PAFT 2018 Problemi Attuali di Fisica Teorica

Current Problems in Theoretical Physics

Quantum Mechanics, Fields, Gravity, Cosmology, Gravitational waves

XXIV Edition - March 24 - 28, 2018
Lloyd's Baia Hotel- Vietri sul Mare (Italy)

Abstract Book

24 - 25 March
Quantum Information & Information Geometry
Chairpersons: E. Ercolessi, P. Facchi

26 March
Gravitational waves
Chairpersons: V. Ferrari, L. Gualtieri

27 March
Topics in non perturbative Quantum Field Theory
Chairperson: L. Rosa

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Cosmology and Theories of gravity
Chairperson: S. Capozziello

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PAFT 2018

Current Problems in Theoretical Physics

Quantum Mechanics, Fields, Gravity, Cosmology, Gravitation Waves

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Programm

Saturday 24
Quantum Information & Information Geometry
Chair: Ercolessi / Facchi

9:00 -9:45	F.M. Ciaglia	The space of quantum states, relative entropies and metric tensors
9:45 – 10:30	A. De Pasquale	A dynamical approach to noisy evolution
10:30 – 11:00	Coffee Break	
11:00 – 11:45	G. Magnifico	Topological QED in 1+1 dimensions
11:45 – 12:30	D. Pomarico	Bound states and entanglement generation in waveguide quantum electrodynamics
	Lunch	
15:00 – 15:45	F. Ciccarello	Open dynamics of a quantum system driven by a single photon
15:45 – 16:30	G. Scarpa	Computational complexity of PEPS zero testing
16:30 – 17:00	Coffee Break	
17:00 – 17:45	L. Catani	Csirelson’s bounds as a refinement of Landauer’s principle

Sunday 25
Quantum Information & Information Geometry
Chair: Ercolessi / Facchi

9:00 -9:45	S. Pascazio	Entanglement critical length at the many-body localization transition
9:45 – 10:30	D. Vodola	Twins Percolation for Qubit Losses in Topological Color Codes
10:30 – 11:00	Coffee Break	
11:00 – 11:45	S. Pappalardi	Scrambling and entanglement spreading in long-range spin chains
11:45 – 12:30	D. Rossini	Chiral edge modes and crystalline phases in atomic synthetic ladders

Monday 26
Gravitational waves
Chair: Ferrari / Gualtieri

9:30 -10:05	P. Astone	Present results and future challenges with the network of gravitational wave detectors
10:05 – 10:430	S. Piranomonte	GW170817 optical/NIR follow-up observations: the first evidence of kilo novae existence
10:40 – 11:05	Coffee break	
11:05 – 11:40	W. Del Pozzo	Tests of general relativity from binary black hole coalescences
11:40 – 12:15	M. De Laurentis	Constraining alternative theories of gravity using GW150914 and GW151226
12:15 – 12:30	T. Abdelsalhin	Tidal deformations in inspiralling compact binary systems
12:30 – 12:45	F. Jimenez Forteza	Indistinguishability of high-PN tidal effects on BNS waveform models.
12:45 – 13:00	C. Pacilio	Quasinormal modes of general Einstein-Maxwell-dilaton theory
	Lunch	
14:30 – 15:05	R. Schneider	The formation and coalescence sites of the first gravitational wave events
15.05-15.40	F. Haardt	Massive black holes in galactic nuclei: dynamics, cosmic evolution and gravitational wave emission
15.40-16.10	Coffee break	
16.10-16.45	A. Maselli	Solving the relativistic inverse stellar problem through gravitational wave observations of binary neutron stars
16.45-17.20	A. Perego	Multimessenger constraints on the equation of state of neutron stars

Tuesday 27

Topics in nonperturbative Quantum Field Theory

Chair: Rosa / Percacci - Vacca / Mastropietro

9:00 -9:45	V. Mastropietro	Anomalies, Constructive QFT and Universality in solid state physics
9:45 – 10:30	C. Dappiaggi	On the role of boundary conditions in the quantization of Bosonic field theories on AdS spacetime
10:30 – 11:00	Coffee Break	
11:00 – 11:45	R. Percacci	Asymptotic safety
11:45 – 12:30	G.P. Vacca	Selected topics on the functional renormalization group and its applications
	Lunch	
15:00 – 15:45	F. Siringo	Exploring Non-Perturbative QCD by Perturbation Theory: an Analytical Study of the Yang-Mills Sector in the IR
15:45 – 16:30	M. Panero	An overview of the lattice approach to strongly coupled quantum field theory
16:30 – 17:00	Coffee Break	
17:00 – 17:45	F. Becattini	Thermodynamic equilibrium with acceleration and the Unruh effect
17:45 – 18:05	L. Petruzziello	On the role of neutrino mixing in accelerated proton decay
18.05-18.30	L. Smaldone	Dynamical generation of fermion mixing

Wednesday 28

Cosmology and Theories of gravity

Chair: Zerbini / Cianci / Scarpigli

9:00 - 9:30	M. Della Valle	Probing the Transient Universe with Supernovae, Hypernovae and Kilonovae in the GWs era
9:30 – 10:00	M. De Laurentis	Test-particle dynamics in general spherically symmetric black hole spacetimes
10:00 – 10:30	G. Covone	Is Dark Matter really collisionless? Recent insights from astronomical observations
10:30 – 11:00	L. Amati	THESEUS mission
11:00 – 11:30	Coffee Break	
11:30 – 12:00	L. Fatibene	Observability and tests in Palatini f(R)-theories
12:00 – 12:30	R. Giambò	Black holes from gravitational waves
12:30 – 13:00	A. Mazumdar	Singularity free, Ghost free & Infinite derivative gravity
	Lunch	
14:30 – 15:00	M. Rinaldi	Scale-invariant gravity and inflation
15:00 – 15:30	P. Mastrolia	Diagrammatic approach to the gravitational two-body dynamics
15:30 – 16:00	G. Esposito A. Tartaglia	Looking for a new test of general relativity in the solar system. I/II
16:00 – 16:30	E. Piedipalumbo	Cosmology with high redshift distance probes: A Gamma-Ray Bursts and Quasars Hubble diagram
16:30 – 17:00	Coffee Break	
17:00 – 17:30	L. Sebastiani	Action growth for static black holes in modified gravity
17:30 – 18:00	C. Stornaiolo	Tomographic analysts of the quantum cosmological models of the de Sitter universes
18:00 – 18:20	L. Buoninfante	Insights into infinite derivative gravity from curvature tensors

