

RECFA visit to Greece, November 10, 2023

High Energy Theory: Greece

Elias Kiritsis

The Theoretical Landscape

- There are High-Energy theory groups in the following institutions (starting from the North)
 - ♠ University of Thessaloniki (**U-Thess**) in Thessaloniki (Western Macedonia).
 - ♠ University of Ioannina (**U-Ioan**) in Epirus.
 - ♠ University of Patras (**U-Patr**) in the Peloponese.
 - ♠ National University of Athens (**U-Ath**)
 - ♠ National Technical University of Athens (**TU-Ath**).
 - ♠ National Centre for Scientific Research “Demokritos” (**Demok**) in Athens.
 - ♠ University of Crete (**U-Cret**) in Heraklion (Crete).

University of Thessaloniki (U-Thess)

- The [University of Thessaloniki](#) in the past few decades had a strong high-energy theory group.
- However, in the last ten years, most of its members retired and were not replaced (the economic crisis is a partial reason).
- Currently there is [A. Petkou](#) (Prof) and [K. Siampos](#) (that was just hired as a assistant professor).
- They work on [CFTs, Quantum Critical Theories, Holography and asymptotic symmetries of gravity](#).
- In the past 5 years they had 3 PhD students and 1 postdoc.
- Their current funding comes from a grant from [HFRI](#) (also known in Greek as [ΕΛΙΔΕΚ](#), Hellenic Foundation for Research and Innovation). [Total funding ~ 400 keuros in 2017-2023](#).

University of Ioannina (U-Ioan)

- Ioannina had for a while a large HEP-theory group.
- Current members are: **A. Dedes** (Prof), **P. Kanti** (Prof), **L. Perivolaropoulos** (Prof), **I. Rizos** (Prof), **I. Florakis** (Assistant Prof).
- There are also active emeriti: **G. Leontaris**, **K. Tamvakis** and **J. Vergados**.
- There are on average **5 PhD students** and **1 postdoc** present in the last few years.
- Recent source of funding is **HFRI (Greece)**.
- **The approximate funding is ~ 160 keuros in 2017-2023**
- There are several topics research: **BSM Physics**, **Black Holes**, **Gravity**, **Cosmology**, and **String Theory**.

University of Patras (U-Patr)

- The HEP Theory group at Patras is composed of **S. Lola** and **C. Anastopoulos** (Associate Prof.)
- Several previous members (K. Sfetsos and I. Bakas) have in the past moved to Athens.
- Their current research topics are BSM physics and **Black-Hole Thermodynamics and Quantum Information**.
- In the period 2017-2023 there were 3 PhD students.
- Funding in 2017-2023 is **around 100 keuros coming from Greek sources**.

University of Athens (U-Ath)

- This was the largest HEP theory group in Greece. It has recently shrank like all others.
- It currently has 6 faculty members: **F. Diakonou** (Prof), **G. Diamandis** (Associate Prof), **I. Papadimitriou**, (Assistant Prof), **K. Sfetsos** (Prof), **V. Spanos** (Associate Prof), **N. Tetradis** (Prof).
- There are also some active emeriti: **E. Floratos**, **A. Lahanas**, **T. Christodoulakis**, **V. Georgalas**, **A. Karanikas**, **X. Maintas**.
- During the last ten years they have on average **7-8 Master's students**, **10 PhD students**, **2-3 postdocs** and **10 unpaid research associates**.
- Funding comes from **IKY**, **HFRI** (or previous incarnations) and **European Structural Funds**.
- **Total funding ~ 1130 keuros in 2017-2023**

- There are several subgroups separated by research topic: Strings-QFT, Particle Physics and Cosmology, BSM, Classical and Quantum gravity and Quantum Information.

Technical University of Athens (TU-Ath)

- It had and still has one of the largest HEP Theory groups in the country.
- Current faculty include five members: K. Anagnostopoulos (assoc. Prof), N. Irges (Prof), A. Kehagias (Prof), C. Kouvaris (Prof) and N. Mavromatos (Prof).
- Several emeriti are active in research: G. Koutsoumbas, E. Papantonopoulos, G. Zoupanos.
- N. Tracas is also emeritus but has done a lot and still does as the responsible in Greece for the International Particle Physics Outreach Group.
- For many years there were on average 7-8 PhD students and 1-2 postdocs although currently the number of PhD students is around 15.
- There are several sources of funding, NTUA, IKY, HFRI, Demokritos from Greece and A. v. Humboldt Foundation, DFG, and DAAD.

- Total funding \sim 400 keuros in 2017-2023
- The research topics include: gravity, supergravity, cosmology, string theory, quantum field theory, CFT, lattice gauge theories, non-commutative geometry.

