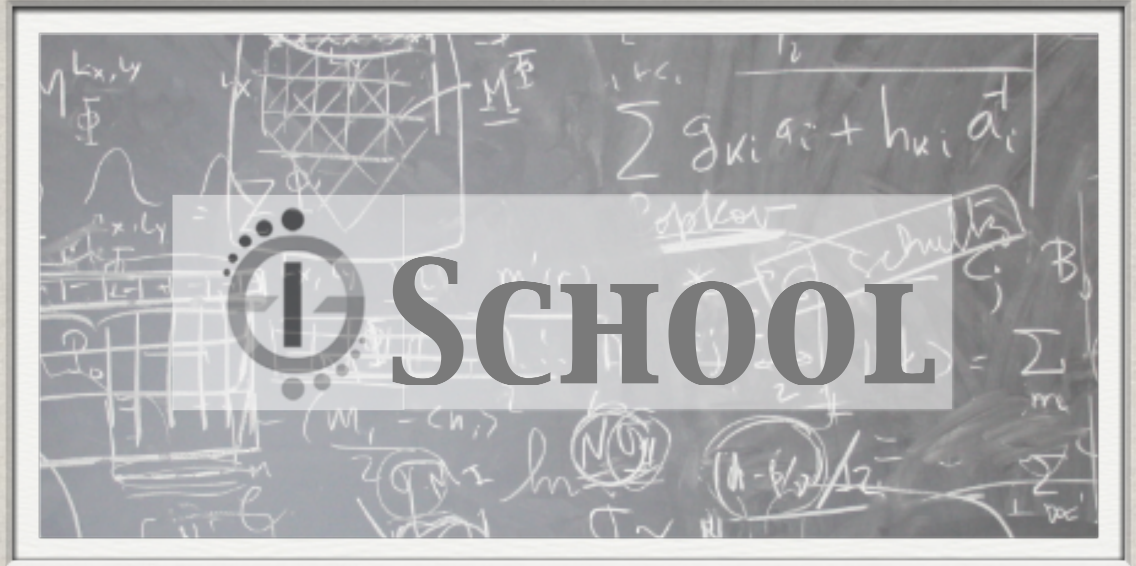


GGI Lectures on the Theory of Fundamental Interactions

7-24 January 2020

GONG-SHOW

INFN Istituto Nazionale di Fisica Nucleare

The Galileo Galilei Institute for Theoretical Physics

BADEL Gil

Gil Badel

- Age 25
- Swiss
- Speak French, English, German
- Studied at EPFL, Lausanne, Switzerland
- Now 2nd year PhD student in the Laboratory of Theoretical Particle Physics, EPFL
- Supervisor : Riccardo Rattazzi

Our projects [1909.01269, 1911.08505]

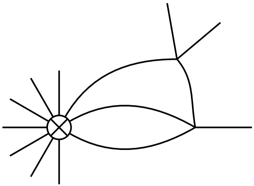
Computing anomalous dimension of ϕ^n operator in $\lambda(\phi\bar{\phi})^2$ theory, at the WF fixed point, in $4-\epsilon$ dimension.

2 techniques :

- standard QFT pertubation theory to 2-loops
  - perturbative expansion breaks down if $\lambda n \gg 1$.
- semiclassical expansion, large charge operators in CFT.
  - works for any value of λn
  - in small λn limit, retrieve leading-n contribution of all loop PT.

$$\gamma_{\phi^n} = n \sum_{\ell=0}^{\infty} \lambda^{\ell} P_{\ell}(n) = n \sum_{\kappa=0} \lambda^{\kappa} F_{\kappa}(\lambda n)$$

Example Diagram



$$\sim \lambda^2 n(n-1)(n-2) \sim \lambda^2 n^3$$

BANIK Amitayus

Amitayus Banik

Currently: Bethe Center for Theoretical Physics, University of Bonn

Future: University of Würzburg

About Me

Born and brought up in New Delhi, India. Undergrad from **Hindu College, University of Delhi**.

Research

- **M.Sc. (Uni Bonn):** Dark matter production in Moduli Cosmology. Looked at production of supersymmetric dark matter from decays of moduli for Master's thesis, *Production of SUSY Dark Matter from Higher Order Moduli Decay*.
- **Ph.D. (Uni Würzburg):** Field-theoretic and numerical studies of the electroweak phase transition in Beyond Standard Model scenarios.

Hobbies

Violin, reading and cooking.

BARNI Giulio

Hi, my name is Giulio Barni!

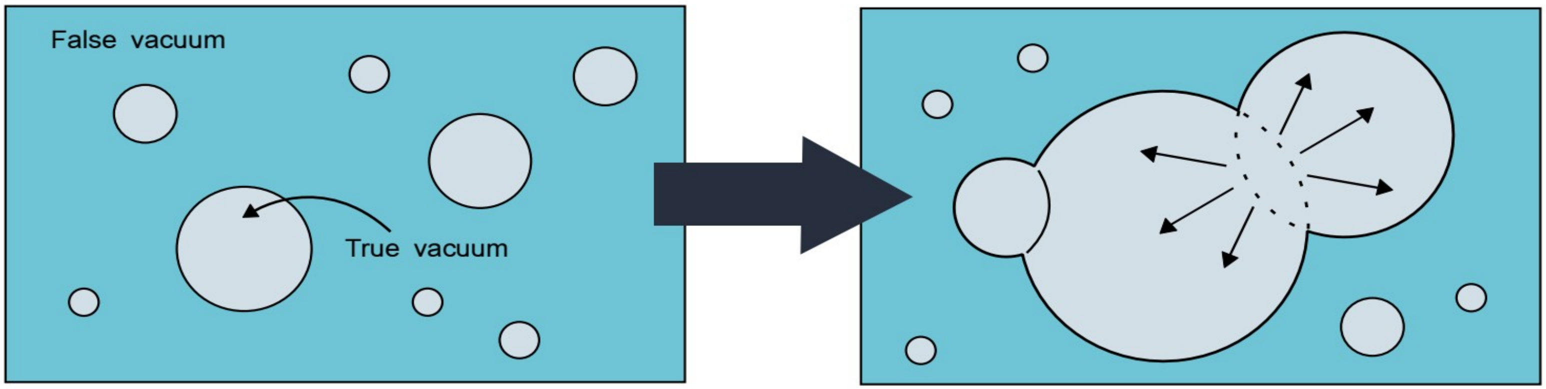
Master student in Florence

What I'm interested in?

Master thesis in

"Cosmological 1st order phase transitions:

Axions and new physics at the high scale"



BENINCASA Nico

The phase transitions in the early Universe and their effects on dark matter

Nico Benincasa

NICPB, Laboratory of High Energy and Computational Physics, Tallinn

Institute of Physics, University of Tartu

GGI Lectures on the Theory of Fundamental Interactions 2020

January 8, 2020

Dark matter :

- solution for some problems in astrophysics (galaxy rotation curves, galaxy-cluster collision,...)
- from Planck data, it accounts for 26.8% of the energy content of the Universe...
- ... but one is still ignorant about its nature
- Higgs boson discovery (2012) as an elementary scalar particle $\rightarrow$ why not dark matter as well ?

$\mathbb{Z}_N$ scalar dark matter model :

- For $N \geq 3$: semi-annihilation feature $\Rightarrow$ reduced direct detection signal
- models of scalar dark matter (e.g. SSDM or 2HDM) can produce richer patterns of phase transition
- signals from phase transitions could be probed by space-based gravitational-wave detectors such as LISA or BBO

$\mathbb{Z}_3$ model $\Rightarrow$ semi-annihilation :

- structure of minima
- temperature dependence
- first- and second-order phase transitions
- gravitational waves via first-order phase transitions

$\mathbb{Z}_3$ model :

- pseudo-Goldstone dark matter due to soft symmetry breaking
  $\rightarrow$ direct detection cross section strongly suppressed
  $\rightarrow$ stochastic gravitational wave background generated by first-order phase transitions

Classically scale invariant version of the $\mathbb{Z}_3$ model :

- solve the hierarchy problem
- yields gravitational-wave signal

BRANCHINA Carlo

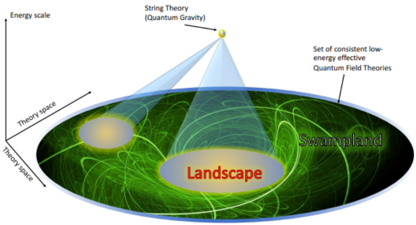
The Swampland and the Weak Gravity Conjecture

Carlo Branchina

LPTHE
Laboratoire de Physique Theorique et Hautes Energies, Paris

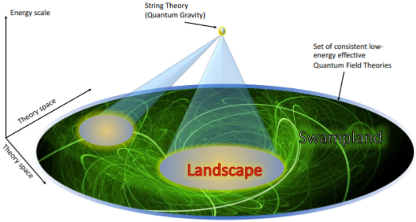
GGI's students gong-show
2020-01-08

The Swampland and the Landascape



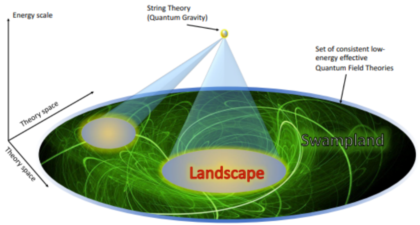
- Many Low Energy EFTs. Can they all be UV completed?
- $\Rightarrow$ Swampland program: Find UV physics characteristics that manifest themselves at lower energies
- Result: Constraints on the EFTs

The Swampland and the Landascape



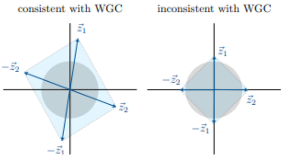
- Many Low Energy EFTs. Can they all be UV completed?
- $\Rightarrow$ Swampland program: Find UV physics characteristics that manifest themselves at lower energies
- Result: Constraints on the EFTs

The Swampland and the Landascape

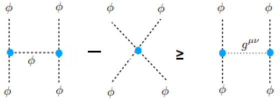


- Many Low Energy EFTs. Can they all be UV completed?
- $\Rightarrow$ Swampland program: Find UV physics characteristics that manifest themselves at lower energies
- Result: Constraints on the EFTs

The Weak Gravity Conjecture

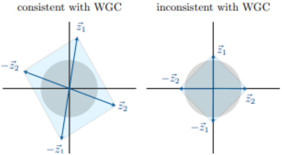


- Starting idea: Gravity is the weakest force
  Simplest form: Gravity weaker than U(1) gauge forces
- Many different setups proposed and studied
- Physical motivations: Black holes evaporation, absence of towers of states
- Goal: Understand how things work with scalars...

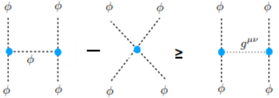


?

The Weak Gravity Conjecture

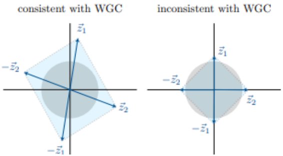


- Starting idea: Gravity is the weakest force
  Simplest form: Gravity weaker than U(1) gauge forces
- Many different setups proposed and studied
- Physical motivations: Black holes evaporation, absence of towers of states
- Goal: Understand how things work with scalars...

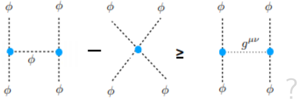


?

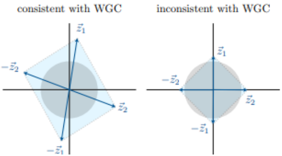
The Weak Gravity Conjecture



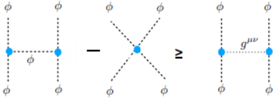
- Starting idea: Gravity is the weakest force
  Simplest form: Gravity weaker than U(1) gauge forces
- Many different setups proposed and studied
- Physical motivations: Black holes evaporation, absence of towers of states
- Goal: Understand how things work with scalars...



The Weak Gravity Conjecture



- Starting idea: Gravity is the weakest force
  Simplest form: Gravity weaker than U(1) gauge forces
- Many different setups proposed and studied
- Physical motivations: Black holes evaporation, absence of towers of states
- Goal: Understand how things work with scalars...



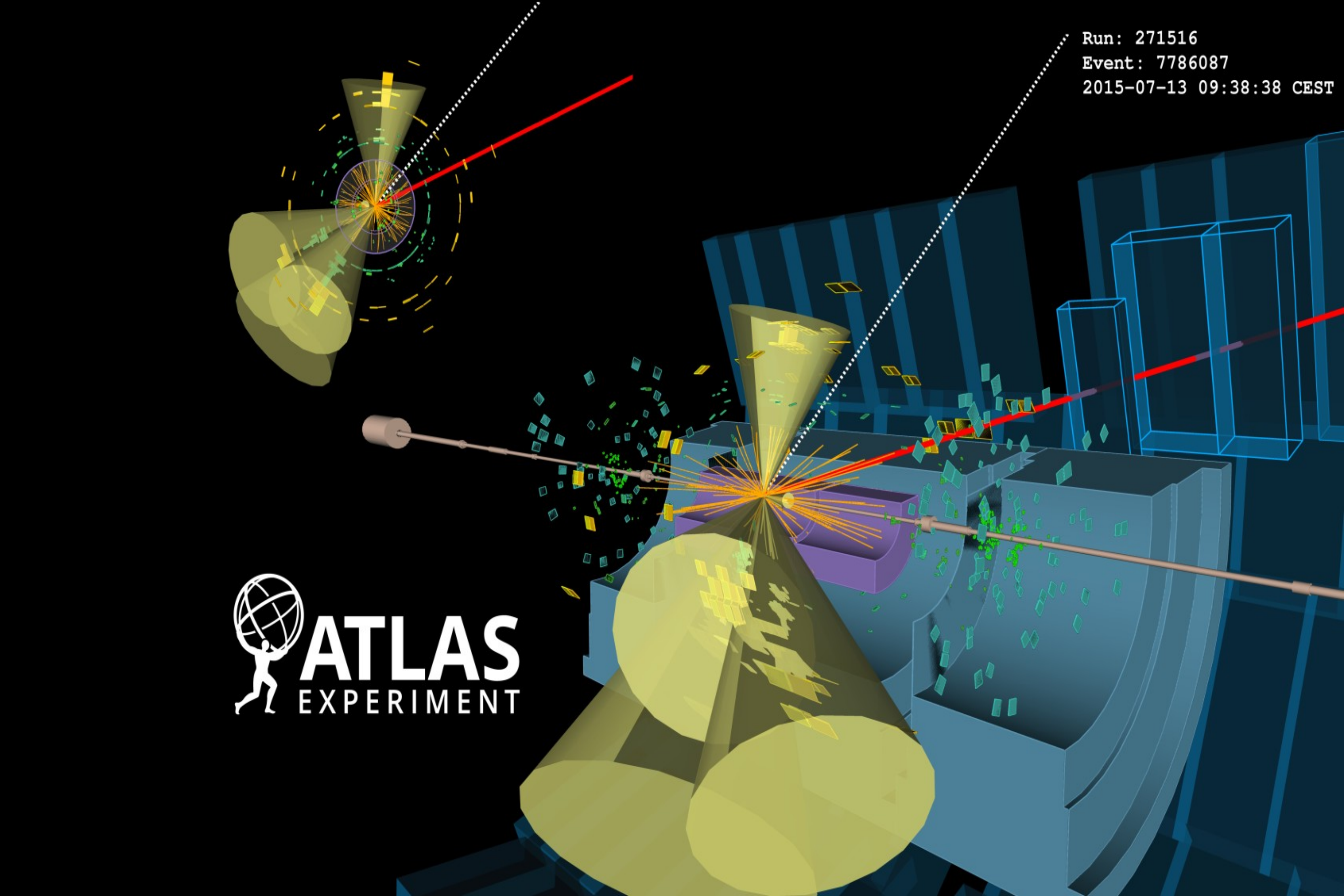
?

CALETTI Simone

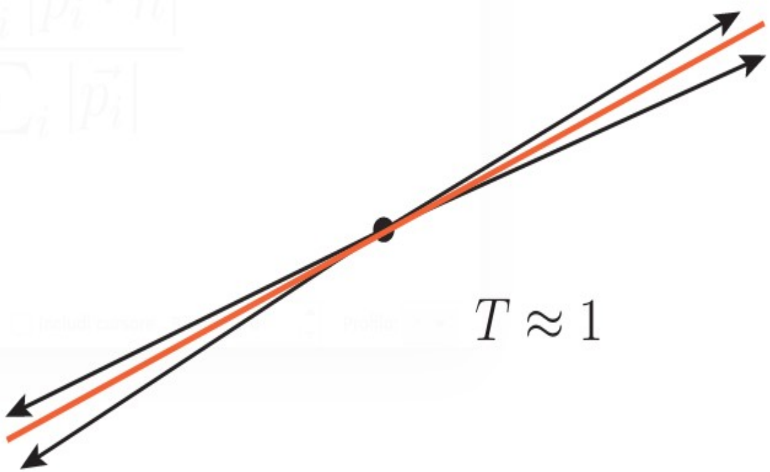
Simone Caletti

Università degli Studi di Genova
Supervisor: Simone Marzani

GGI School - 08/01/2020

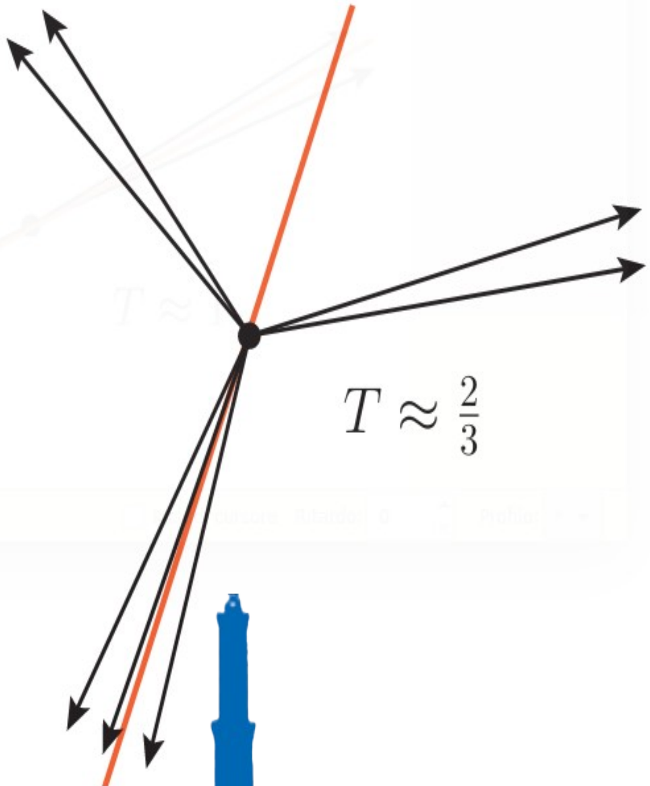

Run: 271516
Event: 7786087
2015-07-13 09:38:38 CEST
ATLAS
EXPERIMENT

$$T = \max_{\vec{n}} \frac{\sum_i |\vec{p_i} \cdot \vec{n}|}{\sum_i |\vec{p_i}|}$$

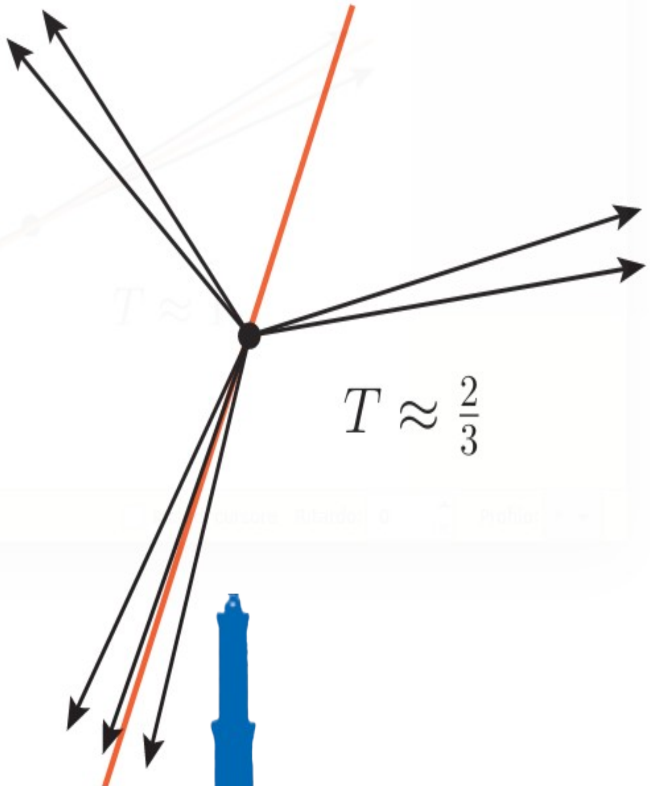


$T \approx 1$

$$T = \max_{\vec{n}} \frac{\sum_i |\vec{p_i} \cdot \vec{n}|}{\sum_i |\vec{p_i}|}$$



