Theory and Phenomenology in HEP

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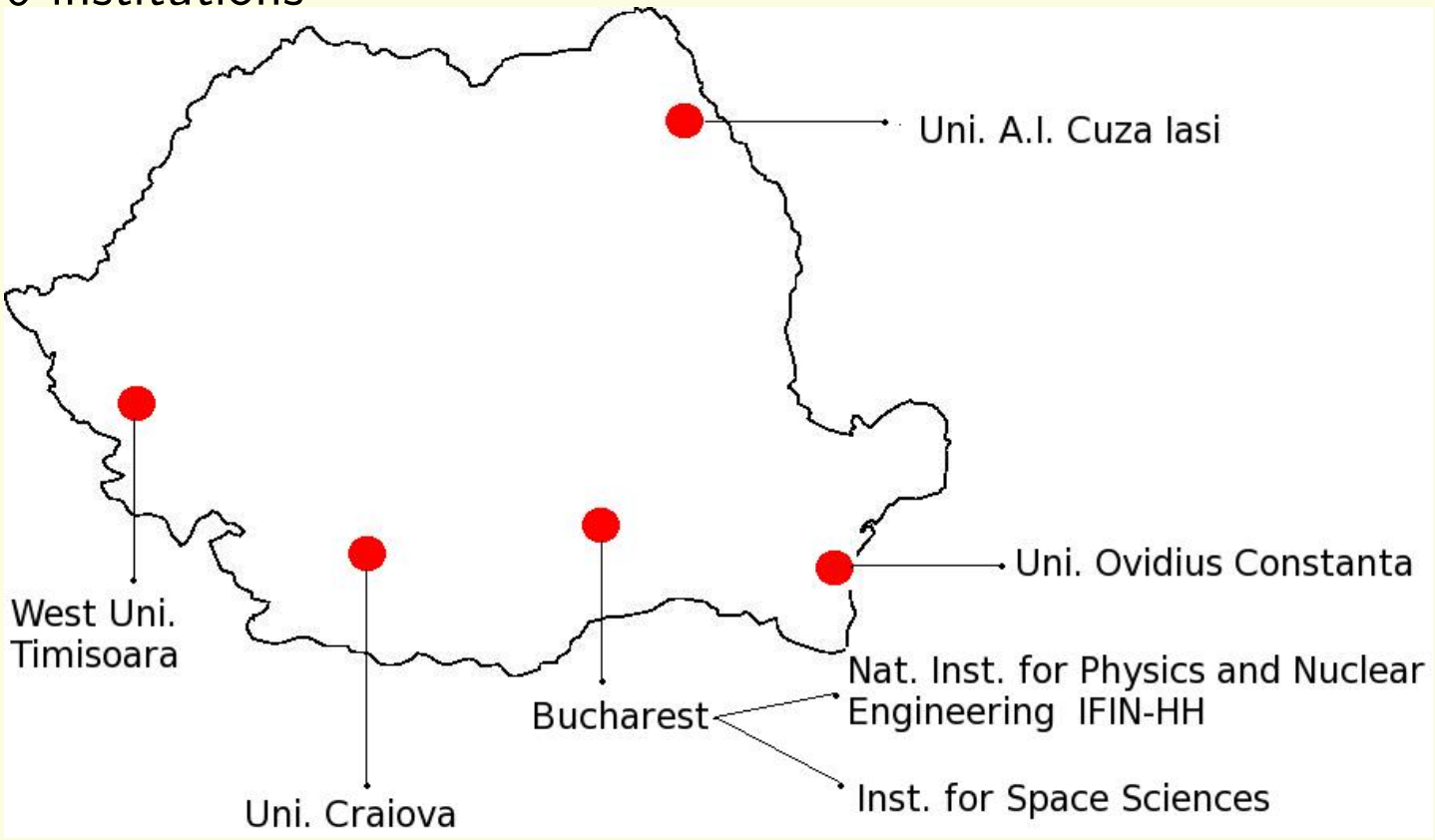
Plan of the talk

- Places and people in HEP-theory
- Research areas in HEP-theory
- Financial issues
- Conclusions and recommendations

People and places in HEP-theory

6 institutions



People and places in HEP-theory

Institution	Number of People	Publications in last 5 years (arXiv hep-th, hep-ph and gr-qc)
IFIN	12(4 on leave $>$ 1 yr) 1 appointed in 2011	103
ISS	3 + 1 appointed Oct 2011	4
U. Iasi	5	27
U. Craiova	5	25
U. Timisoara	4	34
U. Constanta	1	17
Total	**30**	**210**

