Two-minute meeting 2018/19

Niels Bohr Institute, Copenhagen
January 15th, 2019
EoM for the SMEFT
Abdurrahman Barzinji, Masters student with Michael Trott

1. SM extended into an EFT at scales $\Lambda > \bar{v}_T$

2. $\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}} + \mathcal{L}^{(5)} + \mathcal{L}^{(6)} + \mathcal{L}^{(7)} + \ldots$

   $\mathcal{L}^{(d)} = \sum_i \frac{C_{i}^{(d)}}{\Lambda^{d-4}} Q_{i}^{(d)}$ for $d > 4$.

3. Use gauge independent field redefinitions $\rightarrow$ Non-redundant "Warsaw basis" SMEFT Lagrangian

4. E.L.: $0 = \int d^4x \left[ \frac{\partial \mathcal{L}_{\text{SMEFT}}}{\partial \delta \mathcal{F}} \delta \mathcal{F} - \partial_\mu \left( \frac{\partial \mathcal{L}_{\text{SMEFT}}}{\partial (\partial_\mu \mathcal{F})} \right) \delta \mathcal{F} \right]$ upto $\mathcal{L}^6$

5. Matching example using SMEFT EoM corrections to interpret anomalous measurements of $B \rightarrow K^{(*)} \ell^+ \ell^-$ lepton universality ratios ¹

¹Barzinji, Trott & Vasudevan 1806.06354
Name: Emil Bjerrum-Bohr

Course: Modern Methods for Particle Scattering.

Research Interests

- Amplitudes in particle physics.
- Gauge theories
- Gravity
- Phenomenology
- Recursive methods for computation
- String theory inspired methods, CHY etc
- Misc
Two minutes presentation: CFT from Scattering Amplitudes

Carlos Cardona

January 15 / 2019.
Conformal Bootstrap: Constraining observables by imposing physical conditions.

- Conformal symmetry
- Crossing symmetry
- OPE expansion ("locality")
- Unitarity
- Global symmetries

In essence, same as S-matrix program 60 to 70’s: Veneziano amplitudes, Regge Theory, BFKL equation...
In the 80’s to 2d-CFT, revisited and implemented in $d > 2$ CFT ’08.
We focus on $4$-points $= \langle \prod_{i=1}^{4} O_i(x_i) \rangle$.

- Conformal symm. 
  \[ \mathcal{G}(z, \bar{z}) \]

- Crossing Symm.

- OPE expansion
  \[ \mathcal{G}(z, \bar{z}) = 1 + \sum_{\Delta, J} c_{\Delta, J} \mathcal{G}_{\Delta, J}(z, \bar{z}). \]

- Unitarity
  \[ c_{\Delta, J} > 0, \quad \Delta - J > d - 2. \]
\[ \langle \mathcal{O}(0)\mathcal{O}(z, \bar{z})\mathcal{O}(1)\mathcal{O}(\infty) \rangle \]

\begin{align*}
u &= (1 - z)(1 - \bar{z}) = \frac{x_{14}^2 x_{23}^2}{x_{13}^2 x_{24}^2} \\
u &= z\bar{z} = \frac{x_{12}^2 x_{34}^2}{x_{13}^2 x_{24}^2} \end{align*}

- Analytic lightcone - Analytic euclidean - Numerics
Partial wave expansion,

\[ A(s, t) = \sum_{\ell=0}^{\infty} (2\ell + 1) f_\ell(t) G_\ell(\cos(\theta)), \]

\[ f_\ell(t) = \int_{-1}^{1} dz \ A(z, t) \ G_\ell(z). \]
\[ \mathcal{G}(z, \bar{z}) = 1 + \sum_{J=0}^{\infty} \int_{-i\infty}^{i\infty} \frac{d\Delta}{2\pi i} c_J(\Delta) F_J(z, \bar{z}|\Delta). \]

\[ c_J(\Delta) = N_J(\Delta) \int d^2z \mu(z, \bar{z}) F_J(z, \bar{z}|\Delta) \mathcal{G}(z, \bar{z}). \]

by contour deformation,

\[ c_J(\Delta) = \kappa_{\Delta+J} \int_{0}^{1} d^2z \mu(z, \bar{z}) G_{J+d-1, \Delta+1-d}(z, \bar{z}) d\text{Disc}[\mathcal{G}(z, \bar{z})]. \]
Mellin space

\[ G_{J,\Delta}(u, v) = \int_{-i\infty}^{i\infty} ds dt \, \mathcal{M}_{\Delta, J}(s, t) \, u^s v^t , \]