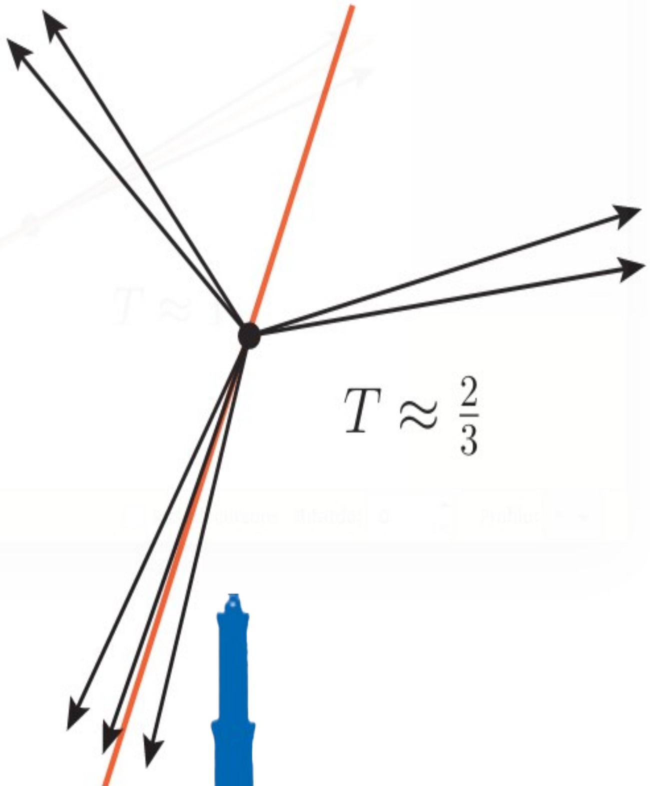
$$T = \max_{\vec{n}} \frac{\sum_i |\vec{p_i} \cdot \vec{n}|}{\sum_i |\vec{p_i}|}$$



Coll. safety: $T^{(n+1)}(\ldots, k_n, k_{n+1}) \to T^{(n)}(\ldots, k_n + k_{n+1})$

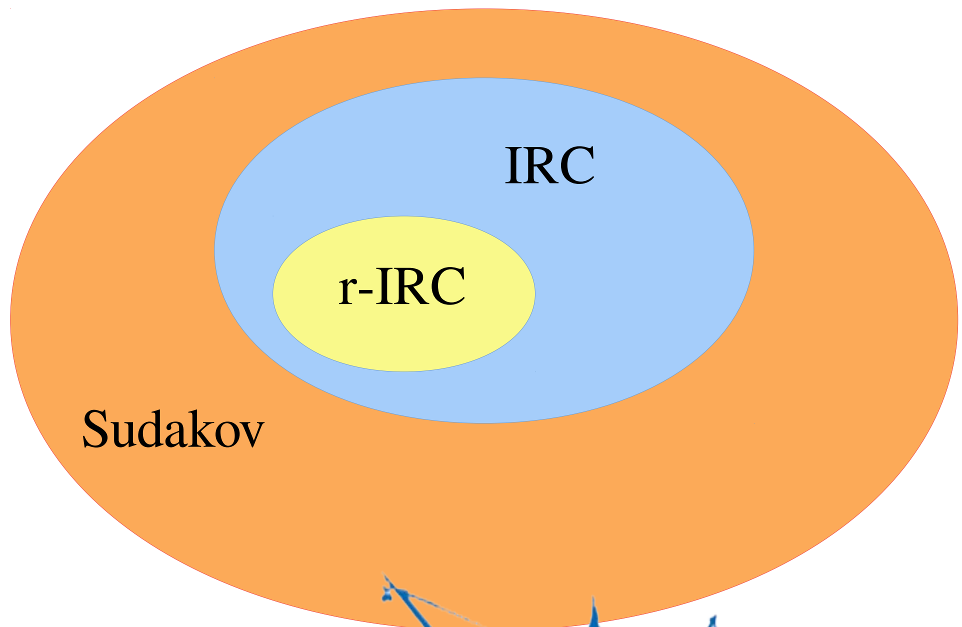
Infrared safety: $T^{(n+1)}(\ldots, k_n, k_{n+1}) \to T^{(n)}(\ldots, k_n)$

$$T = \max_{\vec{n}} \frac{\sum_i |\vec{p_i} \cdot \vec{n}|}{\sum_i |\vec{p_i}|}$$



Coll. safety: $T^{(n+1)}(\ldots, k_n, k_{n+1}) \to T^{(n)}(\ldots, k_n + k_{n+1})$

Infrared safety: $T^{(n+1)}(\ldots, k_n, k_{n+1}) \to T^{(n)}(\ldots, k_n)$



CANDIDO Alessandro

& STEGEMAN Roy

Machine Learning and QCD

for Proton structure determination

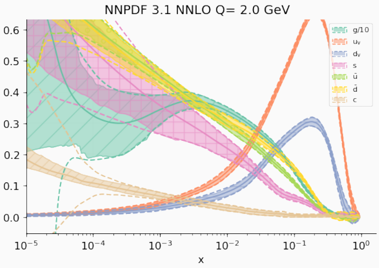
Alessandro Candido - Roy Stegeman
Supervisors: Stefano Forte, Stefano Carrazza

January, 2020

Theory

Parton Distribution Functions (PDF) describe the internal structure of the proton, as it is made by its constituents.

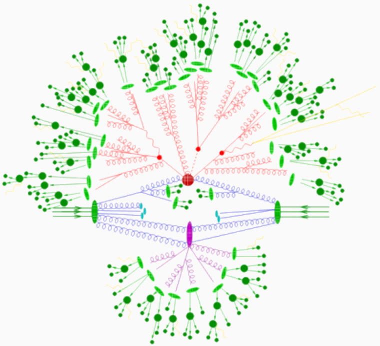
- PDFs are determined from the experimental data (*fit*)
- they are used to make theoretical predictions for collider observables (*factorization*)
- the goal is to improve the accuracy of PDFs and their features (e.g.: *NLO positivity*)



Machine Learning

Determination of the PDF functions using machine learning techniques.

- We need to invert this complicated system
- Using neural networks to remove theoretical bias
- How do we know the result is correct?
- What is the best optimisation method?



CHEN　Miranda

Miranda Chen

University of California, Davis

Past: Unitarity violation from deviations of Higgs couplings from SM value

- Suggests lower bound for scale of new physics
- Looking at VVh, VVhh, tth, tthh
- Compare deviations that are similarly constrained

Current: EW splitting functions; dark matter EP violation

CHEONG Dhong Yeon

Dhong Yeon Cheong

정동연

- Institution : Yonsei University, S. Korea
- Supervisor : Seong Chan Park

연세대학교
YONSEI UNIVERSITY

Dhong Yeon Cheong

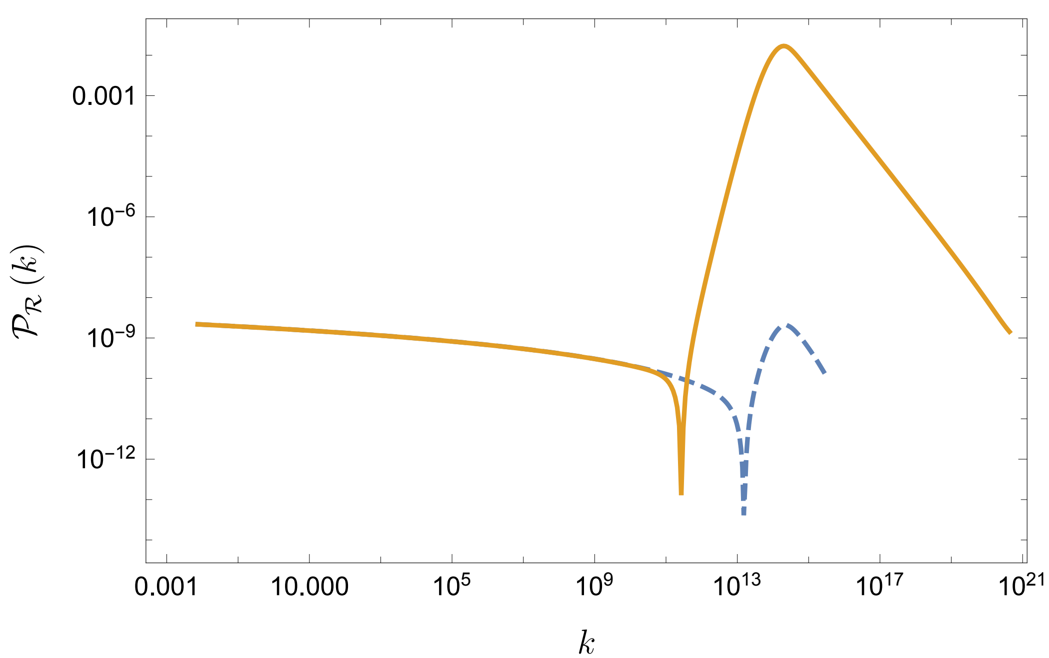
정동연

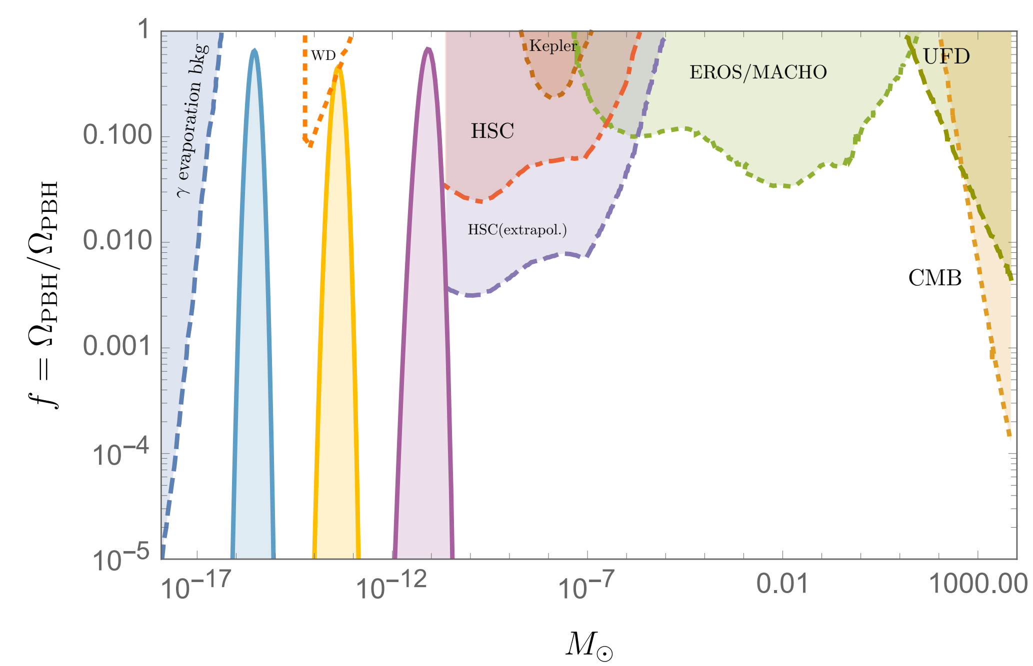
Research Interests

- Inflationary Cosmology
- Primordial Black Holes
- Early Universe Phenomenology

Good probe for small scales, NG, and new physics

Primordial Black Holes in Higgs-R^2 Inflation as a whole dark matter
Dhong Yeon Cheong, Sung Mook Lee, Seong Chan Park. Dec 27, 2019. 6 pp.
YHEP-COS19-005
e-Print: arXiv:1912.12032 **[hep-ph]** | PDF





COSTA Marco

SCUOLA NORMALE SUPERIORE

Marco Costa

PhD Student, Scuola Normale Superiore (SNS), 1st year

PhD Thesis Supervisor: Prof. Roberto Contino
Master Thesis Supervisor: Prof. Dario Buttazzo

Research interests

BSM Physics
Strongly interacting theories

Master

- Composite Higgs models
- Leptoquarks

PhD

- Dark Matter models
- Chiral gauge theories?

DI CARLO Matteo

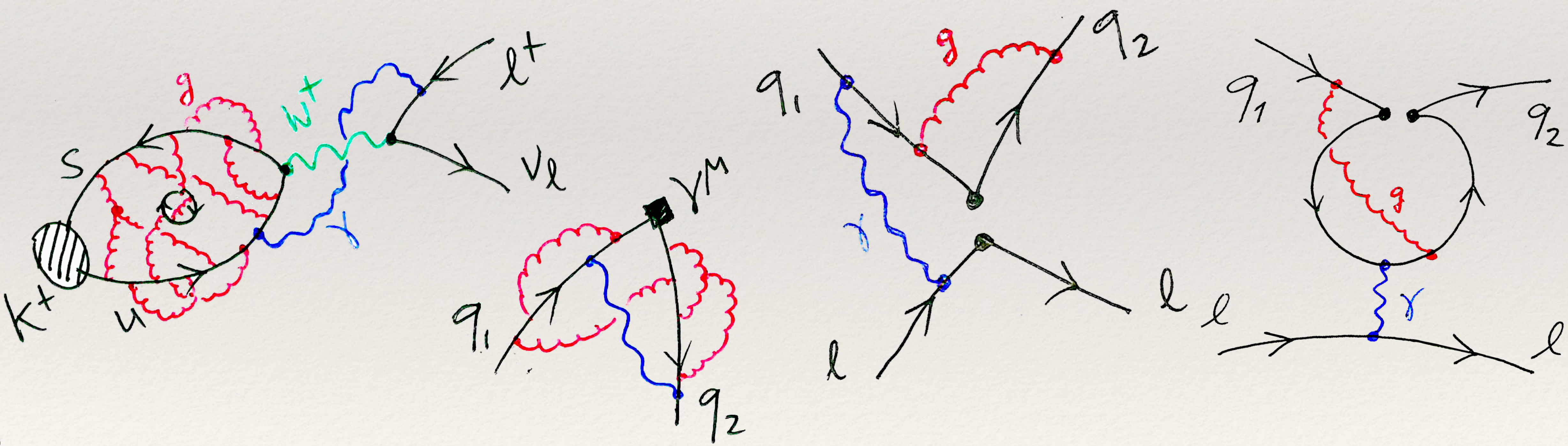
SAPIENZA
UNIVERSITÀ DI ROMA

INFN
Istituto Nazionale di Fisica Nucleare

High Precision Flavour Physics

Student:
Matteo Di Carlo

Supervisor:
Prof. Guido Martinelli



GGI LECTURES ON THE THEORY OF FUNDAMENTAL INTERACTIONS

8 January 2020 — *Galileo Galilei Institute for Theoretical Physics* — Firenze

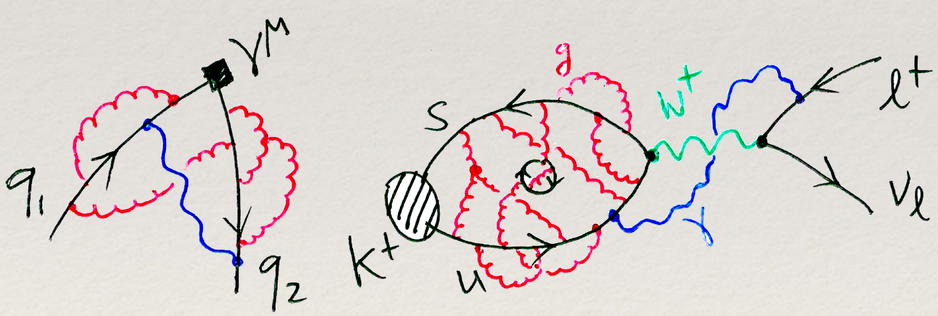
GONG SHOW

Brief summary of the project

- **Why?** Test the **Standard Model** and seek **New Physics** effects
- **How?** Improving the **precision** of theoretical predictions
- **What?** Include **QED corrections** in (Lattice) QCD calculations

❶ Non-perturbative renormalization in QCD+QED

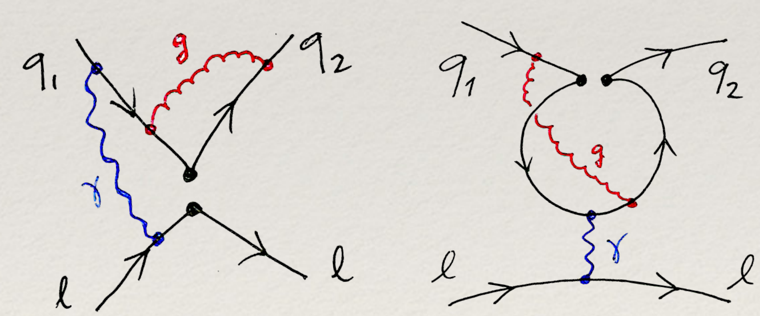
and its application to weak processes:



- Extraction of the **CKM matrix elements** and **unitarity test**

❷ Two loop anomalous dimensions in QCD+QED

and analysis of the bounds to the New Physics scale:



- Can be relevant in many processes, possible applications in **B-physics**

DICHTL Maximilian

GGI Gong Show

Maximilian Dichtl

Theoretical Particle Physics at Colliders
Technical University of Munich

GGI Lectures, 2020

Master's Thesis

M. Ruhdorfer, J. Serra, A. Weiler
Effective Field Theory of Gravity to All Orders
arXiv:1908.08050v1

- EFT of gravity coupled to SM (GRSMEFT)
    - $C_{\mu\nu}{}^{\rho\sigma} C^{\mu\nu\alpha\beta} C_{\alpha\beta\rho\sigma}$
    - $G^{\mu\nu} G^{\rho\sigma} C_{\mu\nu\rho\sigma}$
    - $H^\dagger H C_{\mu\nu\rho\sigma} C^{\mu\nu\rho\sigma}$
    - ...
- Goals:
    - Find suitable observables
    - Put bounds on Λ
    - Constrain Wilson-coefficients

DRAUKSAS Simonas

- Simonas Draukšas of Lithuania
- 1st year PhD student at Vilnius University

- Our group is working with the **Grimus-Neufeld model**
- The model has an additional *Higgs Doublet* and a *4th heavy Majorana neutrino* >>> **neutrino mass generation**
- The main goal of my PhD is to perform the **full renormalisation** of the Grimus-Neufeld model

FUCILLA Michael

Basic information

- Name: Michael Fucilla
- Affiliation: Università della Calabria & INFN-Cosenza
- E-mail: mike.fucilla@libero.it
- Research interests: Investigation of semi-hard regime of QCD, BFKL approach.

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

INFN
Istituto Nazionale di Fisica Nucleare

Research interests

- Semi-hard collision process, featuring the scale hierarchy

$$s \gg Q^2 \gg \Lambda^2_{QCD}, \qquad Q^2 \text{ a hard scale},$$

$\nearrow$

Regge kinematical region

$$\alpha_s(Q^2)\ \ln\left(\frac{s}{Q^2}\right) \sim 1 \implies \text{all-order resummation needed}$$

- The Balitsky-Fadin-Kuraev-Lipatov (BFKL) approach is the general framework for this resummation
  - Leading-logarithm-Approximation (LLA): $(\alpha_s \ln s)^n$
  - Next-to-leading-logarithm-Approximation (NLLA): $\alpha_s(\alpha_s \ln s)^n$
- However, experimental evidences of the BFKL dynamics are not conclusive, thus motivating proposal of new probes.
- Partially inclusive processes with jets and/or identified particles in the final state are suitable for this kind of investigation (e.g. Muller-Navellet jets).
- The BFKL approach is also important for the description of the low-x unintegrated gluon density.

Thanks for the attention!

GAVARDI Alessandro

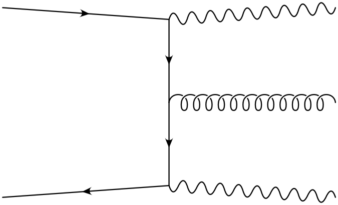
Hello everyone!