Wednesday 28
Cosmology and Theories of gravity
Chair: Zerbini / Cianci / Scarpigli

18:20 – 18:40	G. Harmsen	Quasinormal modes for spin-3/2 _elds near an N-dimensional Reissner-Nordstrom black hole.
18:40 – 19:00	F. Di Filippo	Minimally modified theories of gravity: a playground for testing the uniqueness of general relativity
19:00 – 19:20	R. D'Agostino	Cosmic acceleration from Anton-Schmidt's equation of state
19:20 – 19:30	O. Luongo	TBA

Abstract

Quantum Information & Information Geometry

LORENZO CATANI
University College London UK

Csirelson's bounds as a refinement of Landauer's principle

I will present a simple single qudit protocol that computes a non-linear function. It consists of a system in a fixed state, two gates controlled by classical dits (d-level systems) and a fixed measurement. The goal is to choose gates to optimise the average probability over all input combinations of dits to obtain the target non-linear function as output.
I will show that any strategy in the single-qudit protocol can be mapped to a strategy in a two qudits CHSH game, thus obtaining the known classical Bell bounds for the strategies that only involve classical reversible computation or quantum stabiliser computation, and Csirelson's bounds for general quantum strategies. Since the single qudit protocol restricts the degrees of freedom to gates only, we analyse the bounds obtained in light of Landauer's principle, showing that there is a trade-off in entropic cost versus increased success probability. The single qubit computation can perform better than the reversible bit computation, but it cannot achieve the performance of the irreversible computation. In this sense the protocol acts as an irreversibility witness. In the case of systems of dimension two (bits and qubits) these results have a clear geometric interpretation in the corresponding state spaces.
I will briefly discuss how our scheme also acts as a dimensional witness and I will conclude with some comments on the sources of non-classicality present in the current protocol since non-locality and contextuality (in its standard notions) are not present.

FLORIO MARIA CIAGLIA
Università di Napoli Federico II

The space of quantum states, relative entropies and metric tensors

The habit does not make the monk....the algebraic dress of quantum mechanics hides a beautiful geometrical lingerie that I will try to uncover during the talk.
In this context, I will briefly outline how we may think of the space of quantum states S as being a non-commutative version of classical probability theory, that is, how to look at quantum states as non-commutative versions of probability distributions.
Then, we will see how the complex general linear group GL(n, C) and the unitary group U(n) act on S partitioning it into the disjoint union of orbits.
The beautiful and highly rich geometry of the manifolds of isospectral quantum states - the orbits of U(n) - will be the point of departure in order to look for geometrical structures on the manifold of invertible quantum states - the orbit of GL(n,C) which is the primary object of quantum information theory.
These geometrical structures will be families of quantum metric tensors satisfying the monotonicity property, and we will see how it is possible to extract these families from families of quantum relative entropies satisfying the data processing inequality.
The explicit example of the (huge) two-parameter family of quantum relative entropies known as α-z-Rényi-relative will be fully worked out.
A covariant, coordinate-free, geometrical formalism will be the background spacetime in which we will move.

FRANCESCO CICCARELLO
NEST, Istituto Nanoscienze-CNR and DiFC, Università degli Studi di Palermo

Open dynamics of a quantum system driven by a single photon

Open dynamics of atoms or cavity modes are recurrent in quantum optics. Typically, the field - which embodies the bath - is considered to be initially in a vacuum, thermal, coherent or squeezed state. Another possibility is to prepare a single-photon pure state and let it interact with the system, a case which has remained unexplored until recently but still of utmost importance these days for quantum technologies. Driving the open system with a single-photon results in an open dynamics whose nature is generally deeply different from familiar processes such as spontaneous emission or optical Bloch equations and can feature strong non-Markovian features. For a qubit, the dynamical map is shown to exhibit a number of distinctive features. By resorting to a collision-model picture, the occurrence of non-Markovian behaviour can be understood in terms of an initial correlated state of the field.

References:
- K.M. Gheri, K. Ellinger, T. Pellizzari, P. Zoller, Fortschr. Phys. **46**, 401 (1998)
- B.Q. Baragiola, R.L. Cook, A.M. Branczyk, J. Combes, Phys. Rev. A **86**, 013811 (2012)
- Y.L.L. Fang, F. Ciccarello, H.U. Baranger, arXiv:1707.05946; to appear on New J. Phys.
- F. Ciccarello, Quantum Meas. Quantum Metrol. **4**, 53 (2017)

ANTONELLA DE PASQUALE
University of Florence, Department of Physics and Astronomia

A dynamical approach to noisy evolution

The evolution of quantum systems, in general affected by spurious interactions with the external environment, can be described by using different formal approaches. One is represented by completely positive trace preserving maps, typically encompassing under the same description a pletora of physical phenomena, all characterized by the a given initial and final state of the principal system. Such description circumvents the explicit formalization of the details of the interaction between the system and the environment. Different is the approach followed by the Hamiltonian description, in which the precise shape of the interactions between the system and the environment plays the crucial role. The latter approach, has the drawback of losing generality in the description, but in turn allows for a more direct characterization of the system dynamics.
In this work, we focus on a specific class of quantum evolutions, the so-called entanglement-breaking maps. The main property of such quantum channels is that they annihilate the entanglement between the system on which they are applied, and any arbitrary ancilla. In a seminal paper [1], Holevo has provided a formal and closed expression for this kind of evolutions, leading to their interpretation as measure and reprepare schemes. Here, we plan to extend such description at the Hamiltonian level, ultimately aiming at opening a root towards a dynamical parametrization of the quantum measurement process.