Small number of students

Research areas

- QFT and SM (QCD, precision tests of SM) – IFIN, Craiova, Iasi
- Formal aspects of QFT (BRST, causal approach) – IFIN, Craiova, Timisoara
- Gravity and cosmology – IFIN, ISS, Constanta, Timisoara, Iasi
- BSM I (non-commutative geometry, additional generations in SM) – IFIN, Iasi, Timisoara
- BSM II (supersymmetry, extra dimensions, strings, etc) – IFIN

QFT and Standard Model

- perturbative QCD and the determination of the strong quark gluon coupling
- gluonic corrections to the production of exotic particles at the LHC
- theoretical constraints on the hadronic form factors of interest for flavor physics
- precise results in the frame of Chiral Perturbation Theory

(I. Caprini – IFIN)

- determination of flavour parameters using unitarity
- explain data in neutrino sector

(P. Dita – IFIN)

QFT and Standard Model

- 1/N expansion for strong interactions (Excited baryon physics, Spin-flavor structure of the effective quark interactions)

- Weak interactions of heavy flavors (Determinations of the CKM matrix in heavy flavor decays, studies of the strong interactions in weak processes, radiative and rare B decays)

(D. Pirjol – IFIN)

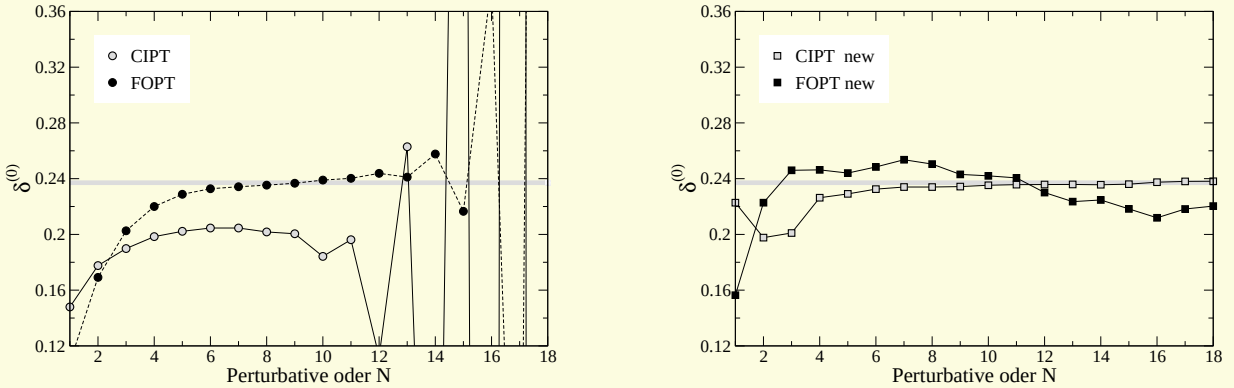
- Kinetic approach to Quark-Gluon Plasma dynamics (Transport model in the quasiparticle approximation)

(V. Baran – IFIN and U. Bucharest)

New expansions in perturbative QCD and α_s determination

- α_s from hadronic τ decays (low scale: $M_\tau = 1.78\,\text{GeV}$)
- strong renormalization scale dependence (CIPT versus FOPT)
- the QCD perturbative expansion is a divergent (asymptotic) series
- new expansions based on convergence acceleration by conformal mappings

I. Caprini and J. Fischer, Phys. Rev. D**60**, 054014 (1999)



$$\alpha_s(M_\tau^2) = 0.3195^{+0.0189}_{-0.0138} \quad \Rightarrow \quad \alpha_s(M_Z^2) = 0.1184^{+0.0019}_{-0.0014}$$

I. Caprini and J. Fischer, Eur. Phys. J. C**64**, 35 (2009); Phys. Rev. D (2011)

Formal aspects of QFT

- Quantization of constrained systems
- Local BRST cohomology – derivation of consistent interactions in gauge theories and gravity
- Tensor fields with mixed symmetries
- Topological BF theories

(C. Bizdadea, E. Cioroianu, R. Constantinescu, O. Saliu, S. Sararu, – U. Craiova), (M. Babalic – IFIN)