For holographic theories \( \rightarrow \) Dual gravity S-Matrix.
High energy limit in gravity by CFT methods! (Regge limits and so on)
Thank you!
James Creswell
PhD student of Pavel Naselsky

Mathematical representation of CMB polarization

\[
\begin{align*}
Q & \\
U & \\
E & B \\
P_E & P_B
\end{align*}
\]

Correcting E-to-B leakage for partial sky coverage

Statistics of polarization angles

\[
\theta = \frac{1}{2} \arctan(U, Q)
\]
Poul Henrik Damgaard

Current research interests:

- Amplitudes from Scattering Equations
- Classical gravity from Feynman diagrams, gravitational waves
- Heavy ion physics analyzed with CMB techniques

Interested in moving more towards:

- Astroparticle physics and cosmology
Work in progress

Paolo Di Vecchia
1. Use string theory to construct the 3-point amplitude involving two arbitrary massive states with spin and a graviton and the 2-body scattering amplitude (with soft graviton exchange) of two particles with arbitrary mass and spin and compare with one gets for the Kerr black hole (metric and deflection angle) 
[A. Koemans Collado and R. Russo]

2. Use the Sakai-Sugimoto-Witten model that gives a good description of the low-energy pion physics to include the axion and compute the topological susceptibility at finite temperature in QCD in order to compare with lattice calculations where there is no complete agreement between different groups. 
[F. Bigazzi and A. Cotrone]

3. Construction of an N-point string amplitude for pions with Adler zeroes generalizing the Lovelace-Shapiro model for 4 pions. It corresponds to a string extension of the non-linear $\sigma$-model. 
[M. Bianchi and D. Consoli]
THE DOUBLE COVER REPRESENTATION OF THE SCATTERING EQUATIONS

NBI-Scattering Amplitudes Group

Humberto Gomez

January 2019
The Double cover Prescription of CHY

- We consider a double cover of the sphere with marked points,

\[
\begin{align*}
\text{Parameters: } & (z) & \rightarrow & (y, \sigma) \\
\text{This double cover is given by the algebraic curve, } & y^2 = \sigma^2 - \lambda^2 \subset \mathbb{CP}^2, \text{ where } \lambda \in \mathbb{C}^* \text{ (} \lambda \text{ controls the opening of the branch cut).} & [H.G - 2016]
\end{align*}
\]
Recent results


\[
A_n^{YM}(1, \ldots, n) = \sum_{\epsilon_M} A_3^{YM}(P_{4:1}^{\epsilon_M}, 2, 3) \times A_{n-1}^{YM}(P_{2:3}^{\epsilon_M}, 4, \ldots, n, 1) \frac{P_{23}^2}{P_{23}^2}
\]

\[
+ \sum_{i=4}^n \left[ \sum_{\epsilon_M} A_{n-i+3}^{YM}(P_{3:i}^{\epsilon_M}, i+1, \ldots, 1, 2) \times A_{i-1}^{YM}(P_{i+1:2}^{\epsilon_M}, 3, \ldots, i) \frac{P_{i+1:2}^2}{P_{i+1:2}^2} \right]
\]

\[
- 2 \sum_{\epsilon_L} A_{n-i+3}^{YM}(P_{3:i}^{\epsilon_L}, i+1, \ldots, 1, 2) \times A_{i-1}^{YM}(P_{i+1:2}^{\epsilon_L}, 3, \ldots, i) \frac{P_{i+1:2}^2}{P_{i+1:2}^2} \bigg|_{2 \leftrightarrow 3}
\]

\[
A_n^{NLSM}(1, \ldots, n) = (-1)^n A_3^{\Sigma}(P_{4:1}^{\Sigma}, 2, 3) \times A_{n-1}^{\Sigma}(P_{2:3}^{\Sigma}, 1, 4, \ldots, n) \frac{P_{23}^2}{P_{23}^2}
\]