[1] A. S. Holevo, Russ. Math. Surv. **53**, 1295 (1999).

GIUSEPPE MAGNIFICO
Università di Bologna

Topological QED in 1+1 dimensions

We will focus on the simplest Abelian lattice gauge theory, a discretized version of the Schwinger model of (1+1) Quantum Electrodynamics, and discuss how a modification of the lattice discretization can lead to a topological Schwinger model that hosts a symmetry- protected topological phase. We will explore these ideas, focusing on the numerical simulation with the DMRG algorithm, which exploit entanglement properties of strongly correlated systems.

SILVIA PAPPALARDI,
SISSA and ICTP Trieste, Italy

Scrambling and entanglement spreading in long-range spin chains

Out of Time Ordered Correlators (OTOCs) have been suggested as a probe of scrambling (generically referred as the delocalization of quantum information) and as a measure of chaos in quantum many-body systems. We explore scrambling in connection to entanglements dynamics in generic long-range systems: in integrable, non-integrable and chaotic models. In the infinite-range Ising model, we study both bipartite and multipartite entanglement dynamics and we compare the results with the OTOCs of collective spin operators. We argue that scrambling and entanglement growth are two distinct phenomena, characterized by two different time scales.
While entanglements saturate at a time $t_{\text{Eher}}\sim \sqrt N$ at which the semi-classical approximation breaks, the OTOCs keep growing in time up to N. In this model, by expanding in spin waves on top of the classical solution, we are able to device an approximated semi-analytic method that predicts the behavior of the OTOC up to t_{Eher} and coincides with the classical limit, computed within the Truncated Wigner Approximation (TWA). This method seems to be generic for long-range interacting hamiltonians.
Furthermore, we study the kicked version of this model: the kicked top, a textbook example of quantum chaos. A expected, in the chaotic regime, the OTOC grows exponentially in time, with the same Lyapunov exponent of his semi-classical limit.

SAVERIO PASCAZIO
Physics Department, University of Bari, Italy

Entanglement critical length at the many-body localization transition

The transition from an ergodic to a many-body localized phase is a crucial problem in quantum statistical mechanics. We investigate a spin-1/2 Heisenberg chain with random magnetic fields and find that its entanglement spectrum deviates from the Marchenko–Pastur law. These deviations enable us to identify a correlation length and predict the location and finite-size scaling exponents of the MBL transition.

DOMENICO POMARICO
Physics Department, University of Bari, Italy

Joint work with P. Facchi, M.S. Kim, S. Pascazio, F.V. Pepe,T. Tufarelli

Bound states and entanglement generation in waveguide quantum electrodynamics

We investigate the behavior of two quantum emitters (two-level atoms) embedded in a linear waveguide, in a quasi-one-dimensional configuration. Since the atoms can emit, absorb, and reflect radiation, the pair can spontaneously relax towards an entangled bound state, under conditions in which a single atom would instead decay. Exploiting the resolvent formalism, we analyze the properties of these bound states, which occur for resonant values of the interatomic distance, and discuss their relevance with respect to entanglement generation. The stability of such states close to the resonance is studied, as well as the properties of nonresonant bound states, whose energy is below the threshold for photon propagation.

DAVIDE ROSSINI
Dipartimento di Fisica, Università di Pisa and INFN Pisa, Italy

Chiral edge modes and crystalline phases in atomic synthetic ladders

Cold atomic gases endowed with a synthetic dimension are emerging as an ideal platform to address the interplay between interactions and static gauge fields. A fundamental question is whether these setups can give access to pristine two-dimensional phenomena, such as the fractional quantum Hall effect, and how.
We show that unambiguous signatures of Laughlin-like states can be observed and characterized in synthetic ladders, thus being related to an unconventional fractional quantum Hall effect in the thin-torus limit. In particular we demonstrate the existence of a hierarchy of fractional insulating and conducting states, showing that the gapped states are characterized by density and magnetic order, whereas the gapless phases can support helical modes.
Our analysis provides a guideline towards the observability and understanding of strongly correlated states of matter in synthetic ladders.

GIANNICOLA SCARPA
UCM Madrid, Spain

Computational complexity of PEPS zero testing

Joint work with A. Molnar, Y. Ge, J. J. Garcia-Ripoll, N. Schuch, D. Perez-Garcia, S. Iblisdir

Projected entangled pair states aim at describing lattice systems in two spatial dimensions that obey an area law. They are specified by associating a tensor with each site, and they are generated by patching these tensors. We consider the problem of determining whether the state resulting from this patching is null, and prove it to be NP-hard; the PEPS used to prove this claim have a boundary and are homogeneous in their bulk. A variation of this problem is next shown to be undecidable. These results have various implications: they question the possibility of a 'fundamental theorem' for PEPS; there are PEPS for which the presence of a symmetry is undecidable; there exist parent hamiltonians of PEPS for which the existence of a gap above the ground state is undecidable. En passant, we identify a family of classical Hamiltonians, with nearest neighbour interactions, and translationally invariant in their bulk, for which the commuting 2-local Hamiltonian problem is NP-complete.

