Nordic Winter School on Particle Physics and Cosmology 2022

Report of Contributions

https://indico.nbi.ku.dk/e/NordicWinterSchool2022

Contribution ID: **1** Type: **Student Talks**

How perturbative QCD constrains the Equation of State at Neutron-Star densities

Sunday, February 6, 2022 8:00 PM (20 minutes)

The rapid evolution of neutron-star astronomy in recent years is for the first time giving us empirical access to the physics of the cores of neutron-stars, the internal structure of which is determined by the equation of state (EoS) of strongly interacting matter. In this talk I demonstrate in a general and analytic way how high-density information about EoS of strongly interacting matter obtained using perturbative Quantum Chromodynamics constrains the same EoS at densities reachable in physical neutron stars. The results can be used to propagate the pQCD calculations reliable around 40ns to lower densities (starting from 2.2 ns) in the most conservative way possible. These purely theoretical results are independent of astrophysical neutron-star input and hence they can also be used to test theories of modified gravity and BSM physics in neutron stars.

Presenter: KOMOLTSEV, Oleg

Track Classification: Student Talks

Contribution ID: **2** Type: **Student Talks**

Stochastic inflation from QFT and the parametric dependence of the effective noise amplitude

Sunday, February 6, 2022 8:20 PM (20 minutes)

During inflation, quantum field fluctuations are placed in squeezed states which undergo quantum-to-classical transitions on super-Hubble scales, in the sense that the non-commutative parts of the fields then become small compared to their anti-commutative parts. An effective theory for the physics of the long-wavelength parts of quantum scalar fields in the super-Hubble regime is the stochastic inflation formalism. In this framework, the non-linear dynamics of the long-wavelength perturbations may be phrased in terms of an effective classical, but stochastic evolution equation. The stochastic noise represents short-wavelength modes which continually redshift into the long-wavelength domain during the inflationary expansion. Long-wavelength observables can be computed from a corresponding Fokker-Planck equation, and has been shown to reproduce the correct IR behaviour of the full QFT statistical propagator to leading order in the coupling. This has made stochastic inflation a popular resummation method in the cosmological context, yet its range of validity compared to other QFT methods remain unclear. In this talk I will discuss some recent progress related to how the stochastic dynamics may be derived from first-principles QFT in an expanding background through a sequence of approximations.

Presenter: ERIKSSON, Magdalena

Track Classification: Student Talks

Contribution ID: **3** Type: **Student Talks**

From Non-relativistic to Post-Newtonian Gravity

Sunday, February 6, 2022 8:40 PM (20 minutes)

In recent years a covariant 1/c-expansion of general relativity, known as non-relativistic gravity, has been developed. This new expansion has many interesting prospects but much is still unknown about it. One thing that remains unclear is what connection, if any, it has to the post-Newtonian approximation. So far, Non-relativistic gravity is believed to be a more general approximation that under certain simplifying assumptions becomes equivalent to the post-Newtonian approximation. In the talk I will explain why this is believed to be true and I will describe some of the efforts that my supervisor Jelle Hartong and I are making to validate this. Furthermore, I will discuss how non-relativistic gravity might be able to improve upon certain aspects of the post-Newtonian approximation if a connection between them is made.

Presenter: MUSAEUS, Jørgen

Track Classification: Student Talks

Contribution ID: **4** Type: **Student Talks**

Carrollian and celestial spaces at infinity

Sunday, February 6, 2022 9:00 PM (20 minutes)

I will discuss how the geometry of the asymptotic infinities of 4-dimensional Minkowski spacetime is captured by homogeneous spaces of the Poincaré group. In addition to the blowups of spatial (Spi) and timelike (Ti) infinities a la Ashtekar-Hansen, which are (pseudo-)carrollian geometries, this construction naturally leads to a novel space Ni that fibers over scri and is equipped with a doubly-carrollian structure. All these spaces embed into a 6-dimensional pseudo-euclidean space of signature (-,-,+,+,+,+), which generalises a similar construction for Minkowski space by Penrose and Rindler. Finally, I will discuss how these geometries can be made dynamical via a gauging procedure.

Presenter: HAVE, Emil

Track Classification: Student Talks

Contribution ID: **5** Type: **Student Talks**

Higher spin formalisms

Monday, February 7, 2022 8:00 PM (20 minutes)

Motivated by higher spin scattering amplitudes in gravity, we review and compare the interactions of higher spin fields in different formalisms

Presenter: STRID, Rasmus

Track Classification: Student Talks

Contribution ID: **6** Type: **Student Talks**

Understanding causality in the effective field theory of gravity

Monday, February 7, 2022 8:20 PM (20 minutes)

Effective field theory (EFT) is a theory-agnostic approach to understanding how high-energy phenomena would manifest in our low-energy universe. It is an expansion in higher-dimension operators built out of light fields with unknown coefficients. These coefficients can either be constrained through experiment or by demanding consistency with theoretical expectations, such as causal wave propagation. In dynamical gravitational EFTs, where there is no globally defined lightcone, defining causality is a nuanced problem. In this talk, using Gauss-Bonnet gravity as an example, I will explain why the recently introduced "infrared" causality is the correct criterion for determining consistency of low-energy EFTs. The crucial ingredient will be properly identifying the "regime of validity" of the EFT expansion, and recognising that it is only sensible to ask whether it is causal within that regime. Based on arXiv:2112.05031.

