Einstein Telescope
Observational Science Board (OSB)

M. Branchesi, A. Ghosh, M. Maggiore

ET Monthly Meeting, October 1, 2024

Structure of the ET monthly meeting:

A general update of OSB activities (OSB chairs)

1) status of Blue-Book
2) preparation of the Annual meeting
3) OSB papers
4) Work with Site Characterization Board

Activities of div 10 (data analysis platform)

Elena Cuoco, Gianluca Guidi, Anuradha Samajdar, Tania Regimbau

see the ET-TDS for the previous presentations (div1, div2, div3, div4, div5, div6, div7, div8, div9)

Blue Book

- ✓ *intense work going on in all divisions*
- ✓ *all divisions provided a mature draft by early summer*

- ✓ *several internal referees appointed for each chapter reports from the referees arrived/arriving between late July and now*

- ✓ *draft circluated to the DIV and collected comments*

- ✓ *coordinators working on the referees' and DIV members' comments*

- ➢ *We received the 'final' version of the chapters from one DIV and we expect them soon from the others*

- ➢ *We will prepare a BB draft (around 600 pages) to be share with the European REA Project Officer of ET-PP*

- ➢ *Editing work by the OSB Chairs in the next months to uniform the content and to produce the* ***final document*** *for the* ***end of the year***

- ➢ *Submit to the journal (LRR?) and final deliverable for ET-PP*

Annual meeting

- The ET Annual Meeting will take place in Warsaw, Nov. 12-15

- **Tuesday and Wednesday**: OSB parallel session for overall 3 hours per day
Blue Book discussion: each division will present its chapter

- **Thursday**: contributed talks (10 slots of 15'+3’). You are welcome to submit an abstract for a talk (https://indico.ego-gw.it/event/764/abstracts/)

- **Poster session**, and posters can be submitted again at https://indico.ego-gw.it/event/764/abstracts/

OSB papers in the last month

Testing gravity with the latent heat of neutron star matter

2024-09-17 **ET-0505A-24** Pablo Navarro Moreno, Aneta Wojnar, Felipe J. Llanes-Estrada

ABSTRACT: The Seidov limit is a bound on the maximum latent heat that a presumed first-order **phase transition of neutron-star matter** can have before its excess energy density, not compensated by additional pressure, results in gravitational collapse. Because latent heat forces a nonanalytic behaviour in plots correlating physical quantities (kinks in two-dimensional, ridges in three-dimensional ones), it can be constrained by data. As the onset of collapse depends on the intensity of gravity, testing for sudden derivative changes and, if they are large, breaching the Seidov limit would reward with two successive discoveries: such a phase transition (which could stem from hadron matter but also from a gravitational phase transition), and a modification of General Relativity (thus breaking the matter/gravity degeneracy). We illustrate the point with f(R)=R+a R^2 metric gravity.

The density of states method for symplectic gauge theories at finite temperature

2024-09-20 **ET-0515A-24** Ed Bennett, Biagio Lucini, David Mason, Maurizio Piai, Enrico Rinaldi, Davide Vadacchino

ABSTRACT: We study the finite-temperature behaviour of the Sp(4) Yang-Mills lattice theory in four dimensions, by applying the Logarithmic Linear Relaxation (LLR) algorithm. We demonstrate the presence of coexisting (metastable) phases, when the system is in the proximity of the transition. We measure observables such as the free energy, the expectation value of the plaquette operator and of the Polyakov loop, as well as the specific heat, and the Binder cumulant. We use these results to obtain a high-precision measurement of the critical coupling at the confinement-deconfinement transition, and assess its systematic uncertainty, for one value of the lattice extent in the time direction. Furthermore, we perform an extensive study of the finite-volume behaviour of the lattice system, by repeating the measurements for fixed lattice time extent, while increasing the spatial size of the lattice. We hence characterise the first-order transition on the lattice, and present the first results in the literature on this theory for the infinite volume extrapolation of lattice quantities related to latent heat and interface tension. Gauge theories with Sp(4) group have been proposed as new dark sectors to provide a fundamental origin for the current phenomenological evidence of dark matter. A phase transition at high temperature, in such a new dark sector, occurring in the early universe, might have left a **relic stochastic background of gravitational waves**. Our results represent a milestone toward establishing whether such a new physics signal is detectable in future experiments, as they enter the calculation of the parameters, α and β, controlling the power spectrum of gravitational waves. We also outline the process needed in the continuum extrapolation of our measurements, and test its feasibility on one additional choice of temporal extent of the lattice.