DAVIDE VODOLA
Swansea University, UK

Twins Percolation for Qubit Losses in Topological Color Codes

Quantum information is the generalisation of the classical information theory to quantum systems. If for a classical computer the bits are the fundamental units, quantum computers are built on an analogous concept, the quantum bits currently implemented in different physical systems (atoms, ions, molecules) due to recent experimental advances in the control of cold and ultra-cold gases. However, these experimental setups are so delicate that qubits can be corrupted by environmental noise and even be completely lost from the apparatus resulting in the partial or total loss of the information there memorised. In this talk, we will consider how losses can affect a particular class of quantum code (the so-called color codes). We introduce a protocol for dealing with losses and we show that checking whether the logical information is still recoverable is equivalent to a generalized percolation process.

Abstract

Gravitartional waves

PIA ASTONE
INFN, Roma

Present results and future challenges with the network of gravitational wave detectors

Observations of compact binary coalescences by the Advanced LIGO-Virgo detector network have marked the beginning of a new era, where we are allowed to exploit new physics and new astrophysics, in some cases also by making use of joint gravitational waves and EM observations. This has been possible through the joint effort of colleagues with expertise in different fields, covering theory, experiment and data analysis. I will present the results achieved so far, together with a description of what is still missing and of what we expect to be accessible in the upcoming future. Plans for the upgrade of the gravitational wave network will also be presented.

SILVIA PIRANOMONTE
Observatory of Rome, Monteporzio

GW170817 optical/NIR follow-up observations: the first evidence of kilo novae existence

On August 17th 2017 the first electromagnetic counterpart of a gravitational wave (GW) event originated by the coalescence of a double neutron star system (GW 170817, Abbott et al. 2017) was finally observed. A world-wide extensive observing campaign was carried out to follow-up and study this source, with the forefront participation of the italian team GRAWITA (Gravitational Wave INAF TeAm). In particular, our unique VLT dataset provided the first compelling observational evidence for the existence of "kilonovae", transient sources powered by radioactive decay of heavy elements resulting from the r-process nucleosynthesis of ejected neutron star matter. In this talk I will present the activities we carried out to optimize the response of the Italian GRAWITA network of facilities to expected GW triggers and our results. All the activities I will describe are expect to provide means and opportunities to the Italian and European astronomical communities to have a leading role in the GW astronomy and Time Domain Astronomy

WALTER DEL POZZO
University of Pisa

Tests of general relativity from binary black hole coalescences

Gravitational waves emitted during the coalescence of compact binary systems are excellent information carriers about the merging objects, the remnant object as well as their interaction with space-time. During the coalescence of extremely compact objects such as binary black holes, the typical curvature and velocity at play are such that, from the observation of the gravitational wave signal, we can access the most extreme dynamical regimes of gravity. Such conditions are ideal for testing our understanding of gravity. The LIGO and Virgo observations of coalescing binary black holes provide wonderful testing grounds for general relativity. During my talk, I will review and discuss several of the tests that have been devised to detect violations of the predictions of general relativity from the observation of gravitational waves from coalescing binary systems. The discussion will be based on the results of the analysis of LIGO and Virgo events. Finally, I will conclude by discussing some of the future prospects of extending the current state-of-the-art methodologies to further aspects of general relativity.

MARIAFELICIA DE LAURENTIS
University of Naples

Constraining alternative theories of gravity using GW150914 and GW151226

The recently reported gravitational wave events GW150914 and GW151226 caused by the mergers of binary black holes provide a formidable way to set constraints on alternative metric theories of gravity in the strong field regime. In this paper, we develop an approach where an arbitrary theory of gravity can be parametrized by an effective coupling Geff and an effective gravitational potential Φ(r). The standard Newtonian limit of general relativity is recovered as soon as G_eff → G_N and Φ(r) → Φ_N. The upper bound on the graviton mass and the gravitational interaction length, reported by the LIGO-VIRGO Collaboration, can be directly recast in terms of the parameters of the theory that allows an analysis where the gravitational wave frequency modulation sets constraints on the range of possible alternative models of gravity. Numerical results based on published parameters for the binary black hole mergers are also reported. The comparison of the observed phases of GW150914 and GW151226 with the modulated phase in alternative theories of gravity does not give reasonable constraints due to the large uncertainties in the estimated parameters for the coalescing black holes. In addition to these general considerations, we obtain limits for the frequency dependence of the α parameter in scalar tensor theories of gravity.

T. ABDELSALHIN
Sapienza, University of Rome

Tidal deformations in inspiralling compact binary systems

Tidal effects play a fundamental role in coalescing compact binary systems. They can affect significantly the emitted gravitational waveform during the last cycles of the inspiral phase. Tidal interactions can be effectively used in fundamental physics, testing the real nature of black holes against other exotic compact objects. Furthermore, they can shed new light on the neutron star internal composition, constraining the equation of state. I will discuss how current models describing tidal interactions in compact binary systems can be improved, including higher-order multipolar tidal deformations, both in the electric and magnetic sectors, and taking into account the coupling between the tidal field and the rotation of the compact object. This will lead to more accurate templates for the gravitational waveforms.

F. JIMENEZ FORTEZA
INFN, Naples

Indistinguishability of high-PN tidal effects on BNS waveform models

The milestone LIGO observation of the first binary neutron star merger coalescense has supposed a great push for a further calibration of BNS waveform models. This BNS event allowed to place for the first time some light constraints to the tidal deformability parameter 'lambda' where non-spinning tidal waveform models were used.
Recent studies by Abdelsalhin et al. also include higher order spin-tidal interactions. These terms, though subdominant, may help to get a better calibration not only of the tidal deformability parameter but also to get a better characterisation of the individual spins. In this talk we show some preliminary fisher-matrix based studies intended to quantify the impact of these new terms in relation

to current BNS waveform models and LIGO noise realisation to finally extend these estimates to 3G GW detectors.

