Ultra-High-Frequency GWs: A Theory and Technology Roadmap

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CERN

Book of Abstracts

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Ultra-high frequency gravitational waves from alpha-attractor models of inflation

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We consider primordial gravitational waves induced by large density perturbations generated by inflation in the very early universe. Cosmological alpha-attractors stand out as particularly compelling models to describe inflation, naturally meeting tight observational bounds from cosmic microwave background (CMB) experiments. We investigate alpha-attractor potentials in presence of an inflection point. The curvature perturbation is enhanced at high frequencies, which can lead to primordial black holes production and second-order gravitational waves. Consistency with the current CMB measurements implies that PBHs can only be produced with masses smaller than 10ˆ8 g and are accompanied by ultra-high frequency gravitational waves, with a peak expected to be at frequencies of order 1MHz or above.

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Ultra-High-Frequency Gravitational Waves from Oscillons

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Gravitational Wave Gastronomy

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The symmetry breaking of grand unified gauge groups in the early universe often leaves behind relic topological defects such as cosmic strings, domain walls, or monopoles. For some symmetry breaking chains, hybrid defects can form where cosmic strings attach to domain walls or monopoles attach to strings. In general, such hybrid defects are unstable and can leave behind unique gravitational wave fingerprints. In this talk, I will discuss the gravitational wave spectrum from 1) the destruction of a cosmic string network by the nucleation of monopoles which cut up and eat'the strings, 2) the collapse and decay of a monopole-string network by strings that 'eat'the monopoles, 3) the destruction of a domain wall network by the nucleation of string-bounded holes on the wall that expand andeat'the wall, and 4) the collapse and decay of a string-bounded wall network by walls that eat'the strings, with a particular focus on the latter for this talk. We call the gravitational wave signals produced from theeating'of one topological defect by another "gravitational wave gastronomy". We find that the gravitational wave gastronomy signals considered yield unique spectra, typically at ultra high frequencies, that can be used to narrow down the SO(10) symmetry breaking chain to the Standard Model and the scales of symmetry breaking associated with the consumed topological defects.

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GW experiments for dark matter direct detection

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Gravitomagnetic resonance and gravitational waves

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Gravitational waves are usually described in terms of a
transverse and traceless (TT) tensor, which allows to introduce the so-called TT coordinates. However, another possible approach is based on the use of a Fermi coordinates system, defined in the vicinity of the world-line of an observer arbitrarily moving in spacetime. In particular, Fermi coordinates have a direct operational meaning, since they are the coordinates an observer would use to perform space and time measurements; indeed, using these coordinates the metric tensor contains (up to the required approximation level) only quantities that are invariant under coordinate transformations internal to the reference frame. Using this approach it is simple to emphasise that what an observer measures depends both on the background field where he is moving and, also, on his kind of motion. This is quite similar to what happens when we study classical mechanics in non inertial frames: inertial forces appear, depending on the peculiar motion of the frame with respect to an inertial one. We show that using Fermi coordinates the effects of a plane gravitational wave can be described by gravitoelectromagnetic fields: in other words, the wave field is equivalent to the action of a gravitoelectric and a gravitomagnetic field, that are transverse to the propagation direction and orthogonal to each other. In particular, the gravito-magnetic field acts on spinning particles and we show that, due to the action of the gravitational wave field a gravitomagnetic resonance may appear. We give both a classical and a quantum description of this phenomenon and suggest that it can be used as the basis for a new type of
gravitational wave detectors.

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Resonant Electromagnetic Gravitational Wave Detectors

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Detecting high-frequency gravitational waves with optically levitated nanoparticles

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Quantum Frequency Interferometry: with applications ranging from gravitational wave detection to dark matter searches

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