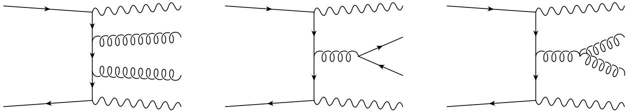
My name is Alessandro Gavardi

and I am a Ph.D. student from

Università degli Studi di Milano-Bicocca

My area of research is the Theory and Phenomenology of the Standard Model and currently I am working on double photon plus jet production at LHC





GOMES Andrew

GGI Winter School 2020

Andrew Gomes

Cornell University (PhD student)

Advisor: Csaba Csáki

Cornell University

Andrew Gomes Research Interests

- Currently extending the on-shell formulation of the chiral anomaly to spontaneously broken gauge theories
- Future interest in Higgs models, extra dimensions, and non-perturbative phenomena both on- and off-shell

GRANELLI Alessandro

Alessandro Granelli

UNIVERSITÀ DEGLI STUDI DI PADOVA

Master in Physics at the University of Padua (PD)
Supervisor: Dott. Francesco D'Eramo
Thesis: A novel dark matter mechanism to produce X-ray lines with unique morphology and spectrum

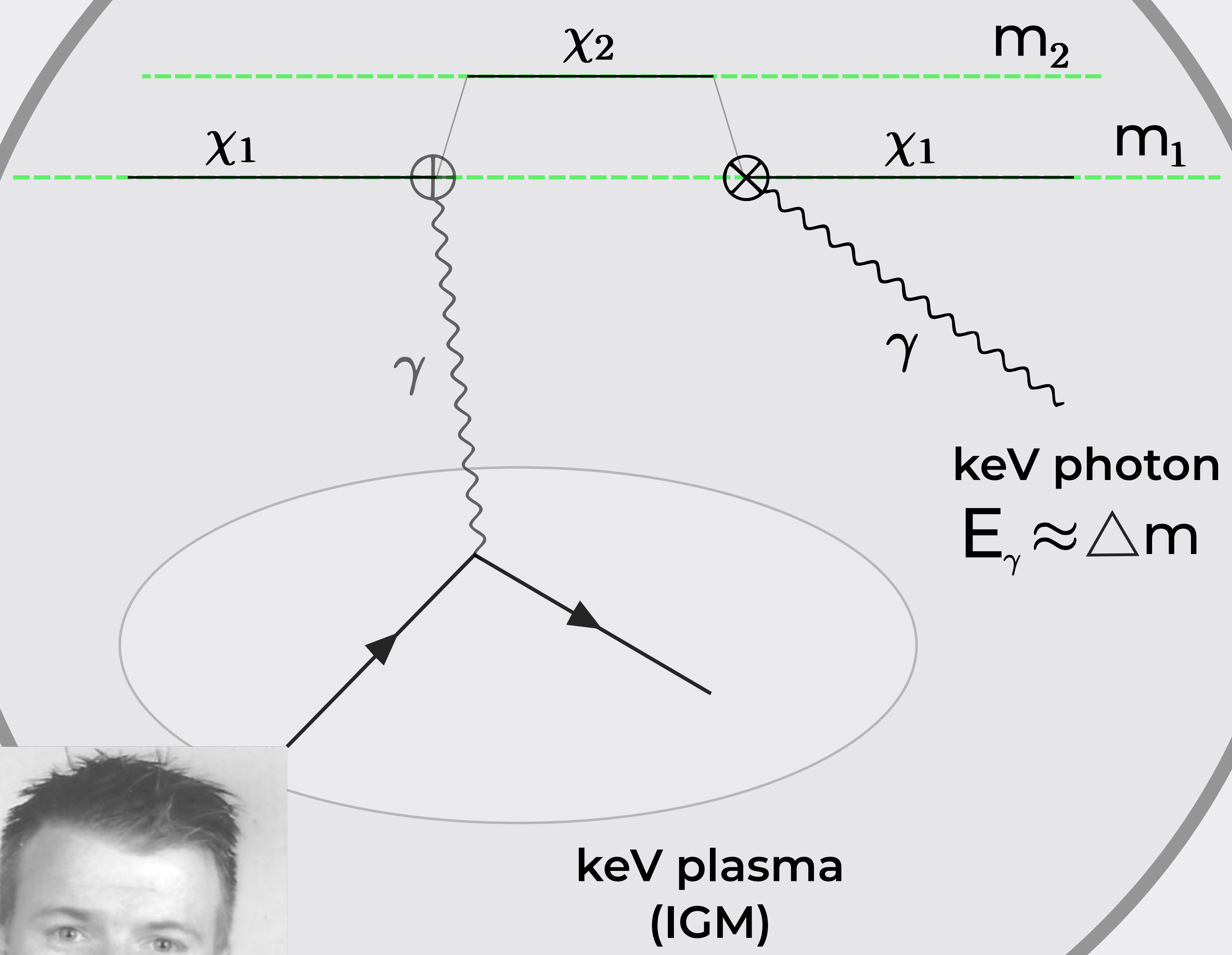
scuolagalileiana di studi superiori

Diploma in Natural Sciences at the
Galileian School of Higher Education (SGSS - PD)

SISSA

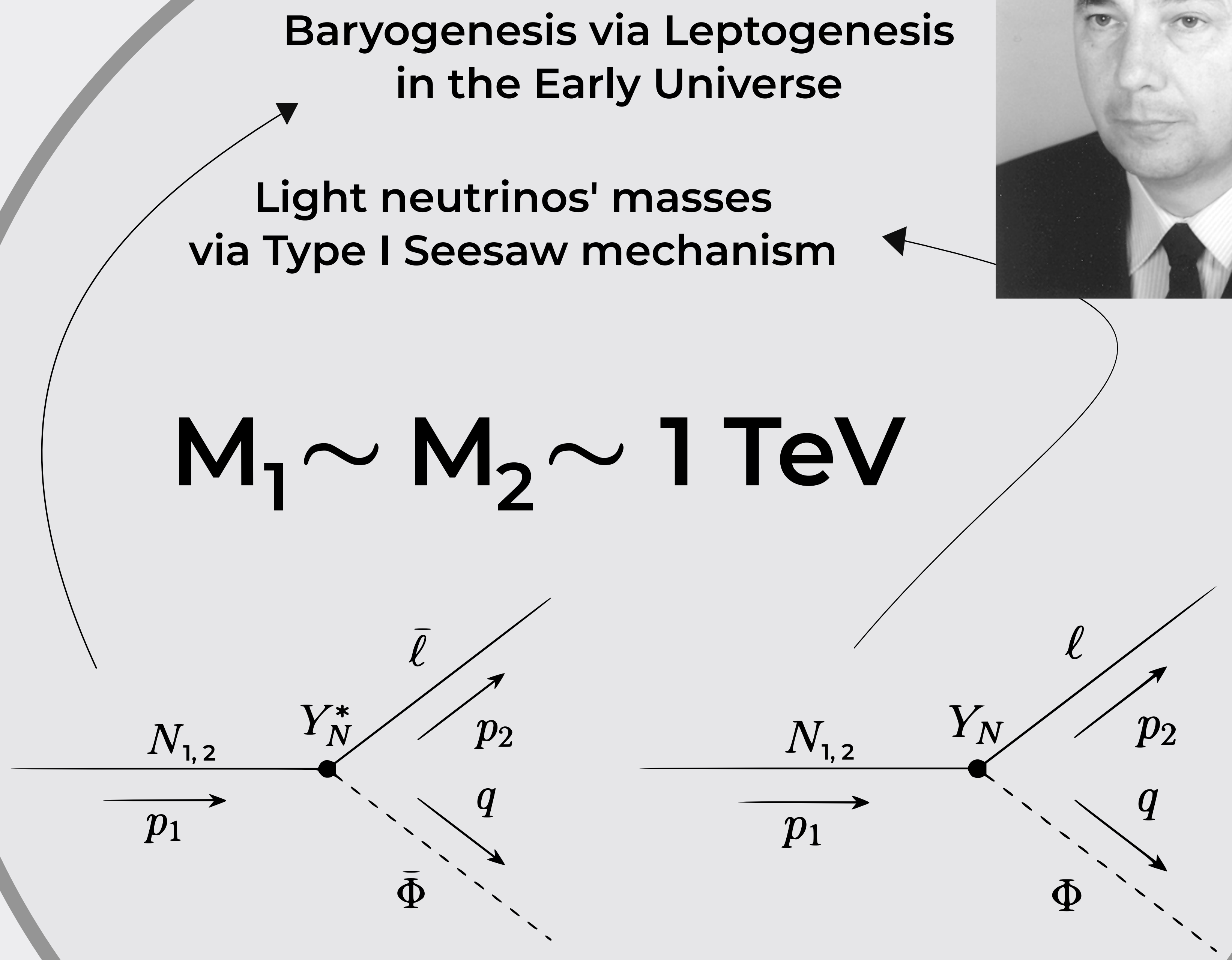
PhD position in Astroparticle Physics at SISSA , Trieste (TS)
Supervisor: Prof. Serguey T. Petcov
Project: Resonant Leptogenesis at the TeV scale

X-Rays from Inelastic Dark Matter



Dott. Francesco D'Eramo

Prof. Serguey T. Petcov



Resonant Leptogenesis at the TeV scale

The Galileo Galilei Institute (GGI) for Theoretical Physics, Florence (IT)
GGI LECTURES ON THE THEORY OF FUNDAMENTAL INTERACTIONS
07-24/01/2020

GUERRERO MENKARA Adriana

Student: Adriana Guerrero Menkara
Affiliation: Chung Ang University
Advisor: Hyun Min Lee
email: amenkara@cau.ac.kr

Research Interests:

Cosmology, Physics beyond the Standard model, Supergravity, Supersymmetry Anomalies.

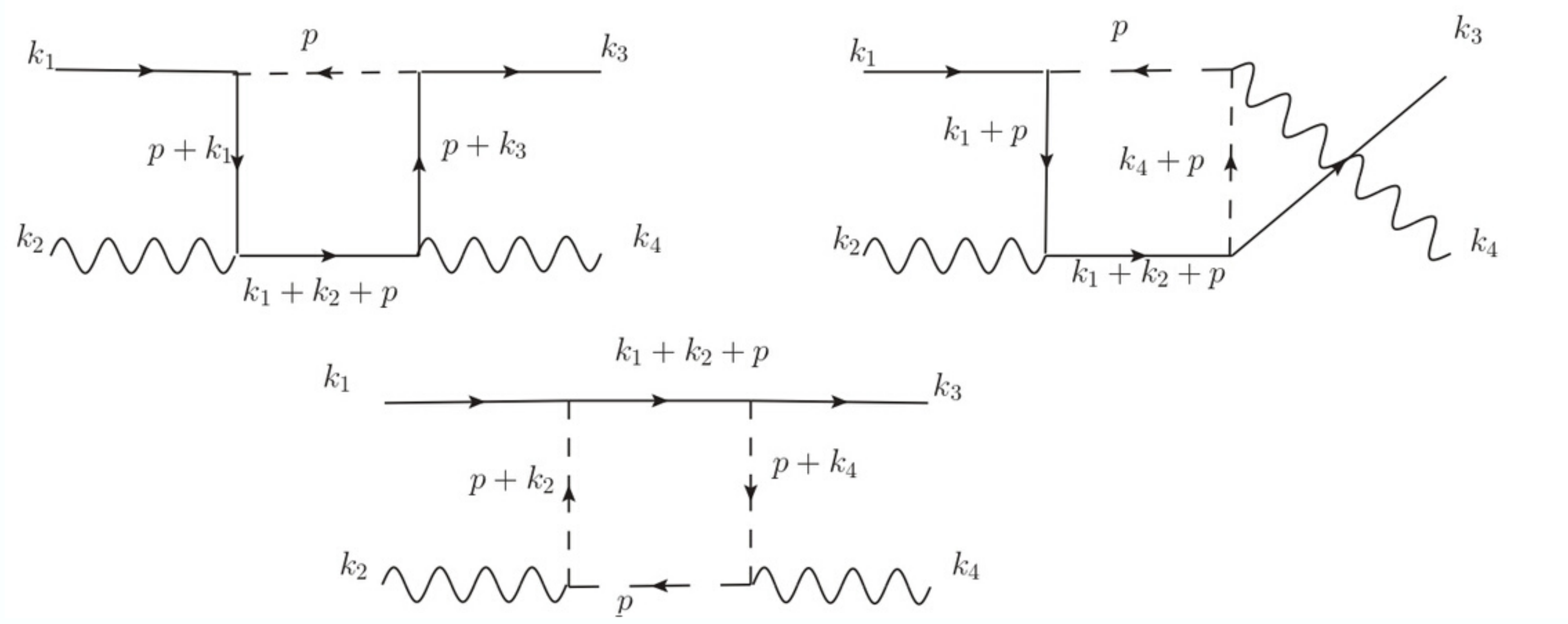
Ongoing work

1. SUSY ANOMALIES

- Prove the SUSY anomalies explicitly.
- Study implications of anomalous U(1) symmetry breaking
- Study low-energy phenomenology.

2. FOUR FORM FLUX

- Hierarchy problem
- Phase transition
- Inflation
- Reheating

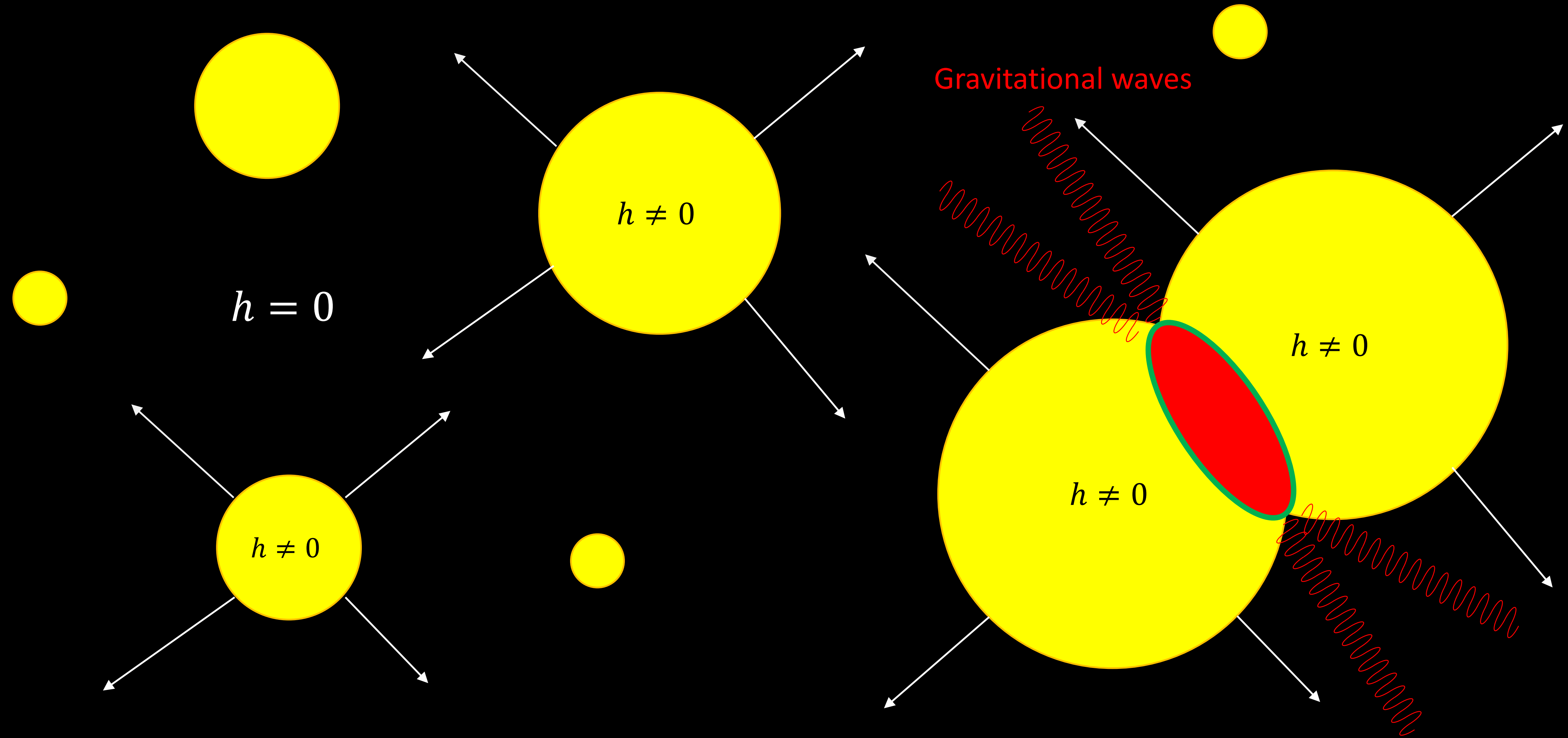


GUIGGIANI Andrea

My name is Andrea Guiggiani!

Master student
University of Florence

Cosmological 1st order phase transitions:



GUPTA Nitin

GGI Lectures on the Theory of Fundamental Interactions 2020

Students' Gong-Show

Student Information :-

Name : Nitin Gupta

Affiliation : QASTM Collaboration & IISER Mohali, India

Advisor : Dr. Sayantan Choudhury, MPIGP-AEI, Potsdam

Field : Open Quantum Cosmology and High Energy Physics

Research Goals & Outline :-

- Goal : To better understand space-time and interactions.

- Cosmological scenario provides a nice platform to study interactions which may lead one to a better understanding of space-time & interactions

- Everything, including interactions, is fundamentally of quantum nature.

- So we have : Cosmology + Quantum Interactions $\rightarrow$ OQC

- Mathematical Tools required : OQS, GR, QFT, Non-Eq SM etc

- Example problem : Study of two atom quantum entanglement in static patch of de-Sitter space.

- Insights : arxiv 1908.09929 : Entanglement is initially zero but later on it increases and then saturates.

ISABELLA Giulia

GONG-SHOW, GGI 2020

Supervisors: Adam Falkowski, Brando Bellazzini

Giulia Isabella, LPT Orsay

8 janvier 2020

MODERN S-MATRIX METHODS FOR HIGHER SPINS

On-Shell Methods

Fundamental principles

↓

$$\mathcal{L} = \bar{\psi}(i\gamma^\mu \mathcal{D}_\mu - m)\psi - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \dots$$

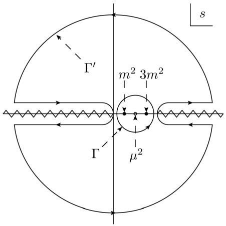
↓

Scattering amplitudes

$$A(p_1, p_2, p_3, p_4) = \mathcal{F}(s, t, u)$$

Effective Field Theory

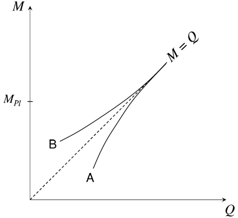
- Positivity constraints



Application to dRGT massive gravity

WEAK GRAVITY CONJECTURE VIA UNITARITY

Weak Gravity Conjecture ($\frac{Q}{M} > 1$)



$$\mathcal{S} = \int d^4x\sqrt{-g}\Big(\frac{R}{2\kappa^2} - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \alpha_1(F_{\mu\nu}F^{\mu\nu})^2 + \ldots\Big)$$

Positivity Constraints

- $\mathcal{M}^{z_1 z_2}(s, t \to 0) = -\frac{s^2}{m_{Pl}^2 t} + \mathcal{O}(s)$
- Regularized by compactification of one dimension
- Computing amplitudes of gravity in 3D

$$\Big(\frac{\sqrt{2}Q}{M/m_{Pl}}\Big)_{ext.} = 1 + \frac{4}{5}\frac{(4\pi)^2 m_{Pl}^2}{M^2}(2\alpha_1 - \alpha_3) > 1$$

ISMAIL Ameen

Ameen Ismail

Cornell University

Supervisor: Csaba Csáki

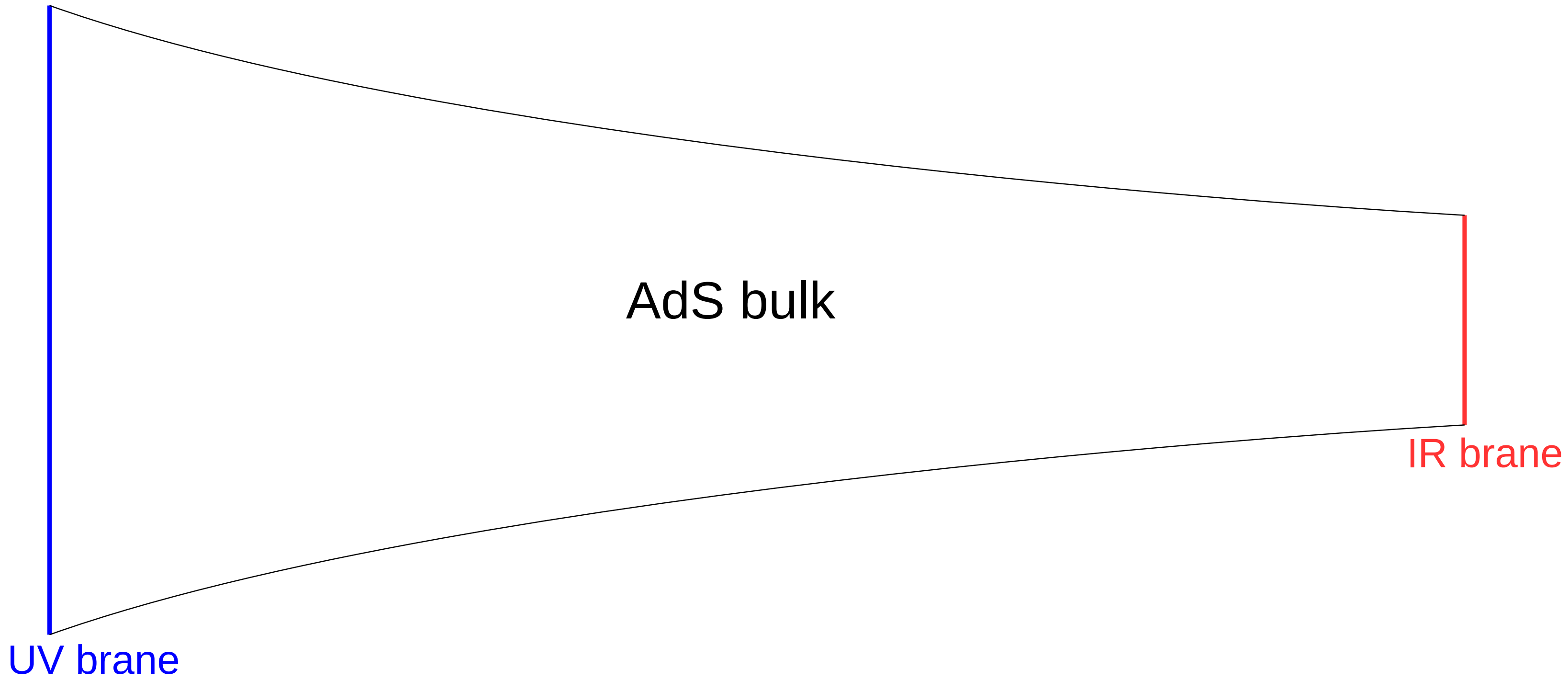
Research interests:

- Hierarchy problem
- Extended Higgs sectors
- Extra dimensions

Other interests (would like to learn more!):

- Machine learning
- On-shell scattering amplitudes

Warped extra dimensions



Dilaton:

- Parametrizes fluctuations of branes
- Goldstone boson of broken conformal symmetry
- Effective action unknown beyond linear order

Spacetime symmetry breaking approach, CCWZ

KIM Jung-Wook

Classical physics of compact spinning bodies from QFT

Jung-Wook Kim, Seoul National University

Works in collaboration with; Ming-Zhi Chung, Yu-Tin Huang, and Sangmin Lee

arXiv:1812.08752, 1908.08463, 1911.12775

- Motivation
  - Recently, obtaining classical physics from QFT has regained interest
    - E.g. 3PM conservative Hamiltonian of BH binary from Zvi Bern's group
  - Usually focused on non-spinning bodies or first few orders in spin
    - Limited by finiteness of spin: spin s particle only has up to 2^{2s}-multipole moments
  - Can we crank up to *arbitrary* orders in spin?