C. PACILIO
SISSA, Trieste

Quasinormal modes of general Einstein-Maxwell-dilaton theory

Einstein-Maxwell-dilaton theory originates from various models of low energy string theory: in addition to the metric field, it contains a gauge vector field and a dilaton scalar field. When the gauge charge is nonzero, black hole solutions deviate from the standard GR ones, thus allowing for possible signatures in gravitational waveforms. We analyze BH perturbations in EMd theory for general values of the dilaton coupling, under the assumption that the BH is weakly charged. We discuss how the quasinormal modes differ from the GR ones and what are the implications for black hole spectroscopy.

RAFFAELLA SCHNEIDER
Sapienza, University of Rome

The formation and coalescence sites of the first gravitational wave events

We present a novel theoretical model that allows to characterize the formation and coalescence sites of compact binary systems in a cosmological context. This is based on the coupling between a population synthesis code, that allows to generate samples of compact binary systems using physically motivated prescriptions for single and binary evolution, with a Local Group simulation, that follows star formation and metal enrichment in each individual galaxy at $0 < z < 20$. Motivated by the recent detection of gravitational waves from merging black hole binaries by the LIGO/VIRGO collaboration, we have applied this technique to understand when and where systems with properties similar to the observed events are more likely to form and where they are more likely to reside at the time of their coalescence.

FRANCESCO HAARDT
University of Insubria, Como

Massive black holes in galactic nuclei: dynamics, cosmic evolution and gravitational wave emission

Massive black-hole binaries (MBHBs) are thought to be the main source of gravitational waves (GWs) in the low-frequency domain surveyed by ongoing Pulsar Timing Array (PTA) campaigns and by the planned space-borne missions (LISA). However, many MBHBs in realistic astrophysical environments may not reach separations small enough to allow significant GW emission. Among various possible solutions, this "final-parsec problem'' can be eased by the appearance of a third massive black hole (MBH), whose perturbation can lead, under certain conditions, towards a binary coalescence. A detailed assessment of the process requires a general relativistic treatment and the inclusion of environmental effects. In this talk, I depict the implications of a sizeable population of MBH triplets that may form during the assembling history of the cosmic structure. Our analysis leverages on a large sample (~ 15,000) of three-body simulations performed taking into account the relevant physics to which MBHs are subjected and spanning a wide parameter space. The results of the detailed three-body dynamics are then embedded in a cosmological framework through a state-of-the-art semi-analytical code of galaxy formation, which provides us catalogues of merging MBHs. The importance of MBH triplets results twofold. First, even assuming a pessimist scenario of systematic MBHB stalling, still a non-negligible fraction (~30%) of the otherwise stalled binaries can actually merge because of the rich three-body dynamics. Second, given the high eccentricities that binaries can acquire in the process, we expect that burst-like sources could emit a signal in the LISA band, whose complete characterisation calls for new dedicated tools.

ANDREA MASELLI
CENTRA, Lisbon

Solving the relativistic inverse stellar problem through gravitational wave observations of binary neutron stars

In this talk we investigate how to characterise the main features of the neutron star nuclear matter, using gravitational wave signals produced by coalescing binaries. We parametrise the stellar equation of state using phenomenological piecewise polytropic models. Adopting a Bayesian scheme of inference, we determine, through Markov chain Monte Carlo simulations, the posterior probability distribution of the equation of state parameters, for a given set of neutron star masses and tidal deformabilities, within their experimental uncertainties measured by gravitational wave detections. Our results show that terrestrial interferometers, supplied by a small number of observations, can be able to set interesting constraints on the phenomenological parameters. The latter can be used to make model selection among the realistic EoS proposed in literature so far

ALBINO PEREGO
INFN Milano Bicocca

Multimessenger constraints on the equation of state of neutron stars

Despite the many theoretical and experimental improvements occurred in the last few years, the equation of state (EOS) of dense matter inside neutron stars remains one of the major uncertainities in nuclear theory and theoretical astrophysics. Compact binary mergers involving at least one neutron star represent unique cosmic laboratories to test and investigate the EOS of matter at and above nuclear saturation density. In this talk, I will present where and how the nuclear EOS can have a detectable impact on the many observables coming from binary neutron star mergers. In particular, I will focus on how GW and electromagnetic detections from these mergers, combined with state-of-the-art numerical models of the coalescence, of its aftermath, can provide genuine multimessenger constraints on the neutron star EOS.

Abstract

Topics in nonperturbative Quantum Field Theory

Vieri Mastropietro
Università di Milano

Anomalies, Constructive QFT and Universality in solid state physics

In several cases, fermionic functional integrals can be showed to be well defined due to the convergence of the renormalized expansion, following from determinant bounds and constructive RG methods.
Explicit bounds on the long distance decay of euclidean correlations can be used to prove universality results in solid state physics, in particular for graphene and Hall insulators. The role the of anomalies in a non-perturbative context of the emerging theories play a special role.

Claudio Dappiaggi
Università di Pavia

On the role of boundary conditions in the quantization of Bosonic field theories on AdS spacetime

We consider the prototypical example of a scalar field on the Poincaré patch of AdS spacetime and we individuate all admissible boundary conditions that can be applied on the conformal boundary,
being at the same time compatible with background isometries. These are nothing but Robin boundary
conditions and we analyse them in detail observing that, in some instances, "bound state" mode solutions are present.
To conclude, we outline a research programme aimed at generalizing this analysis to a generic Lorentzian spacetime with a timelike boundary and at classifying all boundary conditions which are compatible with the standard Dirac quantization procedure.

Roberto Percacci
SISSA Trieste

Asymptotic safety

I will review the theoretical motivations for this non-perturbative version of renormalizability and mention some interesting recent results.