Presenter: MARGALIT, Aoibheann

Track Classification: Student Talks

Contribution ID: **7** Type: **Student Talks**

Resonances, black hole mimickers and the greenhouse effects: consequences for gravitational-wave physics

Monday, February 7, 2022 8:40 PM (20 minutes)

Ultracompact objects with photonspheres are known to mimic many observational features of black holes. It has been suggested that anomalous tidal heating or the presence of resonances in gravitational-wave signals would be a clear imprint of a surface or the absence of a horizon. Such claims and studies are all based on a frequency-domain analysis, assuming stationarity. In this talk, we will see that the object needs to first "fuel-up"until it reaches the stationary regime. The presence of a stable light ring and large light-travel times inside the object may in fact delay enormously the "charging-up"and effectively contribute to the effacement of structure. In other words, black hole mimickers behave as black holes more efficiently than previously thought. Our results have implications for other resonant systems with sharp resonances, including "floating orbits"around spinning black holes.

Presenter: DUQUE, Francisco

Track Classification: Student Talks

Contribution ID: **8** Type: **Student Talks**

Double copy and massless free fields in curved spacetime

Tuesday, February 8, 2022 8:00 PM (20 minutes)

Assuming any massless free-fields with spin higher than 1/2 are constructed by scalar fields (spin-0) and Dirac-Weyl fields (spin-1/2), we introduce a map between spin-2 massless free-fields (gravity fields) and Dirac-Weyl fields in spinor formalism, then associated Dirac-Weyl spinors that can live in certain spacetime are identified. Regarding them as basic units, other higher spin massless free-fields are built. In this way, some hidden fundamental features related to massless-free fields are revealed. In particular, we systematically rebuild the double copy for type N and type D spacetime. We further extend the study to vacuum non-twisting type III solutions, we find there is a special Dirac-Weyl scalar whose square is just proportional to Weyl scalar, then a degenerate Maxwell field is constructed with the aid of an auxiliary scalar field, both fields not only satisfy their field equation in the curved background spacetime, but also in flat spacetime. The result further confirms that there must exist a deep connection between gravity theory and Yang-Mills gauge theory.

Presenter: SHANZHONG, Han

Track Classification: Student Talks

Contribution ID: **9** Type: **Student Talks**

Kerr Black Holes and Higher-Spin Compton Scattering

Tuesday, February 8, 2022 8:20 PM (20 minutes)

Quantum scattering amplitudes for massive matter have received new attention in connection to classical calculations relevant to gravitational-wave physics. Amplitude methods and insights are now employed for precision computations of observables needed for describing the gravitational dynamics of bound massive objects such as black holes. An important direction is the inclusion of spin effects needed to accurately describe rotating (Kerr) black holes. Higher-spin amplitudes introduced by Arkani-Hamed, Huang and Huang at three points have by now a firm connection to the effective description of Kerr black-hole physics. The corresponding Compton higher-spin amplitudes remain however an elusive open problem. Here we draw from results of the higher-spin literature and show that physical insights can be used to uniquely fix the Compton amplitudes up to spin 5/2, by imposing a constraint on a three-point higher-spin current that is a necessary condition for the existence of an underlying unitary theory. We give the unique effective Lagrangians up to spin 5/2, and show that they reproduce the previously-known amplitudes. For the multi-graviton amplitudes analogous to the Compton amplitude, no further corrections to our Lagrangians are expected, and hence such amplitudes are uniquely predicted. As an essential tool, we introduce a modified version of the massive spinor-helicity formalism which allows us to conveniently obtain higher-spin states, propagators and compact expressions for the amplitudes.

Presenter: PICHINI, Paolo

Track Classification: Student Talks

Contribution ID: **10** Type: **Student Talks**

SUSY in the sky with gravitons

Tuesday, February 8, 2022 8:40 PM (20 minutes)

The worldline quantum field theory (WQFT) formalism describes classical gravitational observables including spin effects up to quadratic order in the multipole expansion, and including finite-size corrections. The theory enjoys an N=2 worldline supersymmetry between spin and position degrees of freedom. Recently we have used the WQFT to compute gravitational observables at third Post-Minkowskian (PM) order including quadratic-in-spin effects and radiation-reaction effects. I will discuss this spinning WQFT and our recent 3PM results. I will also consider how our approach is related to other approaches currently used in the PM expansion.