- Method
  - Combine modern amplitude techniques with (NRGR) EFT
  - Study physics of massive higher spin particles (without introducing fields)

Classical physics of compact spinning bodies from QFT

Jung-Wook Kim, Seoul National University

Works in collaboration with; Ming-Zhi Chung, Yu-Tin Huang, and Sangmin Lee

arXiv:1812.08752, 1908.08463, 1911.12775

- Some notable results
  - Black holes couple to photons and gravitons "minimally"

$$M_s^{+2} = \frac{\kappa m x^2}{2m^{2s}} \left[g_0 \langle \mathbf{21} \rangle^{2s} + g_1 \langle \mathbf{21} \rangle^{2s-1} \frac{x \langle \mathbf{2} q \rangle \langle q \mathbf{1} \rangle}{m} + \cdots + g_{2s} \frac{(x \langle \mathbf{2} q \rangle \langle q \mathbf{1} \rangle)^{2s}}{m^{2s}} \right]$$

$$M_s^{-2} = \frac{\kappa m x^{-2}}{2m^{2s}} \left[g_0 [\mathbf{21}]^{2s} + g_1 [\mathbf{21}]^{2s-1} \frac{[\mathbf{2} q][q \mathbf{1}]}{xm} + \cdots + g_{2s} \frac{([\mathbf{2} q][q \mathbf{1}])^{2s}}{x^{2s} m^{2s}} \right],$$

  - Leading order gravitational Hamiltonian to all orders in spin can be computed
  - EM stress tensor of KNBH spacetime can be reproduced from 1-loop computations

$$\frac{8\, T_{\mu\nu}}{Q^2 \pi \sqrt{-q^2}} = -u_\mu u_\nu J_0(\vec{a} \times \vec{q}) + \left(-u_\mu u_\nu + \frac{q_\mu q_\nu - q^2 \eta_{\mu\nu}}{-q^2} + 2i u_{(\mu} E_{\nu)} \right) \left[\frac{J_1(\vec{a} \times \vec{q})}{\vec{a} \times \vec{q}} \right] + E_\mu E_\nu \left[\frac{J_2(\vec{a} \times \vec{q})}{(\vec{a} \times \vec{q})^2} \right]$$

Classical field theory computation

1-loop form factor computation ($q^2 \to 0$ limit; HCL)

$$\langle p_2 | T_{\mu\nu} | p_1 \rangle = \frac{|\vec{q}|}{32} \frac{\alpha_q^2}{M_{pl}} \left\{ -\frac{P_\mu P_\nu}{m^2} \left[\frac{I_1(a \cdot q)}{(a \cdot q)} + I_0(a \cdot q) \right] + 2i \frac{P_{(\mu} E_{\nu)}}{m} \frac{I_1(a \cdot q)}{(a \cdot q)} - \frac{q_\mu q_\nu - \eta_{\mu\nu} q^2}{q^2} \frac{I_1(a \cdot q)}{(a \cdot q)} + E_\mu E_\nu \frac{I_2(a \cdot q)}{(a \cdot q)^2} \right\}$$

LANDINI Giacomo

GGI school 2020

Giacomo Landini
Università di Pisa and INFN, Sezione di Pisa
Phd student
Supervisor: Prof. Alessandro Strumia

Phd Project(s)

Composite Dark Matter

- **Composite** DM candidates coming from **gauge** dynamics + 1 **scalar** field
- Scalar in fundamental or two-index representation of SU(N),SO(N),Sp(N)
- Study of the different **phases** (Higgsed,confined) and **dualities** among them
- DM **phenomenology**

CP-violating Axions

- **CP-violating** couplings of axions with nucleons could mediate new **forces** (long-range or monopole-dipole)
- New experimental setups for monopole-dipole interaction (ARIADNE)
- Possible **sources** of CP-violation from **NP**
- Some concrete model for **baryogenesis**

LEESung Mook

General Information

- **Name : LEE, SUNG MOOK**
  이 성 묵
- **Country : South Korea**
- **Affiliation : Yonsei University**
- **Advisor : Park, Seong Chan**
- **Research Interests : The Physics of the Early Universe**
  BSM from Cosmology

Research Interests

- Previous Works
  - <Higgs Inflation and the Refined dS Conjecture>

    arXiv : 1811.03622
    PLB 789 (2019) 336-340
    D.Y. Cheong, SML, S.C. Park
  - <Primordial Black Holes in Higgs-R^2 Inflation as a whole dark matter>

    arXiv : 1912.12032
    D.Y. Cheong, SML, S.C. Park

- Current Works
  - Matter/Antimatter Asymmetry from the Higgs Inflation
  - QFT in curved spacetime → Dark Matter / Baryogenesis

- Future Works
  - General Aspects of Inflation (Effective Theory, etc.)
  - Anything Interesting & Important!

LIMATOLA Giovanni

Università degli Studi di Milano-Bicocca

Dipartimento di Fisica “Giuseppe Occhialini”

PhD program in Physics and Astronomy, XXXV cycle

Curriculum in Theoretical Physics

Giovanni Limatola

Advisor: Prof. Paolo Nason

Coordinator: Prof. Marta Calvi

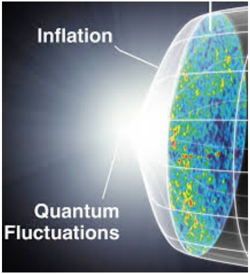
Academic year: 2019/2020

RESEARCH PROGRAM

- Non perturbative QCD (NPQCD) and Renormalon effects in Z+jet associated production in hadronic collisions
- Computation up to Next-to-Leading Order in α_s, in the large n_f approximation
- Looking for corrections of order Λ_{QCD} for specific kinematical observables
- HJJ production with a pseudoscalar Higgs in MiNNLO

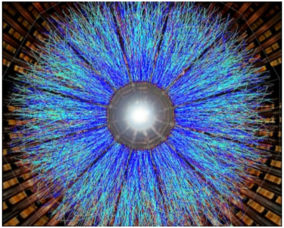
LUNDBERG Torbjörn

Why TQFT?



https://lecospa.ntu.edu.tw

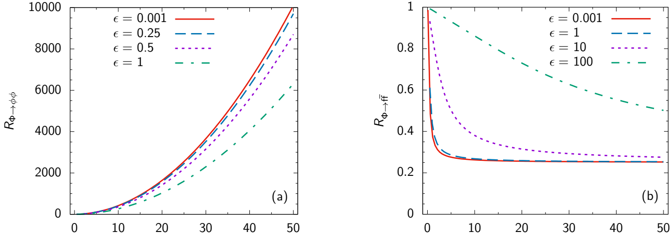

https://en.wikipedia.org/wiki/Supernova


http://news.mit.edu/2010/exp-quark-gluon-0609

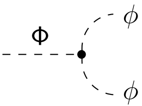
Comparison to $T = 0$

Motivation

Some results



(Figures are reproduced results of Ho&Scherrer, 2015)



- $R_{\Phi\to\text{final}} = \Gamma_D/\gamma_D$, $\epsilon = |\mathbf{p}|/M_\Phi$.
- Results plotted for $p^2 \gg 4m^2$.
- Temperature effects kick in $\sim$ a few-10 MeV. (Zheng et al. 2014)

MANSO António

Physics of the inflationary Universe: particle production and gravity waves

Student: António Torres Manso

Supervisor: Mar Bastero Gil

Institution: Facultad Ciencias Universidad Granada
Departamento de Física Teórica
y del Cosmos

UNIVERSIDAD DE GRANADA

Research Program

- Study GW's production mechanisms during inflation, either due to particle production processes, or the amplification of scalar perturbations due to features in the inflaton potential.

  These are related mechanisms since particle production may enhance both the tensor and scalar perturbations at second order.

- Explore Particle production during the first stages of reheating and preheating.

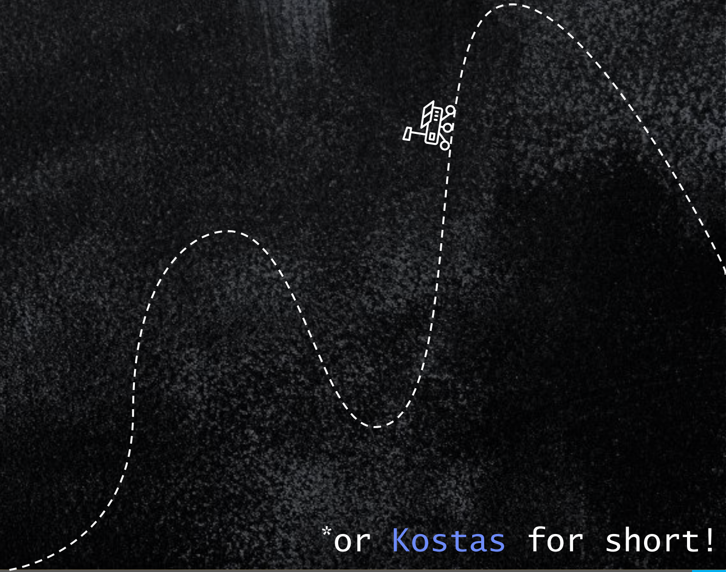
  The same kind of interactions relevant during (p)reheating may be responsible for production processes during inflation, but leaving their imprint on the present spectrum of GW's at different frequencies.

- Study how the amplification of scalar perturbations beyond linear perturbation theory can lead to primordial black holes (PBH), these being a candidate for Dark Matter, and a source of GW's.

MANTZAROPOULOS Konstantinos

Konstantinos* Mantzaropoulos

- Ioannina, Greece
- University of Ioannina, Department of Theoretical Physics
- Supervisor: Athanasios Dedes



*or Kostas for short!

Research Interests

Neutrinos Physics

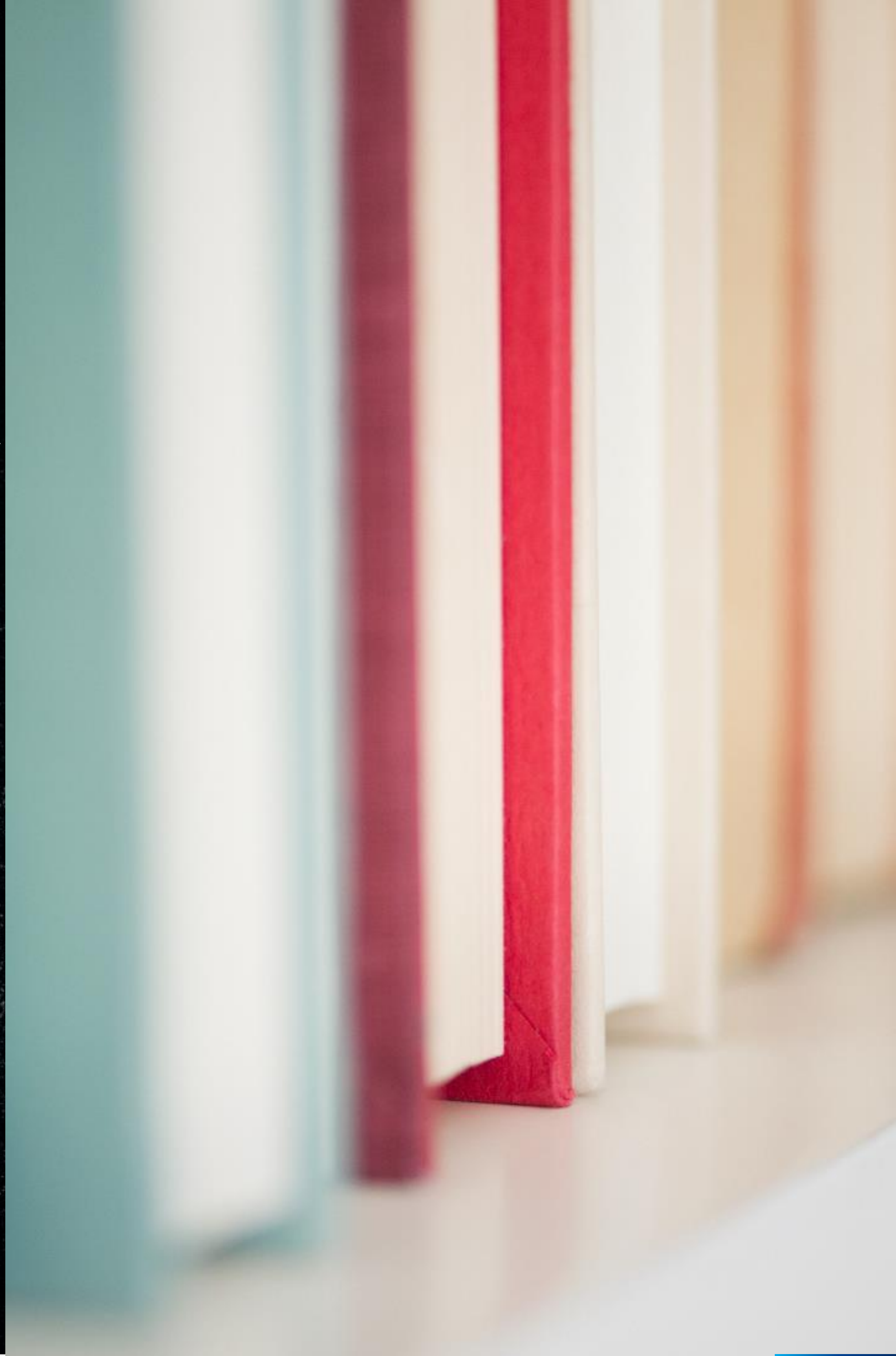
- ❑ Neutrino oscillations in matter in various media
- ❑ Neutrino oscillations with extra families
- ❑ Neutrino Masses

Effective Field Theories (EFTs)

- ❑ Decoupling of heavy particles
- ❑ Functional approaches in decoupling
- ❑ Standard Model Effective Field Theory (SMEFT)
- ❑ Lepton flavor violation

Neutrino Non-Standard Interactions (NSIs)

- ❑ Higher dimensional operators involving neutrino contact interactions with matter
- ❑ Models that can generate NSIs
- ❑ Effects in neutrino oscillations



MEHRA Rahul

Rahul Mehra

24 years old

Physikalisches Institut an der Universität Bonn &
Bethe Center for Theoretical Physics

- Born in Delhi, India

- BSc from St. Stephen's College, University of Delhi (2012-2015)

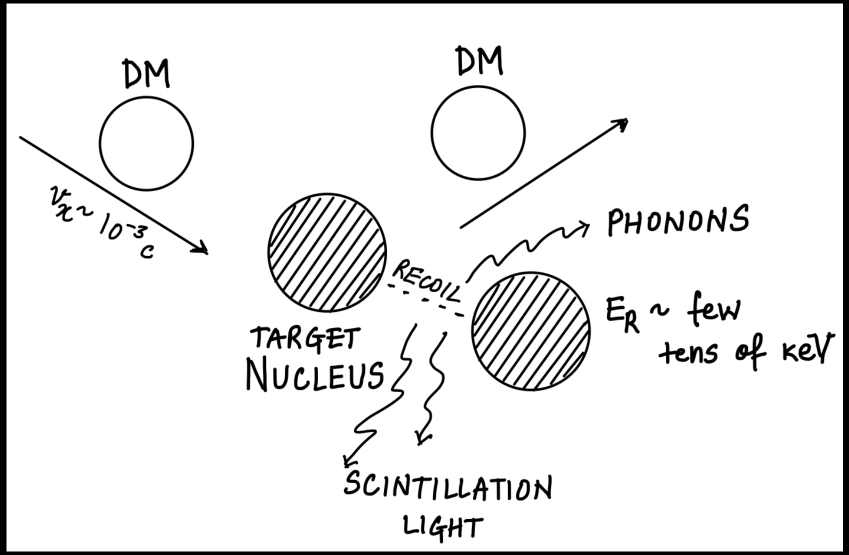
- MSc from Rheinische Friedrich-Wilhelms-Universität Bonn (2015-2017)

- PhD (2018-) in the research group of Prof. Dr. Manuel Drees

Research Interests

1907.10075, Phys. Lett. B799 (2019) 135039

'Neutron EDM constrains direct detection prospects'



- work in the formalism of a Non-Relativistic Effective Theory of Dark Matter Direct Detection (NREFT)

Fan, Reece and Wang - JCAP 1011 (2010) 042; Fitzpatrick et al. - JCAP 1302 (2013) 004; Anand, Fitzpatrick and Haxton - Phys.Rev. C89 (2014) no.6, 065501

predicts previously unexplored kinds of DM-nucleus interactions!

- explore low energy constraints on NREFT of Dark Matter Direct Detection viz. Neutron Electric Dipole Moments (nEDM)

- not all interactions are equally important; identify relevant interactions based on particle physics considerations

old (leading order) interaction may still dominate over newly proposed interactions/ operators (as one would expect)!

MELARA Sheryl

Dark Matter Candidates from Standard Model Extensions

Sheryl Melara

Instituto de Fisica, Universidad Nacional Autónoma de México

Why Dark Matter?

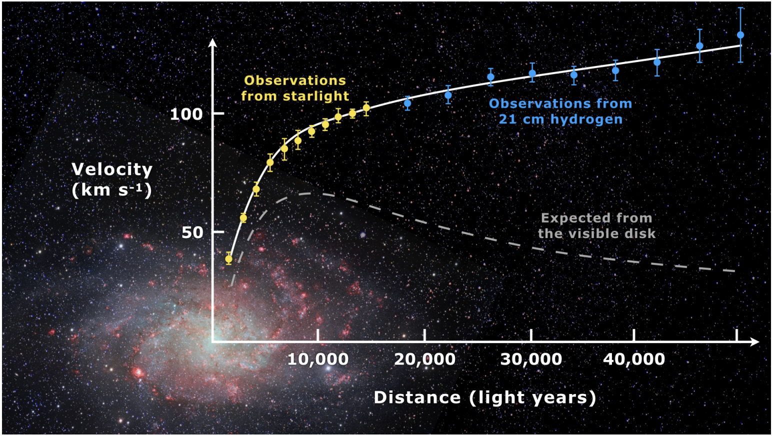


Figura: Evidence for dark matter: rotation curve of spiral galaxy

Standard Model Extensions including Dark Matter Candidates

Possible canditates:

- Scalar bosons
- Fermions (Ex: heavy and esterile neutrinos)

Inert Doublet Model

One doublet is involved in SSB (Higgs Particle) while the other one does not interact with fermions and does not acquire a vev.