Prospects for detecting asteroid-mass primordial black holes in extreme-mass-ratio inspirals with continuous gravitational waves

2024-09-21 **ET-0516A-24** Andrew L. Miller

ABSTRACT: Despite decades of research, the existence of **asteroid-mass primordial black holes** (PBHs) remains almost completely unconstrained and thus could still comprise the totality of dark matter (DM). In this paper, we show that **standard searches for continuous gravitational waves** --long-lived, quasi-monochromatic signals-- **could detect extreme mass-ratio inspirals of asteroid-mass PBHs in orbit around a stellar-mass companion using future gravitational-wave (GW) data from Einstein Telescope (ET) and the Neutron Star Extreme Matter Observatory (NEMO).** We evaluate the robustness of our projected constraints against eccentricity of the binary, the choice of the mass of the primary object, and the GW frequency range that we analyze. Furthermore, to determine whether there could be ways to detect asteroid-mass PBHs with current GW data, we quantify the impact of changes in current techniques on the sensitivity towards asteroid-mass PBHs. We show that methods that allow for signals with increased and more complicated frequency drifts over time could obtain much more stringent constraints now than from standard techniques, though at slightly larger computational cost, potentially constraining now the fraction of DM that certain asteroid-mass PBHs could compose to be less than one.

Variational inference for correlated gravitational wave detector network noise

2024-09-10 **ET-0498A-24** Jianan Liu, Avi Vajpeyi, Renate Mayer, Kamiel Janssens, Jeung Eun Lee, Patricio Maturana-Russel, Nelson Christensen, Yixuan LiU

ABSTRACT: Gravitational wave detectors like the Einstein Telescope and LISA generate long multivariate time series, which pose significant challenges in spectral density estimation due to a number of overlapping signals as well as the presence of correlated noise. Addressing both issues is crucial for accurately interpreting the signals detected by these instruments. This paper presents an application of a variational inference spectral density estimation method specifically tailored for dealing with correlated noise in the data. It is flexible in that it does not rely on any specific parametric form for the multivariate spectral density. The method employs a blocked Whittle likelihood approximation for stationary time series and utilizes the Cholesky decomposition of the inverse spectral density matrix to ensure a positive definite estimator. A discounted regularized horseshoe prior is applied to the spline coefficients of each Cholesky factor, and the posterior distribution is computed using a stochastic gradient variational Bayes approach. This **method** is particularly effective **in addressing correlated noise, a significant challenge in the analysis of multivariate data from co-located detectors**. The method is demonstrated by analysing 2000 s of simulated Einstein Telescope noise, which shows its ability to produce accurate spectral density estimates and quantify coherence between time series components. **This makes it a powerful tool for analyzing correlated noise in gravitational wave data.**

Work with Site Characterization Board

Goal:

- *Work to compare the sites candidate to host ET on the basis of the science targets;*
- *Evaluation of the science similar to the work done for CoBA for the two sites using **site dependent sensitivity curves**;*
- *Urgent ET-PP deliverables – short-term deadlines with a large number of simulations to be performed*

➢ *DIV9 call for volunteers to use tested **Fisher Matrix codes***

Task force of about 10 people (experts+young researchers), coordinators U. Dupletsa and F. Iacovelli

➢ *DIV10 call for volunteers to join the effort, possibility to consider the use **Bayesian codes with an appropriate level of readiness** (which could enter also in the long term) which can be used also in sub-set of science cases to validate Fisher code results*