Formal aspects of QFT

- Causal approach (Epstein–Glaser) to perturbative field theory

(D. Grigore – IFIN)

- Quantum fields on de Sitter space
- Field theory (QED) amplitudes on de Sitter space

(I. Cotaescu – U. Timisoara)

Gravity and Cosmology

- Dynamics and properties of cosmic neutrino background and its impact on small structure formation
- Unified models of dark matter and dark energy motivated by particle physics phenomenology
- Tests of GR (scalar-tensor theory, brane-worlds, non-minimal interaction with gravity)

(L. Popa – ISS)

- Alternative theories of gravity: super-energy and energy-momentum complexes
- Study of a possible temporal variation of the fundamental physical constants in various cosmological models

(P. Stefanescu, O. Tintareanu – ISS)

Gravity and Cosmology

- Hidden symmetries and Killing–Yano tensors in quantum theories and gravity
- Gravitational anomalies

(O. Tintareanu, C. Popa – ISS),(M. Visinescu – IFIN)

- Anisotropic cosmological models; space-time singularities
- Cosmic acceleration and non-standard cosmological models

(D. Vulcanov – U. Timisoara),(M. Visinescu – IFIN)

Gravity and Cosmology

- Exact solutions of field equations and applications to astroparticle physics
- Geometro-dynamical models in extra dimensions.

(C. Dariescu, M. Dariescu – U. Iasi)

- Black hole entropy and the degrees of freedom on the holographic screen
- Gravity - hydrodynamics similarities - Einstein's and Navier-Stokes' equations.
- The connection between RHIC evolution and the formation of a Rindler horizon

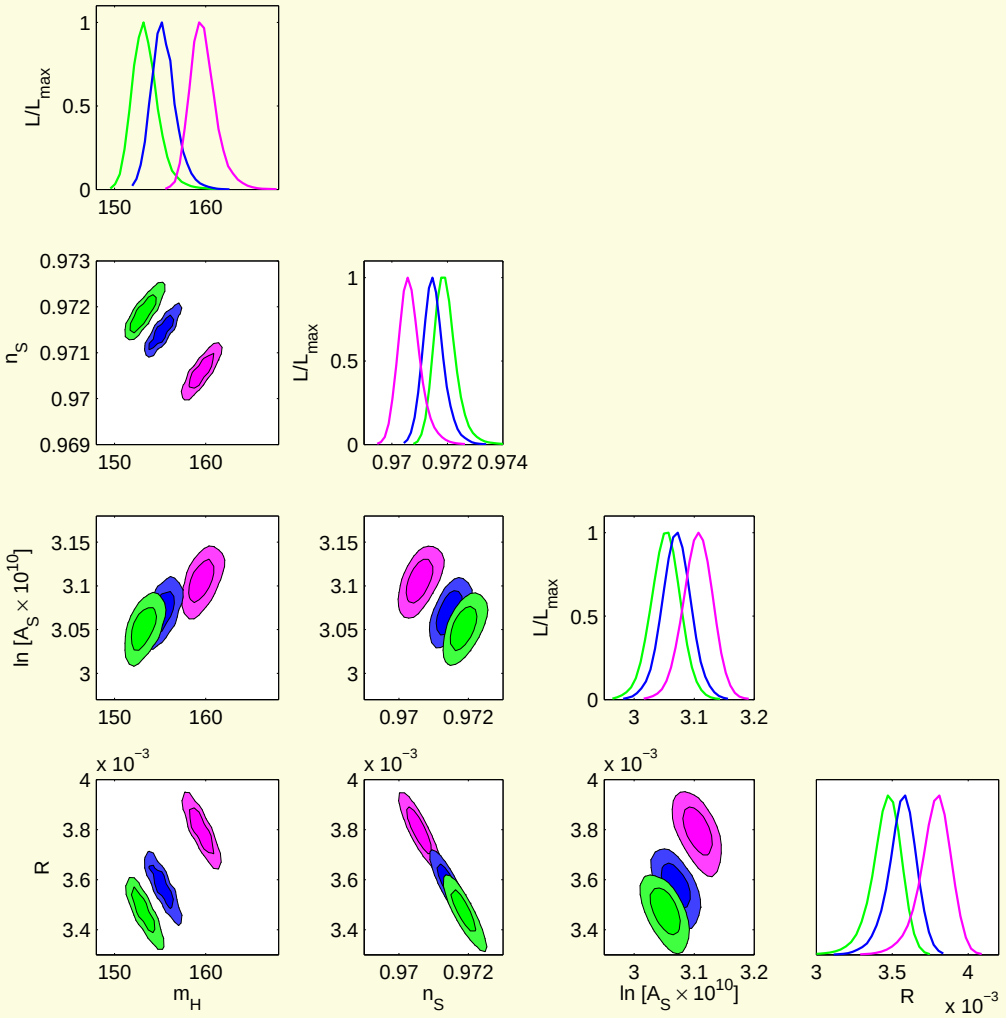
(H. Culetu – U. Constanta)