MIN Ui

Ui Min

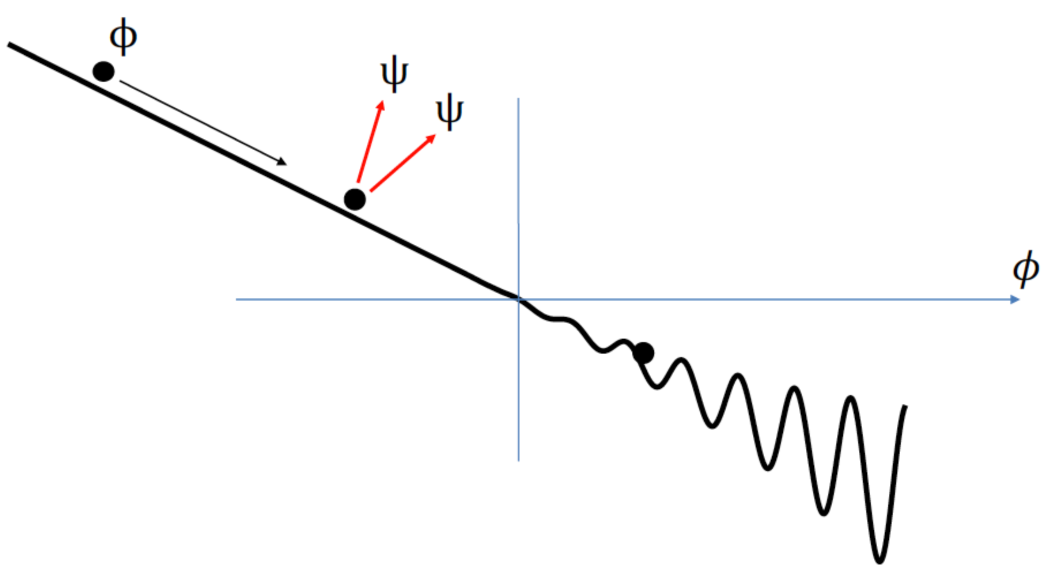
KAIST

Republic of Korea

Ui Min, KAIST

Cosmological Relaxation from Fermion Production

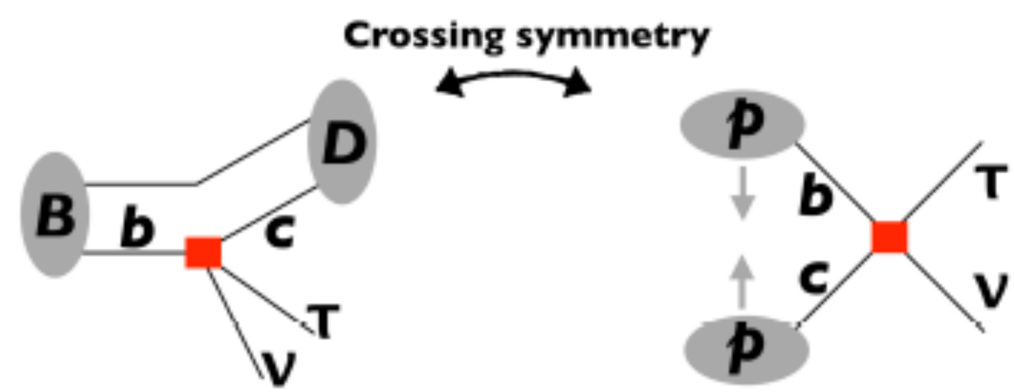
(arXiv: 1909.07706)



- Dynamical solution to the naturalness problem
- Fermion production as main friction for slow-roll

B-anomaly Search in Collider

(on going…)



- Discrepancy in $R_{D^{(*)}}$ between Exp and SM by ~4σ
- Competition between B-meson decay and $bc\tau\nu$ scattering in collider

Thank You

MOUGIAKAKOS Stavros

Scattering Amplitudes in Effective Gravitational Theories

Stavros Mougiakakos

Supervisor: Pierre Vanhove

Based on:

- N. E. J Bjerrum-Bohr, John F. Donoghue, Pierre Vanhove; arXiv : 1309.0804v2
- N. E. J. Bjerrum-Bohr, Poul H. Damgaard, Guido Festuccia, Ludovic Plante, Pierre Vanhove; arXiv : 1806.04920v2
- M. Levi, S. Mougiakakos and M. Vieira; arXiv : 1912.06276
- Upcoming work with P. Vanhove

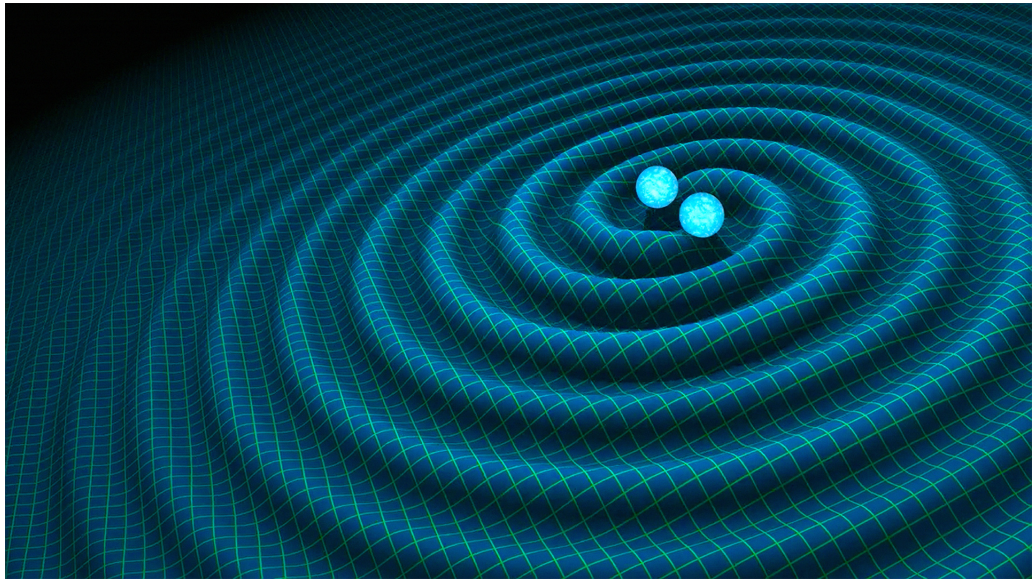
Journee des theses, 3 December 2019, IPhT-CEA

Observational Window on gravity

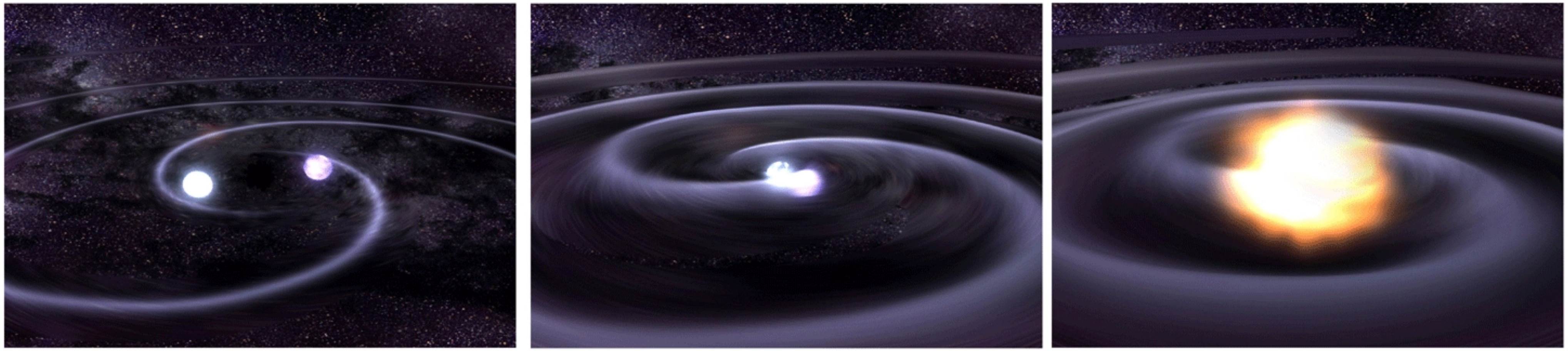
The detection of gravitational waves (GW150914) has opened a new window on the physics of our universe:

- For the first time detection and test of GR in the strong gravity coupling regime
- For the first time dynamics of Black holes

(not just static object curving space-time)



2-body problem



Inspiral **Merger** **Ringdown**

A lot of work has already been done in the analytical solution in perturbative GR.
T. Damour, L. Blanchet, A. Buonanno et al.

Can the particle physics community contribute to this problem?

Particle Physicist's Point of View on the gravitational 2-body problem

↙ ↘

EFT of Post-Newtonian Gravity

W.D Goldberger, I. Rothstein, R. Porto, M. Levi et al

- Classical computation
- Takes advantage of QFT toolbox
- Non relativistic computation
- Can deal effectively with spin effects
- State of the art: 4-PN without spins
  4,5-PN(S^3)

Scattering Amplitudes and Post-Minkowskian

Z. Bern, P. Vanhove, N.E.J. Bjerrum-Bohr, J. Donoghue, D. Kosower et al.

- Quantum computation
- Takes advantage of modern methods for on-shell scattering amplitudes (BCJ relations/double copy)
- Fully relativistic computation
- Active work for inclusion of spin effects
  arXiv:1709.04891, arXiv:1812.08752
- State of the art: 2-PM without spins

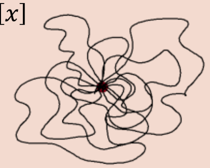
MURATORI Maurizio

A WORLDLINE MONTE CARLO APPROACH IN CURVED SPACE

- 1^{st} quantization technique to **compute QFT-quantities**
  - **QM-path integrals** (σ-models)

    $\int D\phi(x) \rightarrow \int Dx(\tau)$ representing the **dynamics of a point-particle** $x(\tau)$ propagating in spacetime
  - Example: <u>trace anomaly</u>

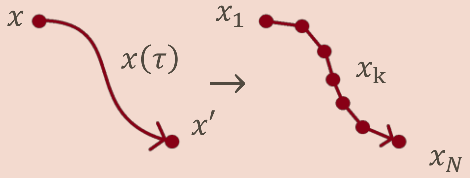
$$\mathrm{tr}\left[\frac{1}{2}\sigma(x)\delta^D(x-y)\right] = \lim_{\beta\to 0}\int_{\mathrm{PBC}} Dx\sqrt{g(x)}\,\frac{1}{2}\sigma(x)e^{-S[x]}$$



$$S[x] = \frac{1}{\beta}\int_0^1 d\tau\left[\frac{1}{2}g_{\mu\nu}(x)\dot{x}^\mu\dot{x}^\nu + \beta^2\left(V_{\mathrm{ext}} + V_{\mathrm{CT}}\right)\right]$$

  - Straightforward **extension from flat space to curved space PIs**
- A wide class of problems can be approached: **strongly interacting fermions**, **Schwinger pair creation**, **Casimir effect**, **CPN models**, **spontaneous CSB**, … in **curved space**

- WL formalism → optimal for **numerical implementations**
  - Each worldline is discretized wrt its proper time τ



- A **Monte Carlo** algorithm is used to choose the points on a flat D-manifold, exploiting the discretized kinetic term of the theory
  - *vloops, yloops, LSOL, …*
- The x-points are not constrained on a lattice
- WLMC output → averaged PI

$$\langle I(\beta)\rangle = \frac{\int Dx\; e^{-S_{KIN}-S_{POT}}}{\int Dx\; e^{-S_{KIN}}} \simeq \frac{\sum_{s=1}^{N_{WL}} e^{-S_{POT}^{(s)}(\beta)}}{N_{WL}}$$

# of WLs

$$S_{POT}^{(s)}(\beta) = \frac{\beta}{N}\sum_{k=1}^{N} V_{ext}\left(x_k^{(s)}\right)$$

# of points per WL

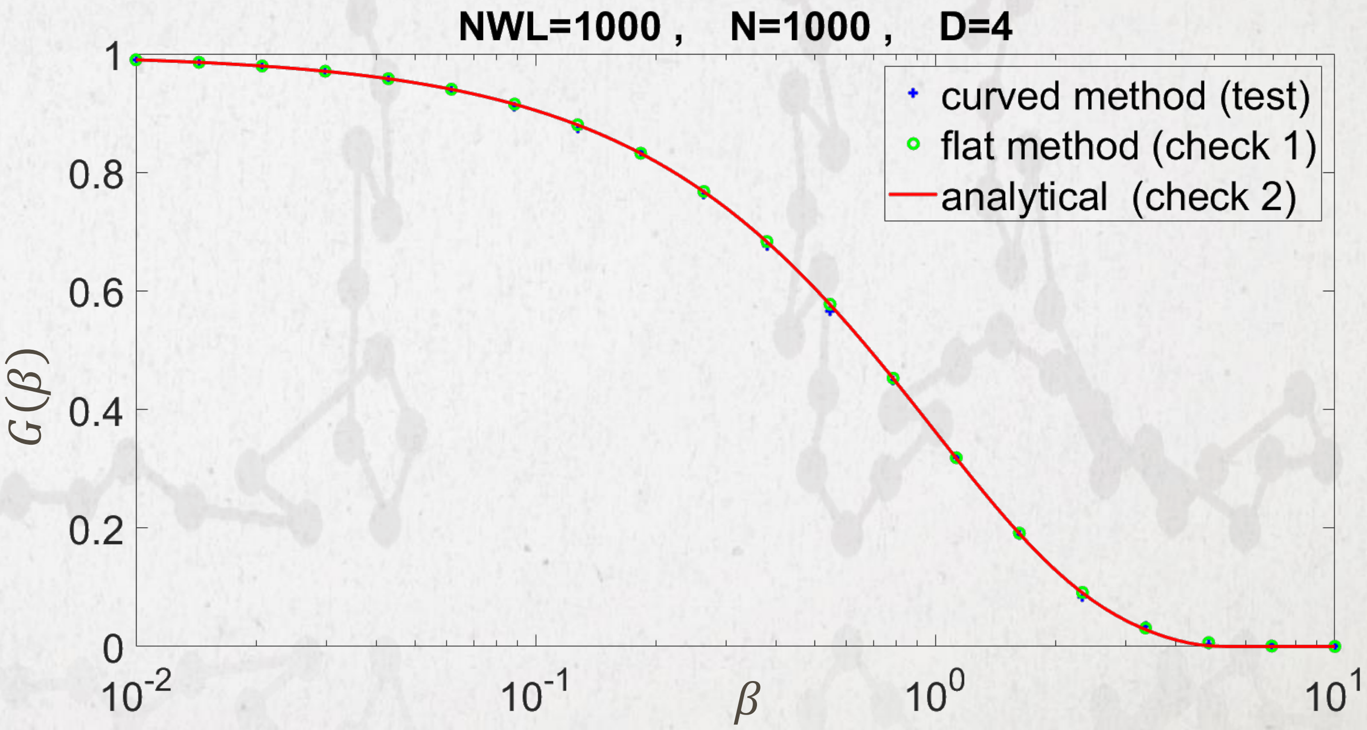
WLMC IN CURVED SPACE

$$\delta_{\mu\nu}\dot{x}^\mu\dot{x}^\nu \to g_{\mu\nu}(x)\dot{x}^\mu\dot{x}^\nu = \delta_{\mu\nu}\dot{x}^\mu\dot{x}^\nu + [g_{\mu\nu}(x) - \delta_{\mu\nu}]\dot{x}^\mu\dot{x}^\nu$$

$$\sum_{s=1}^{N_{WL}} e^{-S_{POT}^{(s)}(\beta)} \to \sum_{s=1}^{N_{WL}} \sqrt{g^{(s)}}\, e^{-S_{POT}^{(s)}(\beta)}$$

$$V_{ext}(x_k) \to V_{ext}(x_k) + V_{KIN}(x_k) + V_{CT}(x_k)$$

Test: heat kernel of free point-particle on a 4-hyperboloid



NOVOA BRUNET Martin

Gong Show GGI Lectures

Who am I? -> Martín Novoa Brunet

25 Years Old

2nd year PhD student at theory pole of **IJCLab (Ex-LPT)**, Orsay (Paris-Saclay University)

Flavour physics and Anomalies on Lepton Flavour Universality (LFU) tests

Fun Fact: I can lick my elbow!

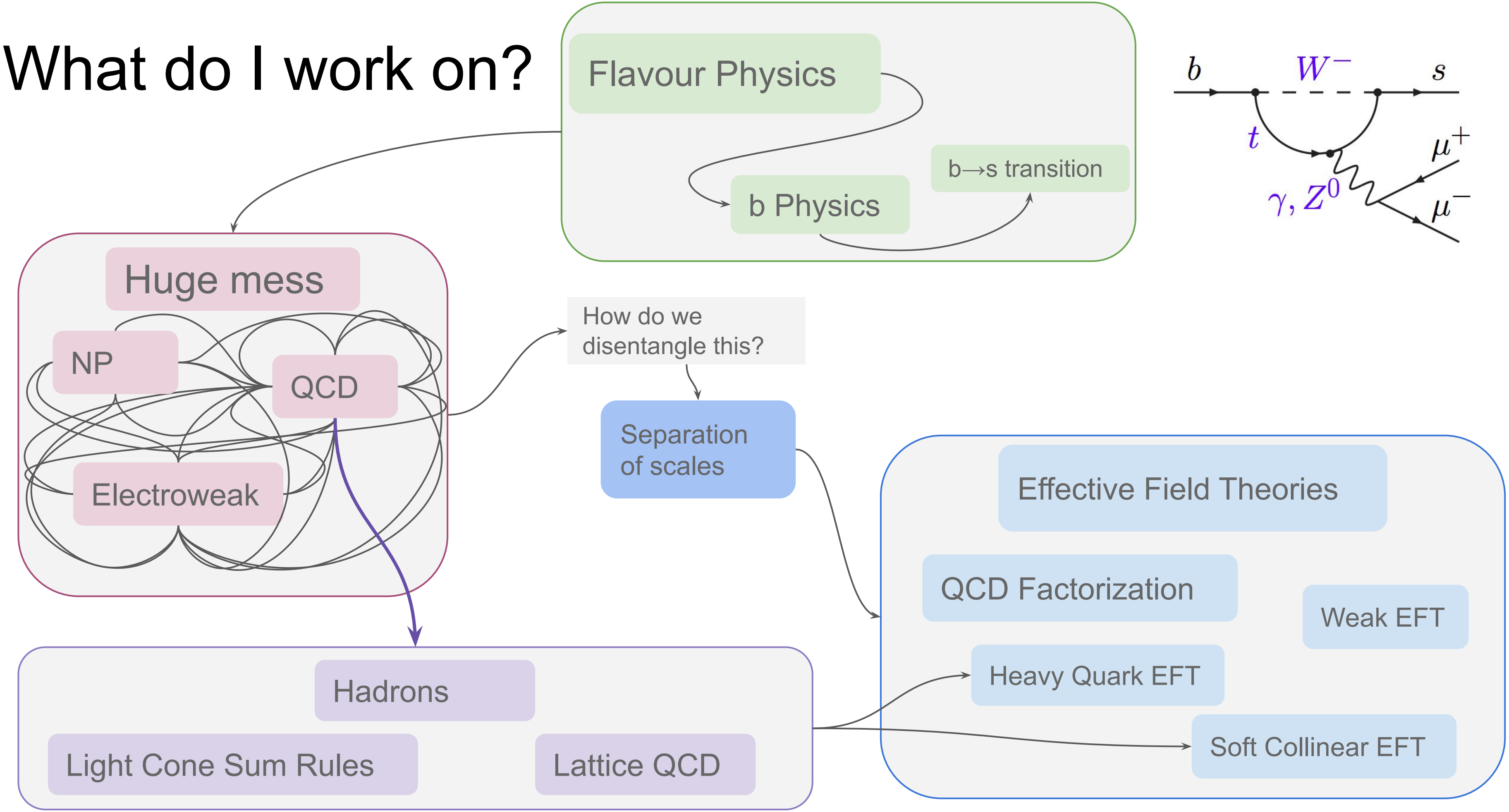
Chilean
(I come from the spaghetto shaped country)

LPT Orsay

Under the supervision of:

Sébastien Descotes-Genon

What do I work on?



ÖSTERMANJuuso

HELSINKI INSTITUTE OF PHYSICS

Juuso Österman

University of Helsinki, Helsinki Institute of Physics

PhD thesis (initial title): Equation of state of dense quark-gluon matter
Supervisor: Aleksi Vuorinen

Goal: Analytical evaluation of g^6 corrections to the cold quark matter pressure as follow up to $O[g^6 \log(g)]$ corrections

PhD program (2020): Particle Physics and Universe Sciences (PAPU)

$$\sum\!\!\!\!\!\!\int_P' \frac{\tilde{\Pi}^T}{P^4} = \frac{T^2}{2(4\pi)^3} \int_r \sum_{p_n}{}' \frac{1}{r^2} \left[\frac{1}{\sinh(2\pi T r)} - \frac{1}{2\pi T r} \right] \frac{e^{-2|p_n| r}}{|p_n|}$$

Background

- Master's Thesis: *Evaluation of Master Integrals in Thermal Field Theory* (2019)
    - Generic results for high temperature perturbation theory
- Perturbative calculations: Matsubara formalism and real-time formalism
- Projects:
    - Validity of dimensional reduction (effective field theories)
    - Analytical loop calculations in lattice and continuum
    - RG equations and scale dependence (*Transcendental equations of the running coupling, arXiv:1912.08016v2 [math-ph]*)

$$
\begin{aligned}
&\int_0^\infty dx x^z \left(\coth x - \frac{1}{x} - 1\right)\left[x \mathrm{Li}_2\left(e^{-2x}\right) + \mathrm{Li}_3\left(e^{-2x}\right)\right] \\
&= 2^{-z-1}\Gamma(2+z)\left[\sum_{k=1}^{\infty}\frac{\zeta(2+z,k+1)}{k^2}\right] - 2^{-1-z}\Gamma(1+z)\zeta(3+z) \\
&+ 2^{-z}\Gamma(1+z)\left[\sum_{k=1}^{\infty}\frac{\zeta(1+z,k+1)}{k^3}\right] - 2^{-z}\Gamma(z)\zeta(3+z) \\
&= \sum_{k=1}^{\infty}\frac{\zeta(2,k+1)}{2k^2} + \sum_{k=1}^{\infty}\frac{\frac{1}{z} - \gamma - \ln 2 - \psi(1+k)}{k^3} \\
&- \frac{\zeta(3)}{2} - \frac{\zeta(3)}{z} + (\gamma + \ln 2)\zeta(3) - \zeta'(3) \\
&= \sum_{k=1}^{\infty}\left[\frac{\zeta(2,k+1)}{2k^2} - \frac{\psi(1+k)}{k^3}\right] - \frac{\zeta(3)}{2} - \zeta'(3) + \mathcal{O}(z) \\
&= -\frac{7\pi^4}{720} + \left(\gamma - \frac{1}{2}\right)\zeta(3) - \zeta'(3) + \mathcal{O}(z),
\end{aligned}
$$

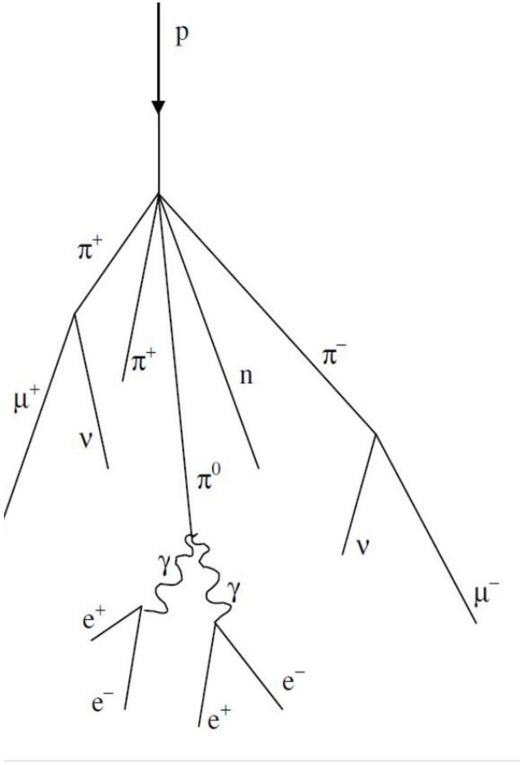
OUESLATI Rami

Forward physics and ultra-high-energy cosmic ray showers

Rami Oueslati : Ph. D. student

In collaboration with Dr. Atri Bhattacharya (post doc) and Prof. Jean-René Cudell (supervisor)