NCSR, “Demokritos” (Demok)

- The HEP Theory group has currently two members, **M. Axenidis** (R1) and **C. Papadopoulos** (R1).
- **G. Savvidy** is retired but he is scientifically active.
- They had 7 PhD students from (2010-2017) and 4 Phd students (2017–).
- They hosted 8 postdocs (2007-2017) and 7 postdocs (2017–).
- Funding comes from **IKY, GSRI** and later **HFRI (Greece)** and from **Marie Skłodowska Curie actions (RTN/ITNs, Host fellowships TOK)**. Some other peripheral Greek sources.
- **Total funding ~ 600 keuros in (2017-2023).**
- Topics that are developed include **Collider Physics, BSM physics, Cosmology, Chaos, Quantum Information** and applications.

University of Crete (U-Cret)

- The **University of Crete** group has never been large but has substantially shrank in the last ten years.
- It currently has three members: **Elias Kiritsis** (Prof), **V. Niarchos** (associate Prof) and **A. Porfyriadis** (Assistant Prof).
- There is also an active emeritus professor: **N. Tsamis**.
- In the past five years it had **2 PhD students** and **8 postdocs**.
- Research funding came from **ERC**, from the **Marie Skłodowska Curie** program of the EU (individual fellowships) and from Greece, **GSRI** and **HFRI**
- **Total funding \sim 1.250 kEuros in 2017-2023.**
- Research topics span **QFT**, **string theory**, **gravity** and **cosmology** as well as some interdisciplinary research in condensed matter.

Standard Model and Collider Physics

- There is important activity in computing **amplitudes and cross sections** mainly to improve QCD contributions.
- This field has had an enormous progress in the last decade spurred by input from the AdS/CFT correspondence and the development of several (on-shell) techniques that bypassed the exponential increase of Feynman diagrams.
- This is an activity that is mainly located in **Demokritos**.
- Another SM-related activity is using **EFT to approach LHC physics**. This activity was pursued in **U-Ioan** over the past few years.

Beyond the Standard Model Physics

- This is a “popular” activity that is represented in many of the Greek Theory groups.
- The particular topics vary:
 - ♠ Supersymmetric Extensions (U-Thess, U-Ioan, U-Ath, TU-Ath)
 - ♠ Supergravity tied to particle physics and to cosmology, (U-Ioan, TU-Ath).
 - ♠ Other extensions involving new particles, new gauge sectors, anomalous low-energy sectors, strong coupling dynamics (technicolor-like) at high energy etc. (U-Ioan, U-Patr., U-Ath, TU-Ath, U-Cret)

Lattice Gauge theory and QCD

- Lattice QCD calculations have been done for a long time in TU-Ath.
- In recent years this has continued with the focus moving away from QCD towards YM-Higgs theories motivated from 5d orbifolds.
- The motivation is the absence of the hierarchy problem for such examples.
- The physics of QCD at finite density and the presence of a critical point has been pursued by U-Ath.
- ♠ The finite density QCD phase diagram and related dynamics relevant for experiments as well as neutron stars/mergers has been pursued by U-Cret using holographic techniques.

Cosmology

- Cosmology is a topic popular with HEP-theory groups.
- It has either particle physics aspects or gravity aspects or both.
- Hot topics include:
 - ♠ Inflation and related observables (with or without susy), (U-Thes, U-Ioan, U-Ath, TU-Ath, U-Cret).
 - ♠ CMB-related physics (U-Ioan)
 - ♠ Dark Matter and Dark Energy (U-Ioan, U-Ath, TU-Ath, U-Cret).
 - ♠ Primordial black holes as Dark Matter (U-Ath, TU-Ath, U-Cret)
 - ♠ Black holes in modified gravity theories (U-Ioan, TU-Ath).

Quantum Gravity and String Theory

- There is theoretical effort in the general area that involves string theory with a dual focus:
 - ♠ As a theory of quantum gravity. The goals in this direction is to understand the puzzles that are associated with quantum gravity (information paradox, cosmological constant problem) and to obtain another perspective on cosmological questions (inflation, dark matter and dark energy). (U-Ioan, TU-Ath, U-Cret)
 - ♠ Understand Constrains on BSM physics imposed by the inclusion of QG and the construction of BSM theories (U-Ioan, TU-Ath, Demok)
 - ♠ Alternatively, studies of quantum gravity using other methods instead of string theory (U-Ath).