Presenter: JAKOBSEN, Gustav

Track Classification: Student Talks

Contribution ID: **11** Type: **Lectures**

Pound Lecture 1: gravitational wave astronomy, the two-body problem, and self-force theory

Sunday, February 6, 2022 8:00 AM (1 hour)

Gravitational wave astronomy: present and future
Gravitational self-force theory

Presenter: POUND, Adam

Track Classification: Adam Pound

Contribution ID: **12** Type: **Lectures**

Pound Lecture 2: the local problem: how to deal with small bodies

Sunday, February 6, 2022 3:00 PM (50 minutes)

Perturbation theory in GR
Small bodies and punctures
Point particles and mode-sum regularization Regularization via Green's functions
Point particles beyond linear order

Presenter: POUND, Adam

Track Classification: Adam Pound

Contribution ID: **13** Type: **Lectures**

Pound Lecture 3: the global problem: orbital dynamics in Kerr

Sunday, February 6, 2022 3:55 PM (50 minutes)

Geodesic motion in Kerr
Perturbed motion in Kerr
Transient resonances

Presenter: POUND, Adam

Track Classification: Adam Pound

Contribution ID: **14** Type: **Lectures**

Pound Lecture 4: the global problem: black hole perturbation theory

Monday, February 7, 2022 8:30 AM (1 hour)

Multiscale expansion of the field equations
Results at 0PA order
Results at 1PA order

Presenter: POUND, Adam

Track Classification: Adam Pound

Contribution ID: **15** Type: **Lectures**

Haney Lecture 1:

Sunday, February 6, 2022 5:15 PM (50 minutes)

Presenter: HANEY, Maria

Track Classification: Maria Haney

Contribution ID: **16** Type: **Lectures**

Haney Lecture 2:

Sunday, February 6, 2022 6:10 PM (50 minutes)

Presenter: HANEY, Maria

Track Classification: Maria Haney

Contribution ID: **17** Type: **Lectures**

Haney Lecture 3:

Monday, February 7, 2022 3:00 PM (50 minutes)

Presenter: HANEY, Maria

Track Classification: Maria Haney

Contribution ID: **18** Type: **Lectures**

Haney Lecture 4:

Monday, February 7, 2022 3:55 PM (50 minutes)

Presenter: HANEY, Maria

Track Classification: Maria Haney

Contribution ID: **19** Type: **Lectures**

Kosower Lecture 1:

Monday, February 7, 2022 5:15 PM (50 minutes)

Presenter: KOSOWER, David

Track Classification: David Kosower

Contribution ID: **20** Type: **Lectures**

Kosower Lecture 2:

Monday, February 7, 2022 6:10 PM (50 minutes)

Presenter: KOSOWER, David

Track Classification: David Kosower

Contribution ID: **21** Type: **Lectures**

Levi Lecture 1:

Tuesday, February 8, 2022 8:30 AM (1 hour)

Presenter: LEVI, Michèle

Track Classification: Michèle Levi

Contribution ID: **22** Type: **Lectures**

Levi Lecture 2:

Tuesday, February 8, 2022 3:00 PM (50 minutes)

Presenter: LEVI, Michèle

Track Classification: Michèle Levi

Contribution ID: **23** Type: **Lectures**

Levi Lecture 3:

Tuesday, February 8, 2022 3:55 PM (50 minutes)

Presenter: LEVI, Michèle

Track Classification: Michèle Levi

Contribution ID: **24** Type: **Lectures**

Levi Lecture 4:

Wednesday, February 9, 2022 8:30 AM (50 minutes)

Presenter: LEVI, Michèle

Track Classification: Michèle Levi

Contribution ID: **25** Type: **Lectures**

Obers Lecture 1:

Tuesday, February 8, 2022 5:15 PM (50 minutes)

Presenter: OBERS, Niels

Track Classification: Niels Obers

Contribution ID: **26** Type: **Lectures**

Johansson Lecture 1:

Tuesday, February 8, 2022 6:10 PM (50 minutes)

Presenter: JOHANSSON, Henrik

Track Classification: Henrik Johansson

Contribution ID: **27** Type: **Lectures**

Kosower Lecture 3:

Wednesday, February 9, 2022 3:00 PM (50 minutes)

Presenter: KOSOWER, David

Track Classification: David Kosower

Contribution ID: **28** Type: **Lectures**

Kosower Lecture 4:

Wednesday, February 9, 2022 3:55 PM (50 minutes)

Presenter: KOSOWER, David

Track Classification: David Kosower

Contribution ID: **29** Type: **Lectures**

Nielsen Lecture 1:

Wednesday, February 9, 2022 5:15 PM (50 minutes)

Presenter: NIELSEN, Alex

Track Classification: Alex Nielsen