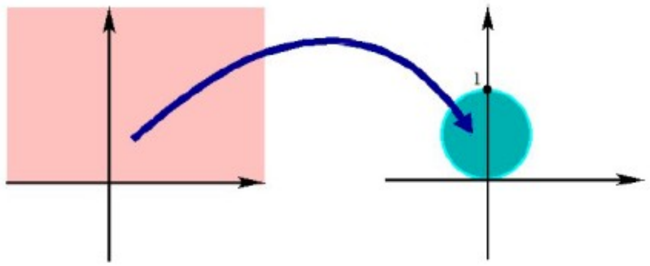
Goal : Better understanding of atmospheric cosmic ray showers and of forward hadronic scattering at ultra-high energies



Muon Physics, Coan, T.E. and Ye, J. Department of Physics, Southern Methodist University

Project 1 Unitarization effects

The naïve extrapolation of low energy hadronic model violates the unitarity of the S matrix

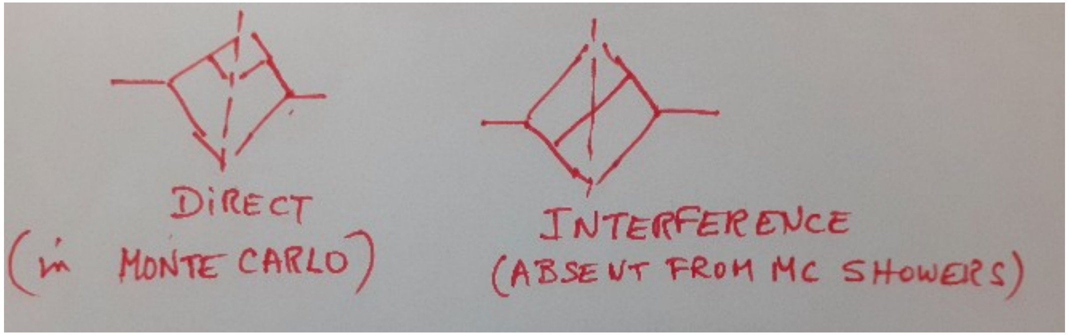


Mapping from the upper complex plane into the unitarity circle

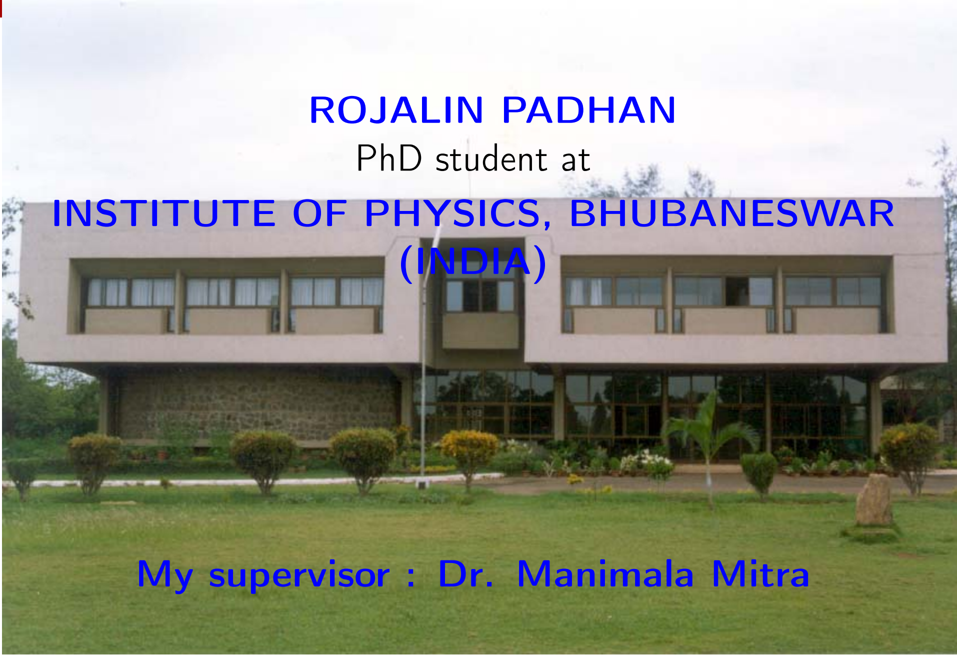
- Unitarity of the S-matrix
- Several ways to map to the unit circle
- They make a significant difference for diffractive scattering

Project 2 Minimum bias

- We shall start with a calculation in $\lambda\varphi^3$ theory



PADHAN Rojalin



ROJALIN PADHAN

PhD student at

INSTITUTE OF PHYSICS, BHUBANESWAR (INDIA)

My supervisor : Dr. Manimala Mitra

Research Interest :

Collider analysis of differet new physics models like

- Neutrino mass model (Seesaw mechanism)
- Lepto-quark
- Dark matter

PÉLI Zoltán

About me

Zoltán Péli*
* postdoctoral research fellow,
MTA - DE Particle Physics Research Group,
Hungary, Debrecen
zoltanpeli92@gmail.com

BSc, MSc years

I have researched the implications of the so called generalized uncertainty principle (GUP) during my BSc [1] and MSc [2] studies. This is a generalization of Heisenberg's uncertainty principle allowing for a minimal possible, measurable length. This has for example motivations from quantum gravity.

PhD years

During my PhD, my research revolved around functional renormalization group (FRG). The main feature of this method is its non-perturbative nature. For one thing, I have studied the critical exponents of 3D $O(N)$ symmetric models in detail [3]. I have also calculated critical exponents in a quantum Einstein gravity model as part of a scholarship [4]. I have also investigated the possible treatment of a spatially periodic ground state in terms of FRG [5, 6, 7].

Current research

In my postdoc job, I research beyond standard model (BSM) physics. I study a specific $U(1)$ extension and a possible inflationary model. In the former I investigate the stability of the scalar potential [8], and the parameter space, where the possible detection of the new gauge boson is constrained by measurements (e.g.: NA64). In the latter, the inflation is triggered during the renormalization group flow of a multifield scalar potential [9].

Research interest

Regarding my future research I don't have anything set in stone. I am mostly interested in the FRG treatment of non-perturbative phenomena. I also find the BSM physics intriguing as well, since it is an important task to combat and push the boundaries of our present knowledge.

References

[1] K. Sailer, Z. Péli, S. Nagy, Some consequences of the generalized uncertainty principle induced ultraviolet wave-vector cutoff in one-dimensional quantum mechanics, Phys. Rev. D 87, 084056 (2013), math-ph/1301.6913.

[2] K. Sailer, Z. Péli, S. Nagy, Particle in a cavity in one-dimensional bandlimited quantum mechanics, J. Phys. A 48, 075305 (2015), hep-th/1410.0175.

[3] Z. Péli, S. Nagy, K. Sailer, Effect of the quartic gradient terms on the critical exponents of the Wilson-Fisher fixed point in $O(N)$ models, Eur. Phys. J. A 54:20 (2018).

[4] S. Nagy, B. Fazekas, Z. Péli, I. Steib, K. Sailer, Regulator dependence of fixed points in quantum Einstein gravity with R^2 truncation, Class.Quant.Grav. 35, no.5, 055001 (2018)

[5] Z. Péli, S. Nagy, K. Sailer, Phase structure of the $O(2)$ ghost model with higher-order gradient term, Phys. Rev. D 94, 065021 (2016), hep-th/1605.07836.

[6] Z. Péli, S. Nagy, K. Sailer, Triple point in the $O(2)$ ghost model with higher-order gradient term, Phys. Rev. D 94, 065037 (2016), hep-th/1608.02080.

[7] Z. Péli, S. Nagy, K. Sailer, Phase structure of the Euclidean three-dimensional $O(1)$ ghost model, Int.J.Mod.Phys. A34 no.02, 1950021 (2019)

[8] Z. Péli, Z. Trócsányi, Stability of the vacuum as constraint on U(1) extensions of the standard model, preprint at ArXiv: 1902.02791.

[9] Z. Péli, I. Nándori, Z. Trócsányi, Particle physics model of curvaton inflation in a stable universe, preprint at arXiv:1911.07082

MAGYAR TUDOMÁNYOS AKADÉMIA 1825

DEBRECENI EGYETEM

RINAUDO Anna

Soft approximations in QCD and possible applications to $g-2$

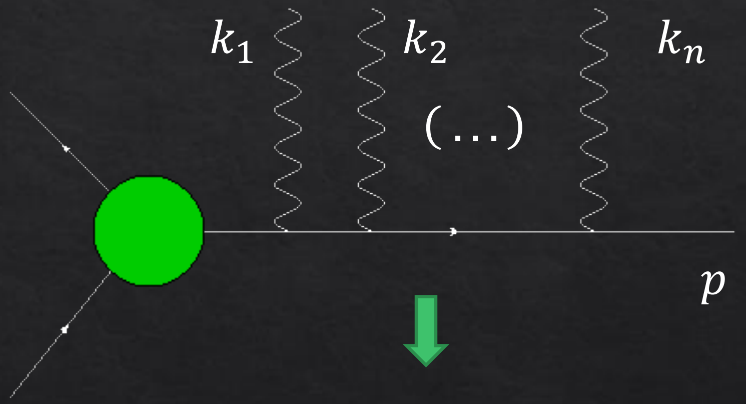
Supervisor: Lorenzo Magnea

$g-2$

High order in perturbation theory

Hundreds of diagrams

Soft approximations



Gauge invariant

Gauge sets

Small-x resummation

Supervisors: Simone Marzani & Giovanni Ridolfi

Perturbative quantities in QCD → Logarithmic enhancements → Spoil the perturbativity of the α_s expansion

$O = \sum_n c_n \alpha_s^n$

$\alpha_s^n \frac{1}{x} \ln^k \left(\frac{1}{x}\right)$

$x \to 0$

$c_n \to \infty$

Resummation

RIVA Massimiliano Maria

Testing gravity with gravitational waves

Srudent: Massimiliano Maria Riva
Supervisor: Dr. Filippo Vernizzi

Institute: Université Paris-Saclay, CNRS, CEA, Institut de physique théorique, 91191, Gif-sur-Yvette, France.

Academic Year: 2019-2020

The binary inspiral problem

Three phases, different approaches

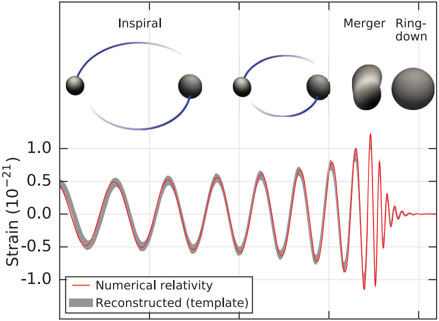


Figure: LIGO scientific collaboration and VIRGO scientific collaboration, Phys. Rev. Lett. **116** 6 (2016).

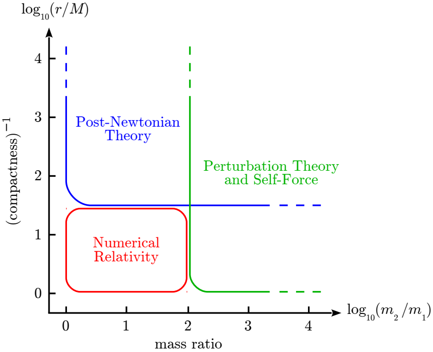


Figure: A. Le Tiec, Int. J. Mod. Phys **23** 10 (2014).

The inspiral phase contains most of the signal. With future detectors, more cycles of this phase will be detectable.

Beyond GR: Modified Gravity

Motivation

Unknown ingredients of the ΛCDM

- Initial condition and Inflation period.
- Nature of Dark matter.
- Nature of acceleration, hence Dark energy.

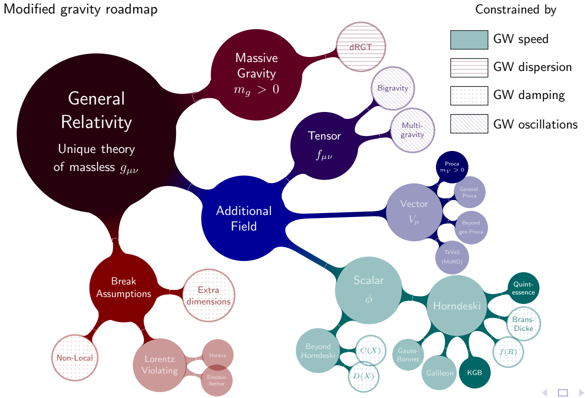
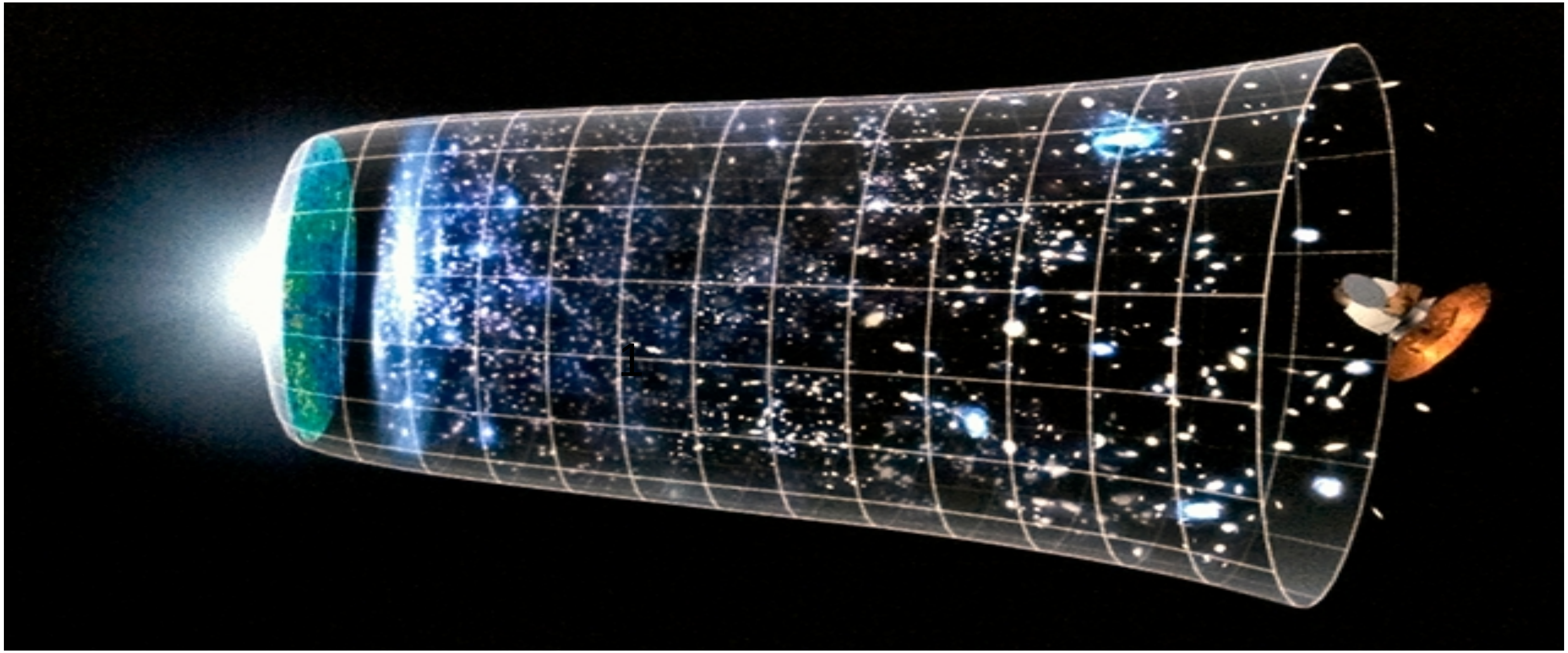


Figure: J. M. Ezquiaga and M. Zumalacárregui, Front. Astron. Space Sci. **5** (2018) 44.

ROLLO Rocco

“Student presentation”



PhD Student: Rollo Rocco,
Supervisors: Luigi Pilo and Sabino Matarrese

Research outline: “Simply Inflation”

- The role of the Weinberg Theorem (WT) in Cosmology,
- Single Field Inflation: WT validity

  - “ΔN formalism and conserved currents in Cosmology ” (Matarrese, Pilo, Rollo)

- EFT Inflation: WT violation

  - “Adiabatic media Inflation” (Celoria, Comelli, Pilo, Rollo)

SANKAR Aparna

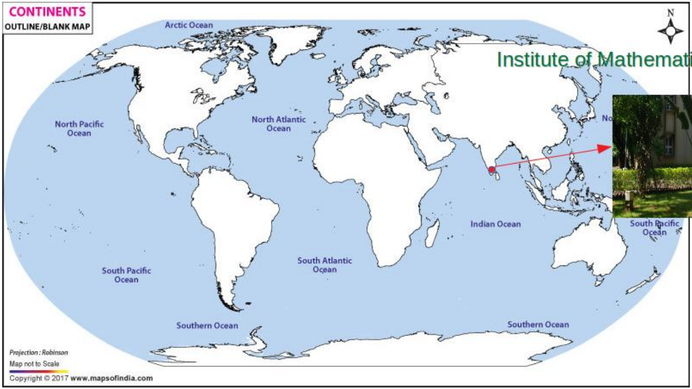
GGI Lectures on the Theory of Fundamental Interactions 2020

Aparna Sankar

The Institute of Mathematical Sciences
Chennai, India

Supervisor : Prof. V. Ravindran

January 9 , 2020



Institute of Mathematical Sciences, Chennai

Research Interest

- Perturbative QCD
- Higgs Physics
- Multileg and Multiloop computations
- Investigating the IR structure of QCD amplitudes
- Soft gluon resummation

SCHIEWALDT Beatriz

USP

Beatriz Tucci Schiewaldt

University of São Paulo

Supervisors
Raul Abramo
Antonio Montero-Dorta

Research

FAPESP
Fundação de Amparo à Pesquisa do Estado de São Paulo

Halo Assembly Bias

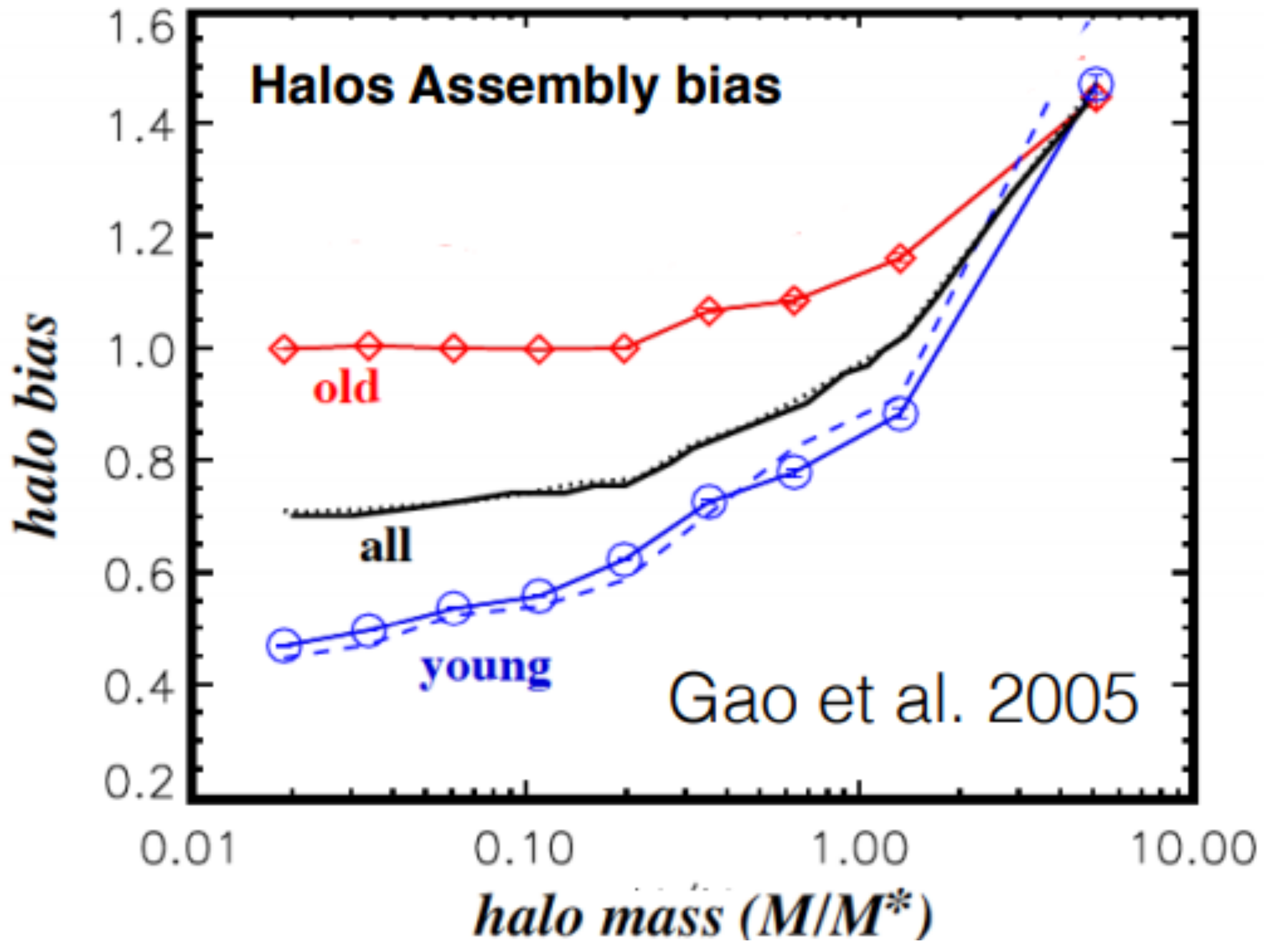
How secondary properties of Dark Matter Halos affect their distribution?