\[
+ \sum_{i=4}^n A_{n-i+3}^{\Sigma}(1, 2, P_{3:i}^{\Sigma}, i+1, \ldots n) \times A_{i-1}^{\Sigma}(P_{i+1:2}^{\Sigma}, 3, \ldots i) \frac{P_{i+1:2}^2}{P_{i+1:2}^2}
\]
A new recurrence relation for the n-point amplitude in NLSM,

\[ A^{\Sigma}_{2n}(P_1, P_2, P_3, 4, \ldots, 2n) = (-1)^n \frac{A^{\Sigma}_3(P_{4:1}, P_2, P_3) \times A^{\Sigma}_{2n-1}(P_1, P_{23}, 4, \ldots, 2n)}{P_{4:1}^2 - P_2^2 + P_3^2} \]

\[ + \sum_{i=3}^{n} \frac{A^{\Sigma}_{2(n-i+2)}(P_1, P_2, P_{3:2i-1}, 2i, \ldots, 2n) \times A^{\Sigma}_{2(i-1)}(P_{2i:2}, P_3, 4, \ldots, 2i - 1)}{s_{3:2i-1}} \]

\[ + \sum_{i=3}^{n+1} \frac{A^{\Sigma}_{2(n-i+2)+1}(P_1, P_2, P_{3:2i-2}, 2i - 1, \ldots, 2n) \times A^{\Sigma}_{2(i-1)+1}(P_{2i-1:2}, P_3, 4, \ldots, 2i - 2)}{P_1^2 - P_2^2 + P_{3:2i-2}^2} \]

\[ A^{\Sigma}_{2n+1}(P_1, P_2, P_3, 4, \ldots, 2n + 1) = \left( P_1^2 - P_2^2 + P_3^2 \right) \times \left[ \sum_{i=3}^{n+1} \left( \frac{1}{P_1^2 - P_2^2 + P_{3:2i-1}^2} \right) \right] \]

\[ \times \frac{A^{\Sigma}_{2(n-i+2)+1}(P_1, P_2, P_{3:2i-1}, 2i, \ldots, 2n + 1) \times A^{\Sigma}_{2(i-1)+1}(P_{2i:2}, P_3, 4, \ldots, 2i - 1)}{s_{3:2i-1}} \]

\[ + \left( \frac{1}{P_{4:1}^2 - P_2^2 + P_3^2} \right) \times \frac{A^{\Sigma}_3(P_{4:1}, P_2, P_3) \times A^{\Sigma}_{2n}(P_1, P_{23}, 4, \ldots, 2n + 1)}{s_{4:1}} \]
Holographic dualities:

- Spin Matrix theory & Non-relativistic geometry
  New string theories with non-relativistic world sheet (L. Bidussi, J. Hartong, N. Obers, G. Olbrg, L. Menculini, Z. Yan)

- SMT & Out-of-time correlators
  Probe of black hole behavior (I. Kalogerakis, N. Obers, K. Schalm, L. Menculini, N. Wintergerst)

- Hagedorn temp. & phases of AdS/CFT (M. Wilhelm)
  Hagedorn temp. at all orders of 't Hooft coupling via QSC
Astrophysical Black Holes:

- Force-free electrodynamics around Kerr BH
- Analytical model of BZ from 1977 doesn't work
  → How to resolve this?

(F. Camilloni, M. Orselli, G. Grignani)

Non-research:
- Head of section
- GR and string theory courses
Scattering Amplitudes & Effective Field Theory

Andreas Helset
Niels Bohr International Academy

January 14, 2019
My research

- Effective Field Theory
- Scattering Amplitudes

Andreas Helset (Niels Bohr International Academy) — Scattering Amplitudes and Effective Field Theory — January 14, 2019
My research

Effective Field Theory

Me

Scattering Amplitudes

Non-interference in the SMEFT
My research

- Effective Field Theory
- Me
- Scattering Amplitudes

- Gauge fixing
- Non-interference in the SMEFT
My research

Effective Field Theory

Scattering Amplitudes

Me

Non-interference in the SMEFT

Gauge fixing

Symmetry currents
My research

Effective Field Theory

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Non-interference in the SMEFT