Gian Paolo Vacca
INFN sezione di Bologna

Selected topics on the functional renormalization group and its applications

After a short review of the functional renormalization group approach to the study of QFTs, both at perturbative and non perturbative level, I will discuss possible applications to the study of systems close to criticality.

In particular I will show in some detail approximate analysis in the non perturbative regime of effective theories of different physical origin with scalar and also fermionic degrees of freedom.

FABIO SIRINGO
Università di Catania

Exploring Non-Perturbative QCD by Perturbation Theory: an Analytical Study of the Yang-Mills Sector in the IR

Some aspects of Yang-Mills SU(N) theory in the IR - in the so called "non-perturbative" regime of strong interactions - can be described by perturbation theory, analytically, provided that the usual expansion point is replaced by the vacuum of a massive gluon.
By a variational argument, the standard vacuum of masless gluons is shown to be unstable against the vacuum of massive particles. At finite temperature, the same variational argument provides a very good description of the deconfinement transition and of the equation of state.
Expanding around the optimal (massive) vacuum, a "massive" perturbation theory is developed which is in perfect agreement with the lattice data. Explicit one-loop analytical expressions are found for propagators and running coupling in the Landau gauge. The analytic properties of the propagator provide direct information on confinement, physical mass and damping ratio, that cannot be extracted from the lattice data.

MARCO PANERO
Università di Torino

An overview of the lattice approach to strongly coupled quantum field theory

I present an overview of the lattice approach to quantum chromodynamics (and to other strongly coupled quantum field theories) aimed at non-practitioners. After defining the key ideas underlying the regularization of quantum field theory on a spacetime lattice, I will discuss some common misconceptions about this approach. Then, I will review a selection of recent lattice results, and some open problems in which significant progress could be achieved in the next few years.

FRANCESCO BECATTINI
Università di Firenze

Thermodynamic equilibrium with acceleration and the Unruh effect

We address the problem of thermodynamic equilibrium with constant acceleration along the velocity field lines in a quantum relativistic statistical mechanics framework. We show that for a free scalar quantum field, after vacuum subtraction, all mean values vanish when the local temperature T is as low as the Unruh temperature T_U = A/2_ where A is the magnitude of the acceleration four-vector. We argue that the Unruh temperature is an absolute lower bound for the temperature of any accelerated fluid at global thermodynamic equilibrium. We discuss the conditions of this bound to be applicable in a local thermodynamic equilibrium situation.

LUCIANO PETRUZZIELLO
Università di Salerno

On the role of neutrino mixing in accelerated proton decay

The inverse beta decay of accelerated protons has been analyzed both in the laboratory frame (where the proton is accelerated) and in the comoving frame (where the proton is at rest and interacts with a thermal bath of electrons and neutrinos). The equality between the tworates has been exhibited as a "theoretical check" of the necessity of Fulling-Davies-Unruh (FDU) effect. Recently, it has been argued that neutrino mixing can spoil this agreement, potentially opening new scenarios in neutrino physics. In this talk, I analyze in detail this problem in order to understand the origin of such an ambiguity. A number of possible solutions is finally proposed.

LUCA SMALDONE
Università di Salerno

Dynamical generation of fermion mixing

A careful non perturbative study of flavor mixing reveals an interesting structure of the flavor vacuum [1]. This is deeply related to the existence of unitarily inequivalent representations of field algebra in Quantum Field Theory. Far from being a mathematical curiosity, this study leads to phenomenological corrections to the neutrino oscillations formula [2]. The particle-antiparticle condensate structure of the flavor vacuum suggests the idea of fermion mixing as an emergent dynamical phenomenon. A non-perturbative model-independent analysis can be elaborated at algebraic level, where Nambu-Goldstone modes are studied via Ward-Takahashi identities [3]. A particular case, by using operator formalism, was studied in Ref.[4], where gap equations were obtained both for the masses and mixing angles.
If we try to derive these sets of gap equations by using one-loop effective action with the help of path integral techniques [5], two immediate questions arise: i) Does path integral know about inequivalent repre-sentations? ii) Is it the standard generating functional of Green's functions capable of distinguishing among different inequivalent vacua? The answer to the first question is positive. In Ref.[6], within the coherent state functional integrals framework, we proved that a canonical transformation always implies a transition to a different representation of canonical commutation relations, possibly inequivalent to the original one. However, the answer to the second question opens new interesting scenarios, leading to the necessity of a generalization of the standard definition of the generating functional of Green's functions, in order to take into account the rich vacuum structure of QFT [7]. In particular it is interesting to derive, in this framework, Green's functions on flavor vacuum leading to exact oscillation formulas. A first step in this direction was done in [8].

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Abstract

Cosmology and Theories of gravity

Della Valle Massimo
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Probing the Transient Universe with Supernovae, Hypernovae and Kilonovae in the GWs era

I'll review the issue of the frequency of occurrence of some classes of Transients that can be relevant as source of GWs

Giovanni Covone
University of Naples Federico II

Is Dark Matter really collisionless? Recent insights from astronomical observations

The LCDM, the standard cosmological model, assumes that the DM component is collisionless, i.e. dark matter particles only interact via gravitational forces. However, recent astronomical observations hint at possible interaction in the dark sector. Indeed, self-interacting dark matter (SIDM) particles could explain discrepancies observed in the core of galaxy clusters between observations and theoretical predictions based on cosmological numerical simulation with in the LCDM framework.
We will discuss an on-goin observational project to the test the SIDM hypothesis and the possible implications on the theoretical side.