The Holographic (AdS/CFT) correspondence

- The **holographic correspondence** is arguably the most revolutionary idea in Physics in the last 40-50 years.
- Although it is a conjecture, it has gathered significant evidence to be considered seriously.
- It posits that **Quantum Field Theories are dual to Quantum Gravity** (ie string) theories.
- It has provided a radical new way of :
 - ♠ Exploring **quantum gravitational phenomena**
 - ♠ The dynamics of some **strongly-coupled QFTs**
- It has had so far an impact in:

- ♠ QCD (and in particular in the physics of the **quark-gluon plasma**) and other strongly coupled QFTs,
- ♠ in some unsolved problems in **condensed matter physics**,
- ♠ in **quantum chaos**,
- ♠ in **far-from-equilibrium phenomena**,
- ♠ in **Quantum Information** and
- ♠ in **black-hole physics** and information paradox.
- There is a research effort in several of the above aspects in **U-Thes, U-Ath, TU-Ath, Demok, U-Cret**

International responsibilities

- Some theorists have international responsibilities. I mention a few.
- ♠ N. Mavromatos is a member of the Scientific Advisory Board of the **Stefan-Meyer Institute (Vienna)** 2014-2021 and physics coordinator of the **MoEDAL-LHC Experiment** (2010-present).
- ♠ N. Mavromatos and E. Kiritsis are members of the evaluation panel in Physics of the **Research Foundation Flanders** (FWO) (Belgium), 2020/2022-present.
- ♠ E. Kiritsis is a member of the Scientific Advisory Board of the **project FORTE** in Chech Republic (2023–) and the evaluation board of the **Utrecht Physics Dept** (2022-2023).
- ♠ E. Kiritsis has served as member (2011-2015) and deputy chair of the **EPS HEP Board** (2015-2018).

The funding Landscape for theory

- Until 5-6 year ago Greece **did not have a funding institution for research.**
- The **GSRT** was a an institution that was distributing some research grants without transparent and proper refereeing and without accountability. The scientific community did not know who got the funding and for what reason.
- The first ever proper funding call, and proper refereeing was organized during the crisis years (probably 2013-2014) by **J. Iliopoulos** who was invited by a minister, set up international refereeing panels with acclaimed scientists and did a proper job.
- Eventually **HFRI** was established 5-6 years ago with the goal of providing regular funding opportunities to Greek research at large. The refereeing so far seems correct.

HOWEVER:

- HFRI has still serious problems:

- ♠ There are no regular funding calls.
- ♠ Every second, the rules change.
- ♠ The grants are typically small in size.
- ♠ The bureaucracy and rules associated to them are mind-boggling (and even Kafka would have been dumbfounded if he knew of this).

Also:

- HFRI until today gives funding by (mostly) borrowing money from European banks because **NO LIVING GREEK POLITICIAN HAS EVER THOUGHT USEFUL TO PUT MONEY AND FUND RESEARCH***.
- Because of this, I am told that the current government is thinking of abolishing again HFRI and probably distributing less funding for basic research, as it was done before.

- Apart from HFRI, there are occasional calls from the so-called **European structural funds**.
- However, such funding comes with even more bureaucracy that make it almost unusable in serious research.
- Some universities, especially **TU-Ath** and to some extent **U-Ath** have a high income from various sources and in the past they spend some of these funds on postdocs and PhD student grants. However, this has been substantially reduced in recent years.
- The University bodies that manage research grants (**EAKE in Greek**) provide some minimal extra funding, which is small/tiny and unreliable.
- Moreover, they add an extra layer of administration/bureacracy that surpasses the Kafkaesque level and enters the nightmarish.
- There is **European funding** at different levels:

- ERC grants
- Marie Skłodowska Curie grants (individual fellowships, and ITNs, as well as RISE/Staff exchanges).
- Widening Class of European programs that are targeted to "less scientifically developed areas of the EU". Recently Greece was included in this class.
- Although the European instruments are important, they cannot substitute rolling grants.
- On the other hand, I think our community could do more to profit from them.

Problems and Challenges

- The economic crisis has taken a [serious toll on Greek Theory \(and Experiment\) groups](#), and occurred at a period of massive retirement waves.
- Most groups were decimated, and in several there is an inverted hierarchy of faculty.
- It is difficult to foresee in the near term, an important improvement in this direction.
- A general issue is that the interest of the “best” students appears to be (slowly) turning away from particle physics.
- Funding and its regularity are far from adequate; prospects for improvement are not positive.
- On the theory front, the different groups in Greece are somewhat secluded one from the other.

- There is a point of contact once a year at the **Corfu meetings**, the **Xmass-U-Ath meeting** or the annual **Greek-HEP society meeting** but this affects a subset of theorists.
- In my opinion there is **need for more coherence and interaction both in research and in teaching**.
- This is of course technically difficult, but in some cases (like the Athens institutions) may be doable.

Summary

- HEP theory was the first science field that managed to attract world class scientists in Greece in the last 70 years.
- Although we are standing today on the “shoulders of giants”, the theory community is as competitive today, if not more.
- There are serious challenges now and ahead, but I believe we shall do better in the future.

THANK YOU!