Scattering equations
My research

Effective Field Theory

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Me

Scattering equations

Amplitude EFT

Gauge fixing

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Non-interference in the SMEFT
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Effective Field Theory

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Anomalies

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Effective Field Theory

Me

Scattering Amplitudes

Scattering equations

Classical Gravity

Amplitude EFT

Anomalies

Gauge fixing

Symmetry currents

Non-interference in the SMEFT
Thermodynamics of $\mathcal{N} = 4$ Super Yang-Mills at finite $N$

- Work in compact space $\mathbb{R} \times S^3$
  - *Only singlets of gauge group* $\sim$ *traces of operators*

- Calculate partition function

- Identify phase transitions
  - *Planar limit:* Confinement/Deconfinement
  - *Gravity dual:* Hawking-Page phase transition
Charlotte Kristjansen

Main theme: Integrability and beyond in AdS/CFT

Currently: AdS/dCFT (with applications to cond-mat and stat phys):

4D defect conformal field theories \quad \text{Probe brane models}

- New types of correlation functions, e.g. one-point functions
- Boundary conformal bootstrap
- Matrix product states & Quantum Quenches
  (Cold atom experiments)

In the Past: Giant gravitons, Wilson loops, Finite N in N=4 SYM, ABJ(M) theory, wrapping interactions, Integrable spin chains, BMN limit, (causal) dynamical triangulations, Matrix models of 2D gravity

In the future: Entanglement entropy, Mellin techniques for boundary Conformal bootstrap, quenched action approach
Lorenzo Menculini - office FB1, lorenzo.menculini@nbi.ku.dk

Double PhD student (Perugia University, Italy and NBI) since Dec 2016. Advisor: Troels Harmark.

Working on: decoupling limits of holographic $\text{AdS}_5$/ $\text{CFT}_4$ duality → Spin Matrix Theories (SMT), with non-relativistic features.

Current projects:

- Covariant quantization of strings with non-rel worldsheet in non-rel backgrounds from SMT limits of $\text{AdS}_5 \times S^5$ strings (1810.05560) → with L. Bidussi, T. Harmark, J. Hartong, N. Obers, G. Oling

- Adding $B$-field and relation to different non-rel string (stringy-NC) → with T. Harmark, J. Hartong, N. Obers, Z. Yan

- Explicit formulation of $\text{SU}(2|3)$ SMT and application to SUSY DBI → with M. Cesàro, T. Harmark

- Features of SMT at finite temperature: chaos/OTOCs, ... → with T. Harmark, N. Obers, K. Schalm and N. Wintergerst
Dennis Müller (FB11)
dennis.mueller@nbi.ku.dk

About:
- PhD at HU Berlin (2014-2018)
- Postdoc in Charlotte Kristjansen’s group (since 10/2018)

Past research activities:
- Yangian symmetry of super Wilson loops in $\mathcal{N} = 4$ SYM
- Yangian symmetry of fishnet Feynman graphs

Current projects:
- Differential equations from Yangian symmetry
- Loop integrals in defect conformal field theories
P. Naselsky and “Danish” Team

$$M = \frac{(m_1 m_2)^{3/5}}{(m_1 + m_2)^{1/5}} = \frac{c^3}{G} \left[ \frac{5}{96} \pi^{-8/3} f^{-11/3} \right]^{3/5}$$

Unwhitened L1

Unwhitened H1

Hanford (unwhitened)

Livingston (shifted, unwhitened)
Small deviations - anomalies - from the Standard Model in B-meson-decay, $g$-$2$, and $\epsilon'/\epsilon$ are interpreted as due to non-perturbative effects. The Standard Model quite correct in spite of these anomalies: we fit them with one parameter, which in principle could be calculated. (w. C. Froggatt).

The 3.55 keV radiation from Dark Matter? The by satellites observed X-ray line at 3.55 keV is interpreted in our dark matter model in which dark matter consists of pearls of cm size being 100000 tons heavy bubes of new type of vacuum. (w. C. Froggatt).