De Laurentis Mariafelicia
Institute for Theoretical Physics - Goethe University Frankfurt

Test-particle dynamics in general spherically symmetric black hole spacetimes

To date, the most precise tests of general relativity have been achieved through pulsar timing, albeit in the weak-field regime. Since pulsars are some of the most precise and stable ``clocks'' in the Universe, present observational efforts are focused on detecting pulsars in the vicinity of supermassive black holes (most notably in the Galactic Centre), enabling pulsar timing to be used as an extremely precise probe of strong-field gravity. In this paper a mathematical framework to describe test-particle dynamics in general black hole spacetimes is presented, and subsequently used to study a binary system comprising a pulsar orbiting a black hole. In particular, taking into account the parameterization of a general spherically symmetric black hole metric, general analytic expressions for both the advance of the periastron and for the orbital period of a massive test particle are derived.
Furthermore, these expressions are applied to four representative cases of solutions arising in both general relativity and in alternative theories of gravity. Finally, this framework is applied to the Galactic Centre S-stars and four distinct pulsar toy models. It is shown that by adopting a fully general-relativistic description of test-particle motion which is independent of any particular theory of gravity, observations of pulsars can help impose better constraints on alternative theories of gravity than is presently possible.

L. AMATI
INAF - Osservatorio di Astrofisica e Scienza dello Spazio

Theseus mission

THESEUS (Transient High-Energy Sky and Early Universe Surveyor) e' un concetto di missione spaziale di classe media (ESA "M" o NASA "midex") sviluppato negli ultimi anni da una grande collaborazione europea con rilevanti contributi e interesse da USA, brasile e Cina. Gli obiettivi scientifici della proposta THESEUS, attualmente in fase di valutazione scientifica da parte di ESA nell'ambito del programma Cosmic Vision - M5 (Lead Proposer: Lorenzo Amati, INAF -OAS Bologna), dopo avere superato la valutazione tecnico-programmatica, sono lo sfruttamento dei GRB ad alto redshift per lo studio dell'Universo primordiale (rivelazione e proprieta' delle prime popolazioni di stelle e galassie, fisica del processo di reionizzazione cosmica, etc.) e la rivelazione, localizzazione e studio di ogni classe di GRB e di transienti dai raggi X soffici fino ai raggi gamma di media energia su tutta la scala cosmica. In particolare, se approvato e realizzato, THESEUS svoglera' un ruolo fondamentale nell'astrofisica multi-messenger del futuro, permettendo la sistematica rivelazione, localizzazione accurata (da pochi minuti al secondo d'arco), caratterizzazione e misura del redshift delle contorparti eletromagnetiche di emettitori di onde gravitazionali e neutrini rivalati dai rivelatori di prossima generazione (aLIGo, aVirgo, I-LIGO, Kagra, Einstein Telescope, LISA, km3net, etc.). Per fare un esempio, per un evento di NS-NS merger come lo storico GW170817A, THESEUS permetterebbe, entro poche decine di minuti o poche ore al massimo, la rivelazione e localizzazione a pochi minuti d'arco del GRB corto e della possibile emissione X soffice associati, nonche' la rivelazione e misura del redshift dell'emissione infrarossa legata al GRB e dell'emissione di kilonova prodotta nel merger. Misure che attualmente richiedono tempi di giorni e grandissimi sforzi osservativi da parte di numerosi satelliti e telescopi.

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FATIBENE LORENZO
University of Torino

Observability and tests in Palatini f(R)-theories

We present a review of Palatini f(R)-cosmology and discuss the possibility to use it as a model for cosmic acceleration without introducing dark sources.
Then we shall review the interpretation of observations in a Weyl conformal frame, discuss the model prediction for the Hubble drift, and compare with LambdaCDM. The model f(R)= a R - b/2 R^2 - c/3R^{-1} will be considered.

GIAMBO' ROBERTO
Università di Camerino

Black holes from gravitational waves

In this talk we will briefly review the main tools needed for the monumental proof in (classical) mathematical relativity about black hole formation from the focusing of gravitational radiation. Recent advances and open questions are also outlined.

ANUPAM MAZUMDAR
University of Groningen

Singularity free, Ghost free & Infinite derivative gravity

I will discuss how infinite derivative theory of gravity can be ghost free and singularity free in a classical and in a quantum sense.

RINALDI MASSIMILIANO
Università di Trento, Dipartimento di Fisica & TIFPA-INFN

Scale-invariant gravity and inflation

Increasingly accurate measurements of the spectrum associated to the cosmic microwave background indicate that the theory underlying cosmic inflation is close to being scale-invariant. This aspect has attracted much interest from theorists and various quasi scale-invariant models have been proposed. In my talk, I will review some of these with particular attention to modified gravity eventually implemented with quantum corrections.

PIERPAOLO MASTROLIA
Dipartimento di Fisica e Astronomia, Università di Padova

Diagrammatic approach to the gravitational two-body dynamics

Working within the post-Newtonian (PN) approximation to General Relativity, I discuss the use the effective field theory (EFT) framework to study the conservative dynamics of the two-body motion, for computing the corrections to the effective potential to fourth PN order, at fifth order in the Newton constant.
This is one of the missing pieces preventing the computation of the full Lagrangian at fourth PN order using EFT methods. I discuss the analogy between diagrams in the EFT gravitational theory and 2-point functions in massless gauge theory, to address the calculation of 4-loop amplitudes by means of standard multi-loop diagrammatic techniques. For those terms which can be directly compared, our result confirms the findings of previous studies, performed using different methods.

