips that may help design a strategy to improve your visibility in the scientific community.

Axel Pelster (Kaiserslautern)

Title: Bose-Einstein Condensation in Microgravity - Challenges and Perspectives

Nowadays, ultracold quantum gases are considered to be ideal quantum simulators, that is, they are best capable to simulate difficult quantum problems in condensed matter physics and other fields of physics as proposed by Richard Feynman from 1982. This appraisal stems from the fact that systems of bosonic or fermionic quantum gases allow for a very high level of experimental tunability concerning all ingredients of the underlying many-body Hamiltonian. Here we report about the recent emergence of an additional differential geometric control knob, which is provided by spatially confining a Bose-Einstein condensate (BEC) in a bubble trap. On earth, due to the gravitational sag, the Bose gas tends to concentrate on the bottom of the bubble trap. However, at the Cold Atom Laboratory at the International Space Station a BEC can be realized in a bubble trap in microgravity.

To this end, we describe a weakly interacting Bose gas on a curved manifold, which is embedded in the three-dimensional Euclidean space by considering a harmonic trap in the normal direction of the manifold, which confines the three-dimensional Bose gas in the vicinity of its surface. Following the notion of dimensional reduction, we assume a large enough trap frequency so that the normal degree of freedom of the condensate wave function can be approximately integrated out. In this way we obtain an effective condensate wave function on the quasi-two-dimensional surface of the curved manifold, where the thickness of the cloud is determined self-consistently. For the particular case when the manifold is a sphere, our equilibrium results show how the chemical potential and the thickness of the cloud increase with the interaction strength. Furthermore, we determine within a linear stability analysis the low-lying collective excitations together with their eigenfrequencies, which turn out to reveal an instability for attractive interactions.

Marvin Pinkwart (Bremen)

Title: Quantum Aspects of Cosmology

Boris Vertmann (Oldenburg)

Title: Mean curvature flow of space-like hypersurfaces

PUBLIC TALK

Location: “Haus der Wissenschaft”

Matthias Bartelmann (Heidelberg)

Title: Schwarze Löcher, Gravitationswellen und das Schicksal des Universums

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OLBERS LECTURE

Location: Hochschule Bremen, Hörsaal B-120

Andreas Eckart (Köln)

Title: Die Kerne von Galaxien: Vom Galaktischen Zentrum bis zu Quasaren

Abstract:
Die zentralen Regionen von Milchstraßen sind äußerst aktive Gebiete. Hier gibt es eine Wechselwirkung zwischen super-massereichen Schwarzen Löchern und ihrer unmittelbaren Umgebung, die aus Gas, Staub und Sternen besteht.
Der Vortrag fasst die wichtigsten Ergebnisse zusammen, die in jüngster Zeit zu dem Zentrum unserer Milchstraße sowie den Kernen einiger naher aktiver Galaxien gewonnen wurden. Hierbei kommen die neusten Instrumente und Teleskope zum Einsatz: das Large Atacama Millimeter Array (ALMA), das Event Horizon Telescope (EHT) und das Very Large Telescope Interferometer (VLTI). Inzwischen kann man den Nachweis erbringen, dass sich Sterne und Gas auf relativistischen Bahnen im Schwerefeld der super-massereichen Schwarzen Löcher bewegen. Die Kerne von Galaxien stellen somit ein einzigartiges Laboratorium dar, in dem die Physik der Superlativen untersucht werden kann.