Gravitational anomaly using Dirac sea thinking. Recalculate gravitational anomaly already found by Alwares-Gaumets Witten. (w. M. Ninomiya).
Holger Bech Nielsens projects 2019 continued:

- **Complex Action, Periodicity, Bouncing Cosmology.** Look for predictions - mainly concerning initial state or history of universe - predicted from the hypothesis that (fundamentally) the action is real but complex. A universe developing periodically and bouncing instead of having big bang singularities is what we seek to show comes out just now. (w. K. Nagao).

- **Locallity Etc. from Diffeomorphism Symmetry.** assuming at first only quantum fields on a manifold and Taylor expandability of the action - but not locallity - we derive locallity and get a very realistic model, but with the exception that the “coupling constants” become dependent on what happens at all times, including the future. (w. A. Kleppe.)
- Fermionization and Spin Statistics Theorem etc... (w. N.Borstnik-Mankoc.)

- Upper Bound on Couplings in Effective Field Theory From existence of some physics at shorter length scale than the scale $\mu^{-1}$ considered a practical or statistical upper bound on effective couplings is estimated. (w. Sekino and Ninomiya.)
Research interests, Niels Obers (2 min. meeting 2019)

typically 1 day/week (Friday) @ NBI
(otherwise Nordita, Stockholm: everybody welcome to visit !)

- **Non-relativistic gravity** from 1/c expansion of GR & applications to real-world GR and non-relativistic (quantum) gravity and holography

- **Non-relativistic strings and limits of AdS/CFT** correspondence and connections with spin Matrix theory

- **Hydrodynamics** of non-boost invariant (quantum critical) systems and fluid/gravity correspondence

- **Newton-Cartan submanifolds** and applications to soft CMT

- **Blackfolds** and the construction of SUSY-breaking (**anti-brane**) solutions in string theory/supergravity

- **Astrophysical black holes:**
  BH shadows, force-free electrodynamics & jets

- …. Chaos, SYK, complexity, TTbar, TJbar, ….
(recent) Collaborators:

Troels Harmark, Gerben Oling, Nico Wintergerst, Bjarke Nielsen, Lorenzo Menculini, Hoapeng Yan

Jan de Boer, Jay Armas (Amsterdam)
Vasilis Niarchos, Nam Nguyen (Durham)
Jelle Hartong, Emil Have, Leo Bidussi (Edinburgh)
Dennis Hansen (ETH)
Watse Sybesma (Iceland)
Koenraad Schalm (Leiden)
Thomas van Riet (Leuven)
Ziqi Yan (Perimeter)
Stefan Vandoren (Utrecht)
Yang Lei (Wits)
Kevin Grosvenor (Wurzburg)

PhD student: Hoapeng Yan
MSc student: Jørgen Sandøe Musaeus
Gerben Oling

Then: Universiteit van Amsterdam, PhD 2018

- Applied AdS/CFT (modeling quenches)

![Graph showing quench function](image)

- AGT correspondence and generalized Toda theory

- Asymptotic symmetries of nonrelativistic gravity

\[ \operatorname{sl}(2) \oplus u(1) \rightarrow P_2^c \]

Now: in FB3

current: nonrelativistic strings and holography
 (w/ Niels, Troels and Lorenzo)

other: \( c_{gToda} \) from equivariant localization,
 ADM charges for Newton-Cartan gravity,
 holographic complexity and symplectic structures
Subodh Patil’s remote two minute presentation

I’m a theoretical cosmologist (but culturally hep-th)
• For the past few years, I’ve mainly been concerned with looking for new physics (higher dimensional operators) in cosmological observables.
Recent work/ things I’m currently thinking about:

Day job:
- Gravitational waves: probes of small scale structure, probes of hidden sectors, their damping (effect on quasi-normal modes by dense matter environments? w/ Chris Pethick)
- Large Scale Structure: a 3D tracer of primordial correlation functions. We can see more of inflation at work – can we learn something about its particle physics origins?
- Primordial Black Holes: are they really there? Are mechanisms invoked to produce them actually consistent? Constraining them with multiple probes.