ESPOSITO GIAMPIERO - ANGELO TARTAGLIA
INFN - Politecnico di Torino and INdAM

Looking for a new test of general relativity in the solar system. I/II

PIEDIPALUMBO ESTER
Dipartimento di Fisica "E. Pancini", Università Federico II

Cosmology with high redshift distance probes: A Gamma-Ray Bursts and Quasars Hubble diagram

So far large and different data sets revealed the accelerated expansion rate of the Universe, which is usually assumed to be driven by the so called dark energy, that, according to recent estimates, provides about 70% of the total amount of the matter- energy in the Universe. The nature of dark energy is yet unknown. Several models of dark energy have been introduced: a non zero cosmological constant, a potential energy of some scalar field, effects related to the non homogeneous distribution of matter, or effects due to alternative theories of gravity. Whatever future data discover, the simple plot of the Hubble diagram (HD) as a function of redshift will remain one of the primary tool for cosmological investigations, as the conversion between redshift and distance depends on the specific parameters of the underlying models. We show that the dark energy equation of state can be explored, using a high redshift HD. We, actually, join the Quasars and Gamma-Ray Bursts HDs, obtained calibrating the non linear relation between the UV and X-ray luminosities in Quasars, and the correlation between the peak photon energy, Ep,i, and the isotropic equivalent radiated energy, Eiso in GRBs.
It turns out that an evolving dark energy is favored by the present data. Moreover, the GRBs and QSOs HD alone is able to set the transition region from the decelerated to the accelerated expansion of the Universe without SNeIa.

SEBASTIANI LORENZO
TIFPA INFN

Action growth for static black holes in modified gravity

We derive the general form of the action growth for a large class of static black hole solutions in F(R)-gravity. By making use of the First Law of thermodynamics, we demonstrate that the action growth is bounded by a term proportional to the black hole energy, in analogy with the results of General Relativity. The action growth of a Weyl black hole solution is also investigated.

STORNAIOLO COSIMO
INFN sezione di Napoli

Tomographic analysts of the quantum cosmological models of the de Sitter universes

The reconstruction of the state of quantum system is obtained by quantum tomography. It has been successfully applied to quantum optics and quantum mechanics as tomograms are observables and bear with them all the information of a quantum state. A tomographical representation of conventional quantum mechanics has been developed in the last twenty years. We apply the tomographic approach to quantum cosmology. I discuss its applicability and the possibility and its limits to reconstruct the early stages of the quantum universe and eventually the boundary conditions.

In this talk I examine the properties of the quantum and classical de Sitter models by analysing the corresponding tomograms putting in evidence the transition from quantum to classical and the possible signatures of the early stages of the universe.

LUCA BUONINFANTE
Università degli Studi di Salerno, University of Groningen and INFN Sezione di Napoli

Insights into infinite derivative gravity from curvature tensors

In this talk we will analyze all the linearized curvature tensors in the infinite derivative ghost- and singularity-free theory of gravity, in the static regime. We will show that at short distances the Ricci tensor and the Ricci scalar are not vanishing, meaning that we do not have a Schwarzschild vacuum solution anymore due to the smearing of the source induced by the presence of a non-local gravitational interaction. It also follows that, unlike in Einstein's gravity, the Riemann tensor is not traceless and it does not coincide with the Weyl tensor. Moreover, these curvatures are regularized at short distances such that they are singularity-free, in particular the same happens for the Kretschmann invariant. Unlike the others, the Weyl tensor vanishes at short distances, implying that the spacetime metric becomes conformally flat in the region of non-locality. As a consequence, the non-local region can be approximated by a conformally flat manifold with non-negative constant curvature.

GERHARD HARMSEN
National Institute of Theoretical Physics South Africa,
University of the Witwatersrand and University of Groningen

Quasinormal modes for spin-3/2 _elds near an N-dimensional Reissner-Nordstrom black hole.

We will determine the quasinormal modes (QNMs) produced by spin-3/2 _elds in an N-dimensional Reissner-Nordtr�om black hole background. To begin we determine the e_ective potential for our spin-3/2 _elds near the black hole. Using the Wentzel-Kramers-Brillouin and asymptotic iterative methods we obtain the QNMs generated for the spin-3/2 _elds. We are then in a position to determine what e_ect the number of dimensions and charge of the black hole have on the emitted QNMs. Finally we use the Unruh method to determine the absorption probabilities associated to the _elds near the black hole, where again we perform comparisons to determine the e_ect of charge and dimensionality.

FRANCESCO DI FILIPPO
SISSA

Minimally modified theories of gravity: a playground for testing the uniqueness of general relativity

I will analyze a class of gravitational theories with only two local degrees of freedom, recently presented in the literature. The existence of such theories seems to challenge the unique role of general relativity as the only non-linear theory of massless spin-2 particles. Using on-shell scattering amplitudes techniques I provide indications that these theories are equivalent to general relativity. The work is a good example of the usefulness of such techniques in the study of modified gravity theories.

ROCCO D'AGOSTINO
University of Rome Tor Vergata

Cosmic acceleration from Anton-Schmidt's equation of state

We propose a new class of barotropic factor for matter, motivated by properties of isotropic deformations of crystalline solids. Our approach is dubbed Anton-Schmidt's equation of state and provides a non-vanishing, al- beit small, pressure term for matter. The corresponding pressure is thus pro- portional to the logarithm of the universe's volume. In the context of solid state physics, we demonstrate that by only invoking standard matter with such a property, we are able to frame the cosmic speed up in a suitable way, without invoking a dark energy term by hand. Our model extends a recent class of dark energy paradigms named logotropic dark fluids and depends upon two free parameters, namely n and B. Within the Debye approxima- tion, we find that n and B are related to the Grüneisen parameter and the bulk modulus of crystals. We highlight the most relevant properties of our new equation of state on the background cosmology. Discussions on both kine- matics and dynamics of our new model are presented. We demonstrate that the ΛCDM model is inside our approach, as limiting case. Finally, we por- tray an effective field description of the dark energy potential associated to Anton-Schmidt's equation of state. We focus on the case $n = -1$, for which analytical solutions can be found.

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