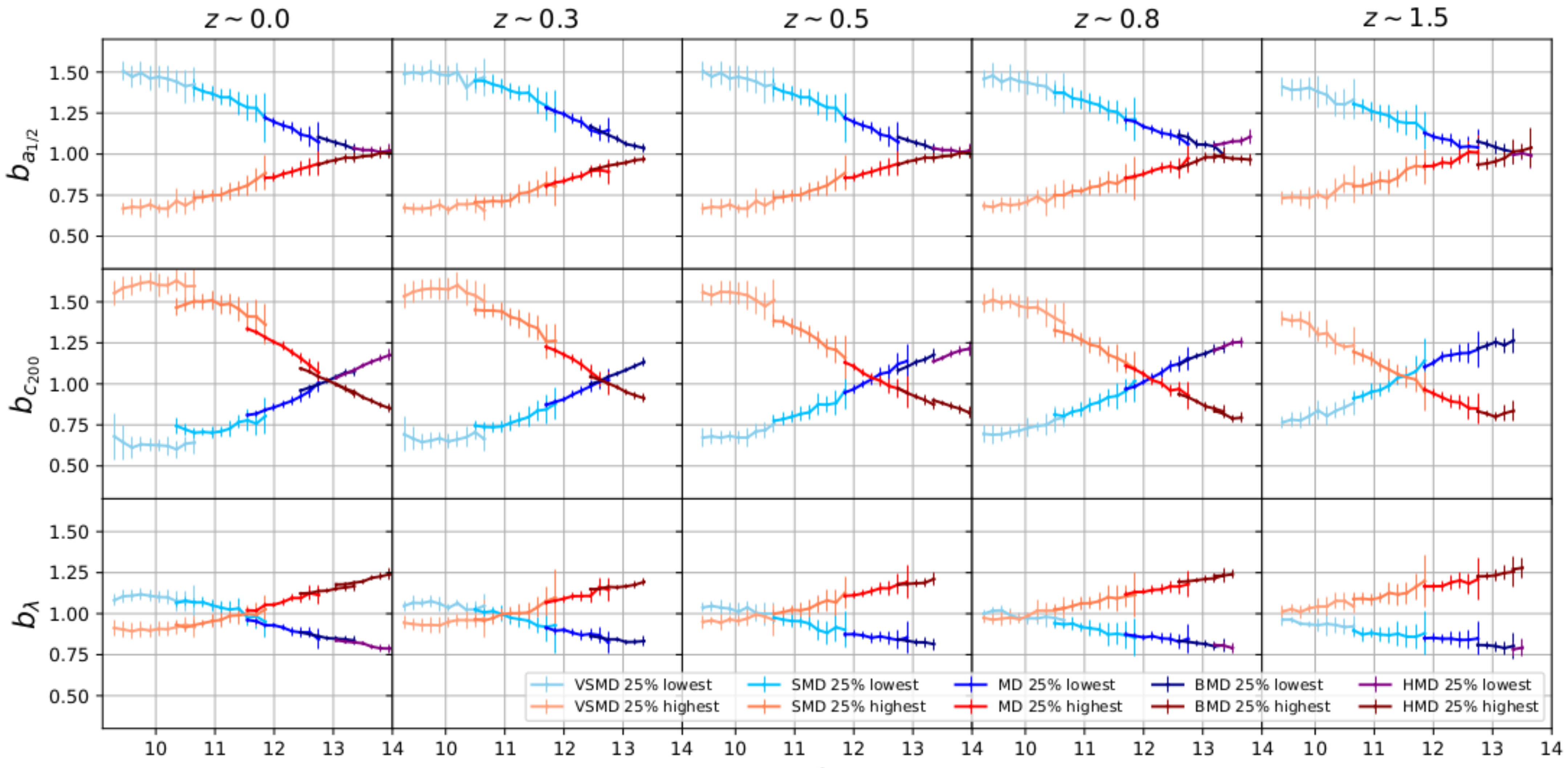
MultiDark

Evolution of Secondary Bias
Spin, Concentration and Age

Spin Bias Origin?

Derive spin bias from the inital anisotropic conditions





SCHREIBER Anders

Cluster Adjacency in $\mathcal{N} = 4$ Super Yang-Mills Theory

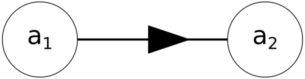
Anders Øhrberg Schreiber

Brown University
Supervisor: Anastasia Volovich

GGI Lectures On The Theory Of Fundamental Interactions
January 9, 2020

Cluster Algebra

– What is a cluster algebra? A_2 cluster algebra [Fomin, Zelevinsky, 2002]



$$b_{ij} = (\#\text{ arrows } i \to j) - (\#\text{ arrows } j \to i) = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}$$

– Mutation rule $a_k a'_k = \prod_{i|b_{ik}>0} a_i^{b_{ik}} + \prod_{i|b_{ik}<0} a_i^{-b_{ik}}$ and flip all arrows connected to the note you're mutating, e.g.

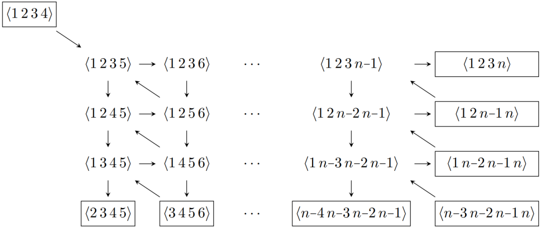
$$a_3 \equiv a'_1 = \frac{1}{a_1}\left[a_1^0 a_2^0 + a_1^0 a_2^1\right] = \frac{1+a_2}{a_1}$$

– All cluster coordinates

$$a_1\,,\ a_2\,,\ a_3 = \frac{1+a_2}{a_1}\,,\ a_4 = \frac{1+a_1+a_2}{a_1 a_2}\,,\ a_5 = \frac{1+a_1}{a_2}\,.$$

Cluster Adjacency

- We are interested in properties of scattering amplitudes and how to compute them efficiently.
- SYM has lots of symmetries, in particular dual conformal symmetry: $p_i = x_{i+1} - x_i$.
- Recast kinematics in momentum twistor space, $Z_a^I \in \mathbb{P}^4$ ($I = 1, \ldots, 4$ and $a = 1, \ldots n$). Mandelstam invariants $\propto \det Z_a^{I_a} Z_b^{I_b} Z_c^{I_c} Z_d^{I_d} = \langle a\, b\, c\, d \rangle$.



- How momentum twistors appear in the amplitude $\Leftrightarrow$ how momentum twistors appear together in the clusters [Golden, Spradlin, Vergu, Volovich, 2013], [Drummond, Foster, Gurdogan, 2017].

SELLER Károly

Károly Seller

Eötvös Loránd University, Budapest, Hungary

GGI Lectures, January 2020.

Research interests

- **Main interests**: Cosmology and particle physics
- **PhD thesis**: Cosmological constraints on a U(1) extension of the standard model
  - Dark matter
  - Effects of the new U(1) on cosmological evolution
- **Supervisor**: Zoltán Trócsányi
- **Masters thesis:** Functional renormalization group treatment of nuclear matter inside neutron stars, supervisor Zsolt Szép

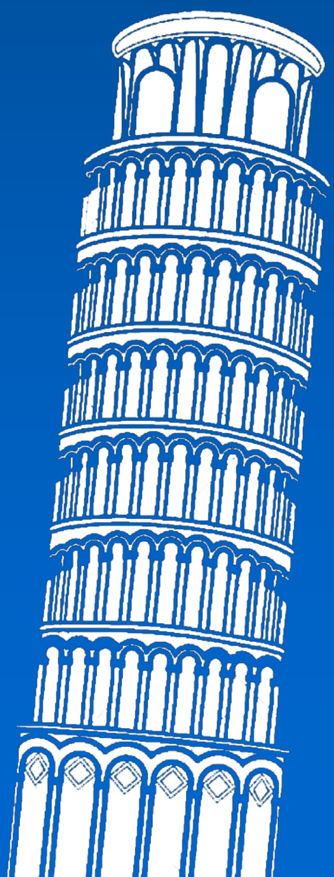
SERRA Francesco

SCUOLA NORMALE SUPERIORE

Francesco Serra

Advisor: Enrico Trincherini

INFN
Istituto Nazionale di Fisica Nucleare



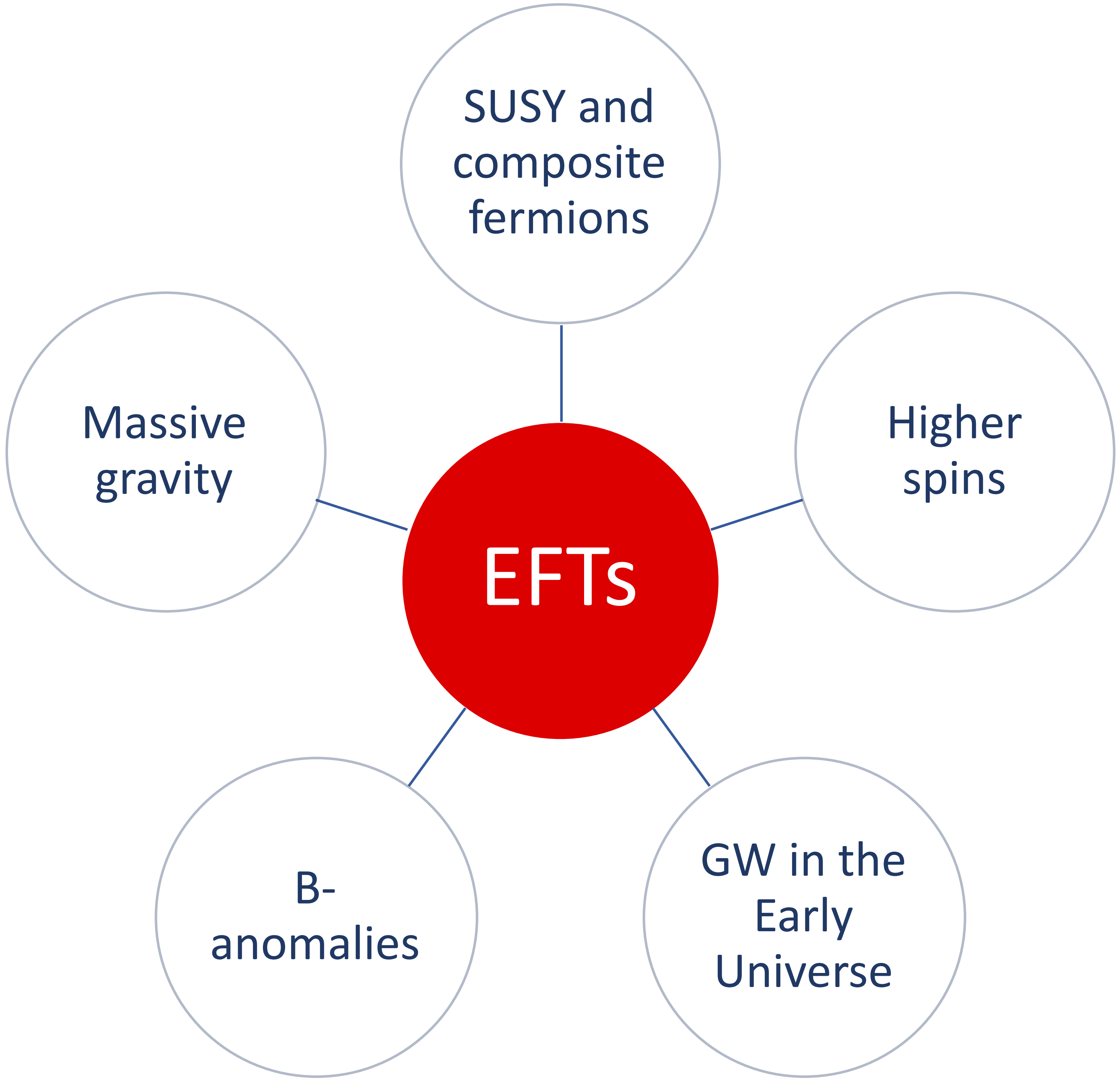
Research:

- Black holes;
- Scalar hair;
- Massive vector hair;

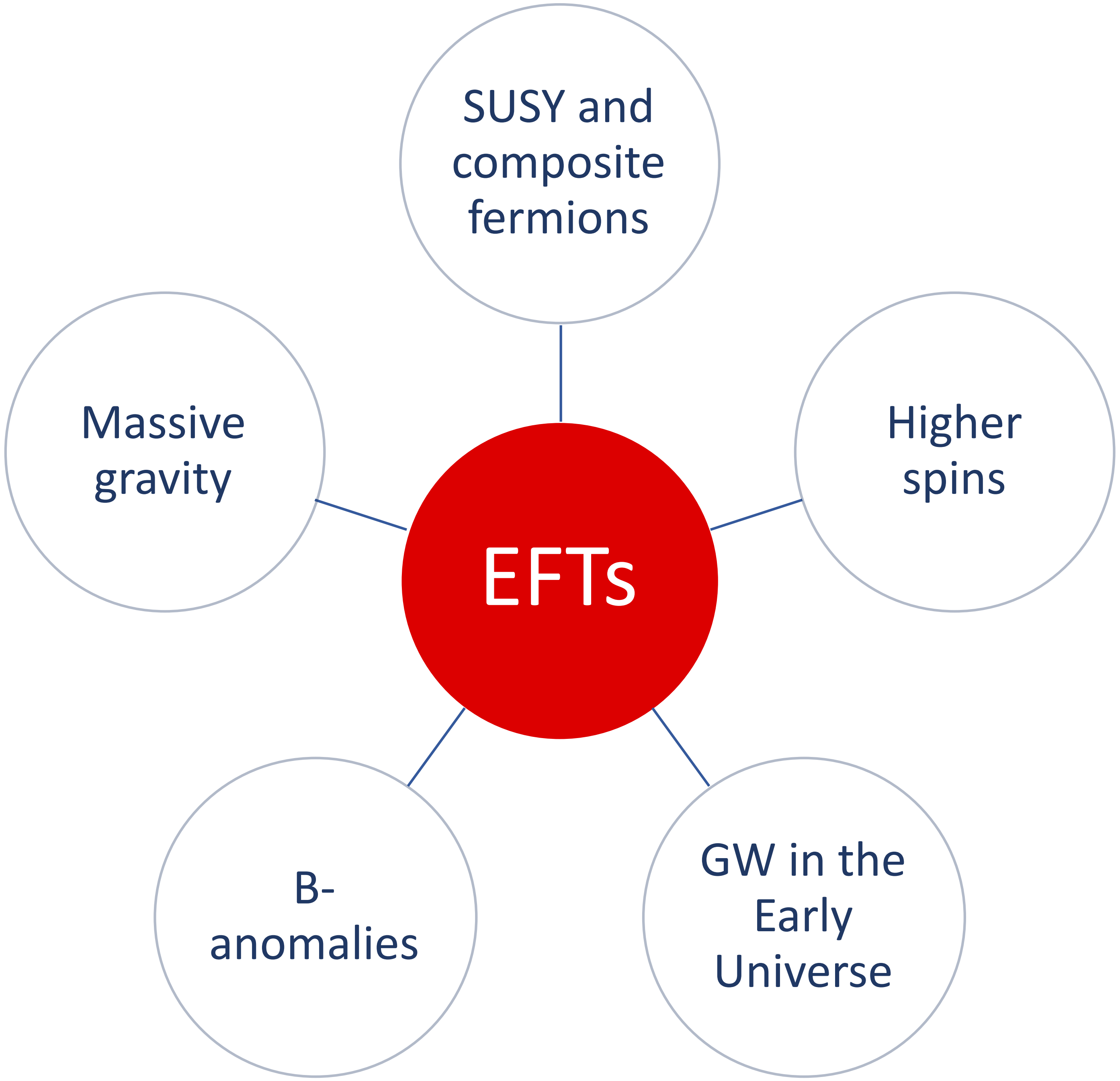
Other interests:

- Gravitational waves and BH mergers;
- Scattering amplitudes;
- Dark energy;

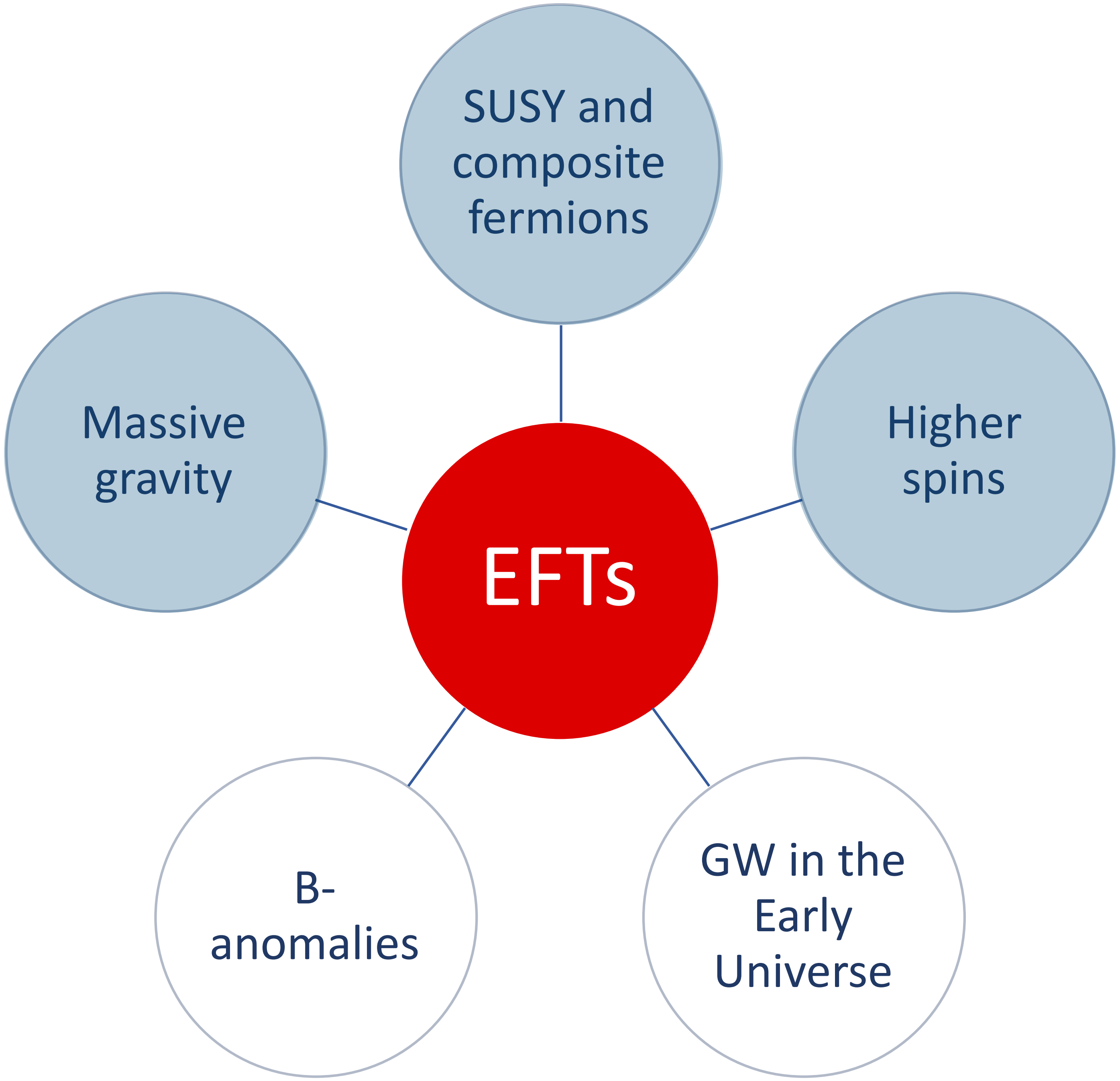
SGARLATA Francesco



Advisors: Aleksandr Azatov (SISSA), Brando Bellazzini (IPhT, Saclay)

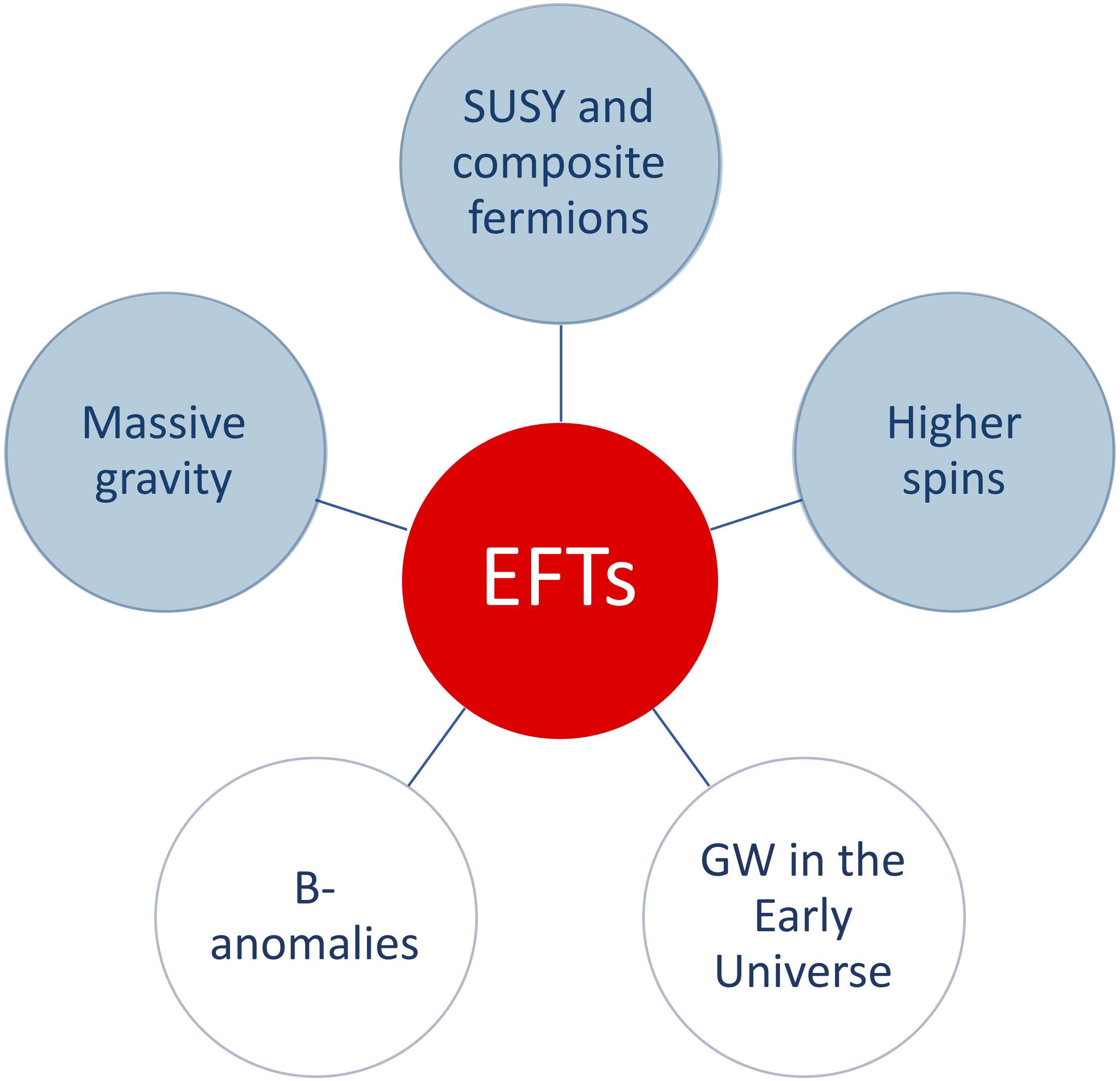


Advisors: Aleksandr Azatov (SISSA), Brando Bellazzini (IPhT, Saclay)



Advisors: Aleksandr Azatov (SISSA), Brando Bellazzini (IPhT, Saclay)

Are the SM particles arising from SUSY breaking?