Night shift:
- Complex networks + disordered systems (or, fun with real space RG)
- Non-relativistic fluids: an action formulation? (w/ Niels Obers and Kevin Grosvenor)
- Improved techniques to calculate particle production (Im part of the effective action: applications to Schwinger pair production, semi-classical stability of dS w/ David McGady)
TWO-MINUTE TALK - JAN 15 2019

CHRIS PETHICK
(NBIA & NORDITA)

1. PASTA PHASES IN NEUTRON STARS

JUST BELOW NUCLEAR DENSITY
ROUND NUCLEI \( \Rightarrow \) "SPAGHETTI" \( \Rightarrow \) "LASAGNA" \( \Rightarrow \) UNIFORM MATTER
SMALL PART OF STAR BUT IMPORTANT FOR OBSERVATION.

\[
\text{Neutrons} \\
\text{Nuclear Matter} \\
(\text{+ Electrons})
\]

COLLECTIVE MODES. SIMILAR TO LIQUID CRYSTALS.
LASAGNA NOT PERFECTLY FLAT.
(WITH NITYA KOBYAKOV, ST. PETERSBURG)

2. NEUTRON STAR STRUCTURE WHEN DENSE MATTER HAS A
PHASE TRANSITION

(WITH GORDON BAYH)

UNDER WHAT CONDITIONS DOES A FIRST-ORDER TRANSITION
DESTABILIZE THE STAR?
Scattering Amplitudes and Geometry

Cristian Vergu

Niels Bohr International Academy

14/01/2019
Scattering Amplitudes
Geometry
Matthias Volk

PhD student (since November 2018)

**Supervisors:** Jacob Bourjaily, Charlotte Kristjansen

**Work and interests:**

- Defect CFTs with holographic dual (D3-D7 system)
- One-point functions (all-loop results via integrability)
- Scattering amplitudes
- Feynman integrals
Functions in Scattering Amplitudes:

**Well-Known**

\[
\frac{1}{\epsilon} + (2 - \ln(-s)) + \mathcal{O}(\epsilon)
\]

\[G(w_1, w_2, \ldots; z) = \int_0^z \frac{1}{x - w_1} G(w_2, \ldots; x) dx\]

**Known?**

- Planar N=4 SYM: six particles through seven loops!
- Nonplanar? Correlation functions?

**Unknown**

- "Calabi-Yau functions": Very little known, lots to explore!

**Elliptic functions in N=4:**
- Can we understand them with new tools?
- Bootstrap them?

**Amplitudes bootstrap:**
- Planar N=4 SYM: six particles through seven loops!
- Nonplanar? Correlation functions?
Goal Analytic and preferably non-perturbative understanding of the structure of gauge theories
→ $\mathcal{N} = 4$ supersymmetric Yang-Mills theory and beyond

Scattering amplitudes and Integrability

- On-shell methods beyond scattering amplitudes: form factors, anomalous dimensions, beta functions

- Number theory of Feynman integrals

- Defect CFTs: One-point functions, particle-interface potential

- Thermodynamics of gauge theories: Hagedorn temperature, towards finite $N$
Nico Wintergerst
Postdoc, Fe-3

❖ Holography:
  ❖ Black holes from CFT
  ❖ Role of **singlet constraint** in weakly coupled O(N)/U(N) vector and matrix models
  ❖ **Chaos, thermalization** in Spin Matrix Theory (w/ Troels, Niels, Lorenzo, …)
  ❖ Moving towards **breakdown of effective field theory** for small BH.
  ❖ Bulk solitons and their boundary interpretation: Cosmic strings and fractional statistics, skyrmions and discrete gauge symmetries

❖ **Cold quantum gases**
  ❖ Critical Bose condensates with **BH like information properties**, e.g. large entropy, scrambling, …
  ❖ **Quantum gravity in AMO**, e.g. SU(N) Gross-Neveu from Hubbard <-> HS gravity

❖ **Cosmology**
  ❖ **Quantum consistency** of dark energy models
Haopeng Yan, PhD student of Niels Obers
2-minute meeting, January 15, 2019

Theoretical Aspects of Astrophysical Black Holes
-with regard to observations

**Current focus:** Optical appearance of high-spin black holes (and hot spot)
- in modified gravity theory (STVG or MOG) [1806.05249](https://arxiv.org/abs/1806.05249)
- with charge (in GR and beyond) **in progress**
- and influence of BH surroundings (such as plasma) **in progress**

**Other interests:**
- Force-free electrodynamics and jets
- Gravitational waves and effective field theory in non-Lorentz gravity theory