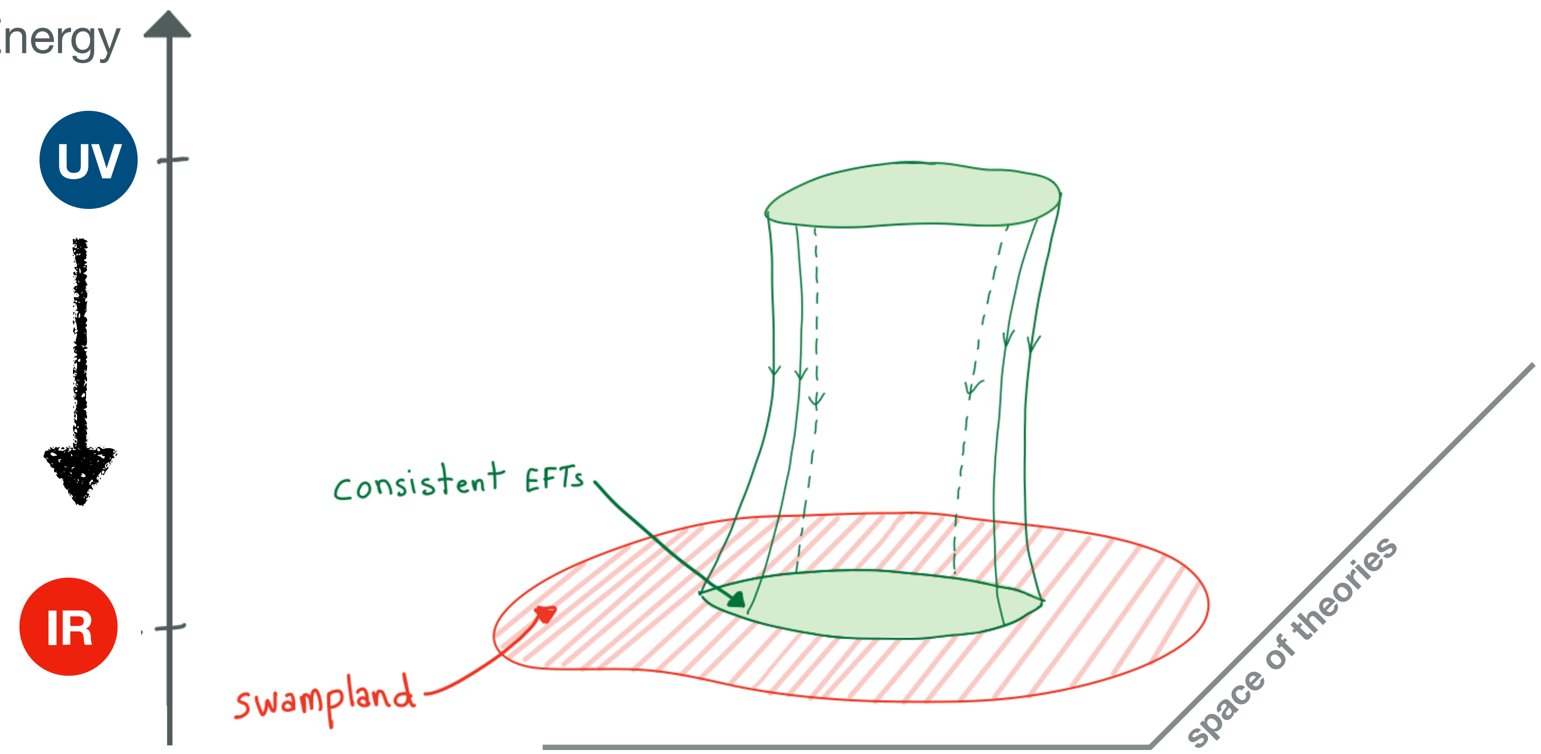
Is the graviton massive?

Is there a consistent EFT for massive HS?

Advisors: Aleksandr Azatov (SISSA), Brando Bellazzini (IPhT, Saclay)

EFT Swampland Program

$$\mathcal{L}_{IR} = \sum_i g_i \mathcal{O}_i$$



<u>Fundamental properties of UV theory</u> ⟶ <u>Criteria to identify boundary of consistent EFTs</u>

(causality, unitarity, symmetries, analyticity of S-matrix…)

<u>Conditions on scattering amplitudes</u> ⟶ **Positivity bounds on Wilson Coefficients**

$$\boxed{\mathcal{A}''(s) > 0}$$

<u>Some implications :</u> no massive gravity, no EFTs for single HS, gravity is the weakest force….

SHARMA Punit

Name	-	Punit Sharma
From	-	New Delhi, India
Pursuing	-	Snooker, Badminton, . . . etc and Ph.D. too
Affiliation	-	IIT Kanpur, India
Supervisor	-	Arjun Bagchi

Broad Research Area

“Tensionless String Theory”

This can primarily be divided into two parts:

1. **“Tensionless limit” of the usual Tensile String Theories.**

2. **“Fundamental” Tensionless Strings.**

Aspects that we are looking at :

- Building up an operator pictures for tensionless strings (Both Bosonic and Superstrings).
- Finding out symmetry structures in these regimes.
- Construction of physical spectrum and finding out the "Critical Dimensions" for Lorentz Invariant theories.
- A long term goal is to develop the "Path Integral Quantization" of these strings and finding scattering amplitudes.

SILVETTI Federico

Federico Silvetti

Institution: Sapienza Università di Roma

Position: Phd student, first year

PhD supervisor: Marco Bonvini

Contact email: federico.silvetti@uniroma1.it

Degree: Master's degree in Physics at the same university completed on 25/10/2019

Thesis title: All-order resummation of high-energy logarithms in the production of a heavy-flavor quark pair at the LHC

Thesis supervisors: Marco Bonvini and Roberto Bonciani

Brief overview:

Parton-level cross sections at hadron colliders are computed **perturbatively** and depend on the dimensionless $x = \frac{Q^2}{s}$. **Radiative corrections** generate a **single logarithm enhancement**

Federico Silvetti, Sapienza Università di Roma, email: federico.silvetti@uniroma1.it

Brief overview:

$$\begin{aligned}\hat{\sigma} = {} & \alpha_s \ln(x) b_{11} + \alpha_s b_{10} \\ & + \alpha_s^2 \ln^2(x) b_{22} + \alpha_s^2 \ln(x) b_{21} + \alpha_s^2 b_{20} \\ & + \alpha_s^3 \ln^3(x) b_{33} + \alpha_s^3 \ln^2(x) b_{32} + \alpha_s^3 \ln(x) b_{31} + \alpha_s^3 b_{30} \\ & \quad \vdots \qquad\qquad \vdots \qquad\qquad \vdots \qquad\qquad \vdots \qquad\qquad \ddots \\ & \quad \text{(LL)} \qquad \text{(NLL)} \qquad \text{(NNLL)} \qquad \cdots \end{aligned}$$

For $x \ll 1 \ \rightarrow \alpha_s \ln(x) = \mathcal{O}(1)$, fixed order pert. theory breaks down and a resummation of these logarithms is required to all orders in α_s

Foreseen developments:

- Finalize the study of small-x resummation in heavy quark hadroproduction started in my thesis
- PDF determination with resummed input using from LHCb data for heavy meson production in the small-x region
- Extension of small-x resummation formalism to NLL accuracy

SJÖ Mattias

Who am I?

- Mattias Sjö, 1st year PhD student
- Lund University, Sweden (born and raised)

What do I do?

- ...not quite sure yet — still discussing with supervisor

Johan (Hans) Bijnens
AKA "mr. Two-loop" ⇒

- Effective field theories (with Karol Kampf)
  - Master's thesis
  - Paper: `1909.13684`, also in JHEP
- High-precision Low-energy SM Penomenology
  - Hadronic contributions to muon $g-2$?
  - Kaon decays?
  - CP breaking?

LUND UNIVERSITY

STEGEMAN Roy

TANTARY UBAID HUSSAIN

Ubaid H Tantary

- 3rd Year PhD student.
- Institution - Centre for Nuclear Research, Ohio USA.
- PhD Advisor – Prof. Michael Strickland.

Current Research

- Thermodynamics of N=4, d=4 SUSY SU(N) Yang-Mills theory.
- Specifically, write down the perturbation expansion of the free energy of N = 4 supersymmetric SU(N) Yang-Mills at finite temperature in powers of ’t Hooft’s coupling g^2N in the large N limit.
- Goal: perturbative calculation of the free-energy density of d = 4, N = 4 super Yang-Mills theory beyond $O(\lambda^3)$.
- Weak Coupling Limit: Using EFT techniques due to Agustin Nieto and Michel H.G. Tytgat (https://arxiv.org/abs/hep-th/9906147) and the Imaginary time formalism techniques due to Peter Arnold and Zhai (http://arxiv.org/abs/hep-th/9408276).
- Strong coupling Limit: In the strong ‘t Hooft coupling limit, the free-energy density is calculated using Ads/CFT correspondence. Super Yang-Mills theory at high temperature T is described, in large N and strong ‘t Hooft coupling limit, by a Schwarzschild AdS_5 black hole.

- Does the interpolation of thermodynamics between weak and strong ‘t Hooft coupling regimes stay smooth, as suggested by Maldacena’s AdS/CFT correspondence(?).

Will be out Soon!

Past Research: Non-Equilibrium attractor

- We started with a question that can the concept of a non-equilibrium attractor be extended beyond the lowest-order moments typically considered in hydrodynamic treatments or in other words an the concept of a non-equilibrium attractor be extended beyond the 14 degrees of freedom described using the energy-momentum tensor, number density, and diffusion current?
- We showed that Yes We Can !!
- Using a previously known exact solution to the relaxation-time approximation Boltzmann equation for a transversally homogeneous and boost-invariant system subject to Bjorken flow. Using numerical solutions, we showed that, similar to the pressure anisotropy, all moments of the distribution function exhibit attractor-like behavior wherein all initial conditions converge to a universal solution after a short time (http://arxiv.org/abs/arXiv:1903.03145) and (http://arxiv.org/abs/arXiv:1809.01200).
- Can this be extended to QCD (work in progress)?

TOMASELLI Giovanni Maria

SCUOLA
NORMALE
SUPERIORE

IN SUPREMÆ DIGNITATIS
1343
UNIVERSITÀ DI PISA

Giovanni Maria Tomaselli

Master student in Theoretical Physics, 5th year

Master thesis supervisor: Enrico Trincherini

My greatest interest: gravity

- Black holes
  - theory: mathematical results, higher dimensions, semiclassical aspects, ...
  - phenomenology: QNMs, gravitational waves.
- Cosmology: mostly Inflation and Dark Energy.

Master thesis

Hairy black holes: any detectable effect? QNMs and stability issues.

- Scalar-tensor gravity.
- Hair by infalling matter.

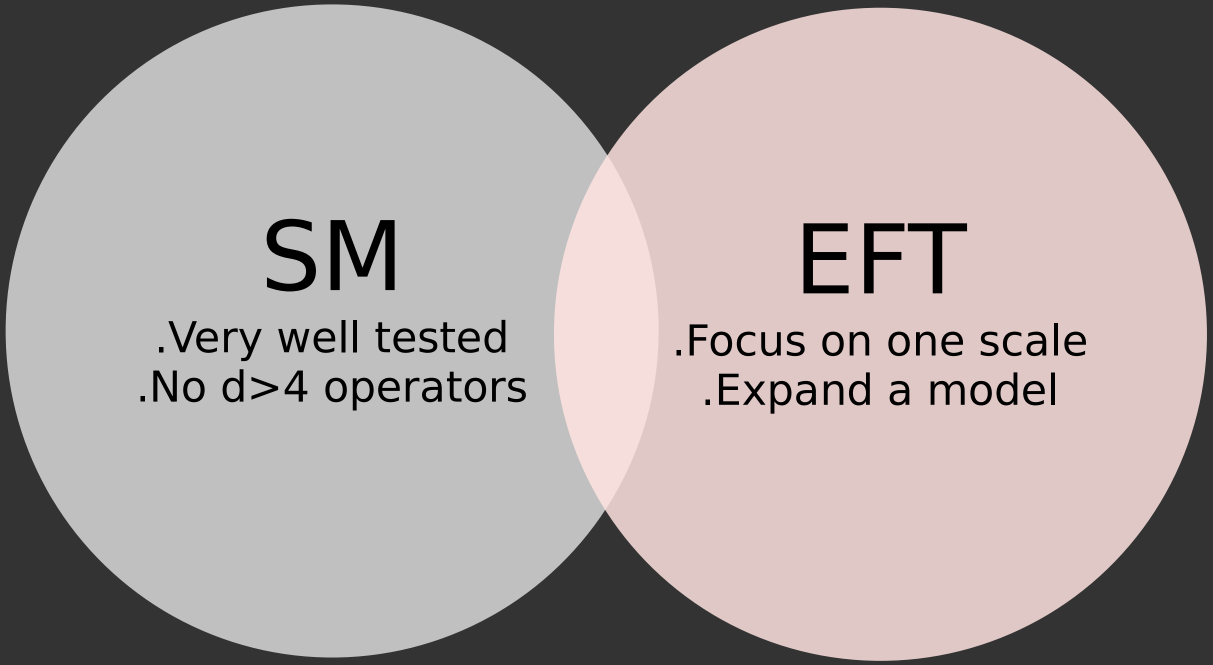
TRIFYLLIS Lampros

Lampros Trifyllis

PhD student
University of Ioannina, Greece

Supervisor: Prof. Athanasios Dedes

The SM as an EFT



.Use SM field and gauge symmetry
.Add higher-dimensional operators
.SM is a limit of SMEFT!

Publications
h → γγ [arXiv:1805.00302]
h → Zγ [arXiv:1903.12046]
smeftFR [arXiv:1904.03204]

Collaborators
Athanasios Dedes [Ioannina U.]
Michael Parakseva s [Warsaw U.]
Janusz Rosiek [Warsaw U.]
Kristaq Suxho [Ioannina U.]

VANVLASSELAER Miguel

GGI conference

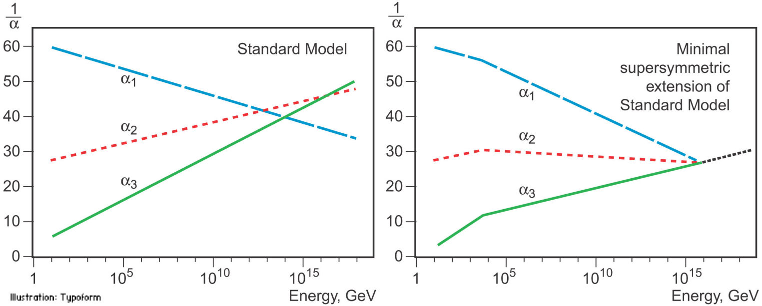
Phase transitions in early universe

Vanvlasselaer Miguel

Sissa : Astroparticles department

18 january 2019

Coupling constants running and phase transitions



- Electromagnetism : very slow increase
- Weak : symmetry breaking around 100 GeV. symmetric $U(1)$ phase and symmetric phase $SU(2) \times U(1)$
- Strong : Decrease. $T < 100$ MeV : confined phase, protons, neutrons ... $T > 100$ MeV : Quarks phase, quarks, higgs, leptons ...

Order of phase transition

Ginzburg-landau classification for phase transitions :

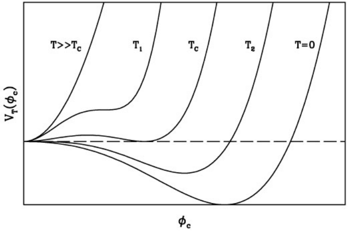


Figure – Potential first order phase transition

- Barrier in potential
- Supercooling, delayed transition ⇒ discont
- Transition via bubble nucleation

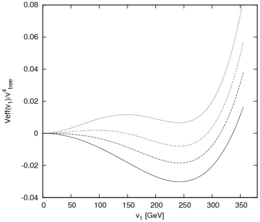


Figure – Potential second order phase transition

- No barrier in potential
- No supercooling ⇒ smooth

VITTI Marco

GGI Lectures on the Theory of Fundamental Interactions 2020

Marco Vitti
Roma Tre University – INFN, Roma Tre

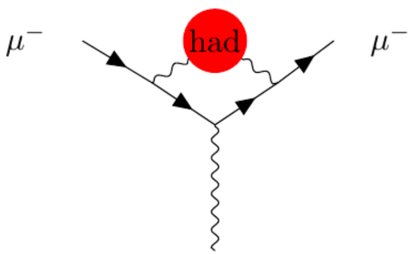
Supervisor: Prof. Giuseppe Degrassi

Precision calculations within the EW sector of the Standard Model

Research

- **Master (Padova):**

HLO contribution to the muon g-2



MUonE Experiment

Hadronic contributions to muon-electron scattering cross section

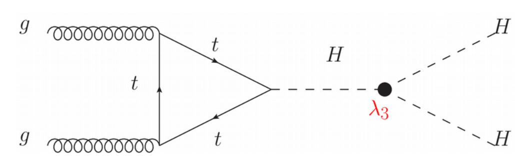
- **PhD:**

Higgs boson properties in the SM

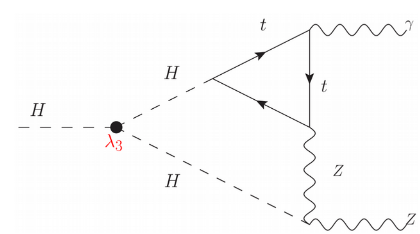
Trilinear self-coupling

$$V(H) = \frac{m_H^2}{2}H^2 + \lambda_3 H^3 + \lambda_4 H^4$$

Production



Decay



WANG Jin-Wei

Basic Info: Jin-Wei Wang (王金伟);

PhD student at Institute of High Energy Physics (IHEP), Chinese Academy of Sciences (CAS);

Supervisor: Prof. Xiao-Jun Bi

- ✓ Visiting PhD student at University of Pisa and working with Prof. Alessandro Strumia

Hobbies: Novels, Music, Badminton, Climb mountains.

Research Fields:

- Phenomenology of BSM, in particular, the phenomenology of DM and TeV physics at colliders; arXiv:1711.05622

  Direct production at hardron colliders and loop effects at lepton colliders.

- The effects of NP models on the Higgs vacuum stability; arXiv:1811.08743

  Two-loop RGEs and one-loop matching.

- Gauge group dynamics; arXiv:1911.04502

  one gauge group (SU, SO or Sp) and one scalar in a two-index representation, and studied the gauge group dynamics and the properties of DM candidates for each case.