Gravity and Cosmology

- Einstein–Finsler gravity and cosmology
- General solutions of Einstein equations
- Fractional Exact Solutions and Solitons in Gravity

(S. Vacaru – U. Iasi), (D. Baleanu – ISS)

Cosmological constraints on the Higgs boson mass



$M_T = 168\ GeV$

$M_T = 171.3\ GeV$

$M_T = 173\ GeV$

L. Popa, A. Caramete, Astrophys. J. 723 (2010) 803

Physics Beyond Standard Model I

- Renormalization of gauge theories on non-commutative space-time
- Symmetries in non-commutative field theories
- Non-commutative gauge theories of gravity with covariant star-product

(Gh. Zet – TU Iasi)

- Renormalizable models on Moyal space; UV-IR mixing
- Renormalizable models of quantum gravity (group field theory)

(A. Tanasa – IFIN)

Physics Beyond Standard Model I

- Causality and unitarity in non-commutative theories
- Space non-commutativity vs. bilocality

(C. Acatrinei – IFIN)

- Models with more generations of quarks and leptons or additional gauge bosons

(M. Visinescu – IFIN)

- New physics searches in heavy flavors (Constraining models of new physics using data on heavy flavor weak interactions)

(D. Pirjol – IFIN)

Physics Beyond Standard Model II

- Supersymmetry and model building (Higgs sector in MSSM models, fine-tuning, effective operators, non-linear SUSY, Goldstino physics)

- Effective field theory approaches to compactification (physics of large extra-dimensions: model building, radiative corrections; link with strings)

- Phenomenological implications of String Models (extra U(1)'s, one-loop threshold corrections; gauge unification).

(D. Ghilencea – IFIN and CERN-TH)

Physics Beyond Standard Model II

- String compactifications with fluxes and dualities
- Moduli stabilization in string compactifications
- Non-perturbative effects in string compactifications
- F-theory phenomenology

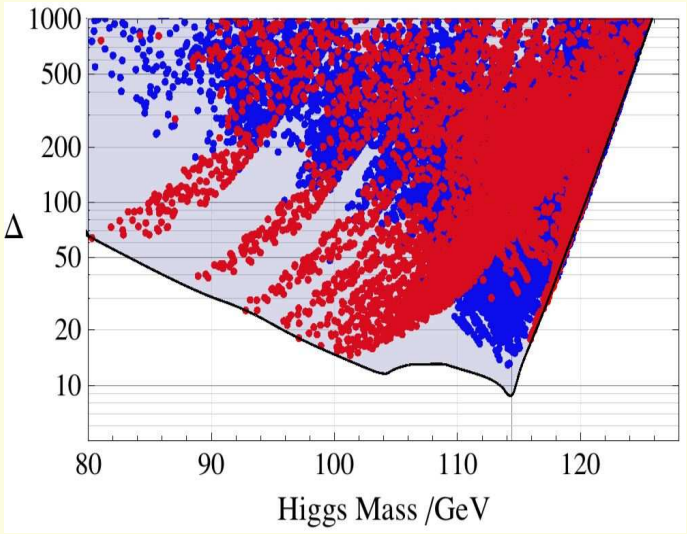
(C. Condeescu, A. Micu – IFIN)

- String theory fluxes from the worldsheet perspective
- Formal aspects of string theory

(M. Babalic, C. Lazaroiu, A. Micu – IFIN)

BSM physics: MSSM: precision corrections and effective operators

1. MSSM at 2-loop: $m_{\rm Higgs}$ prediction from min fine-tuning (Δ) and Ω_{DM}:
(no LEP2 bound on $m_{\rm Higgs}$)



$$\Delta = \max \left| \frac{\partial \ln v^2}{\partial \ln p} \right|_{p=\mu_0^2, m_0^2, m_{1/2}^2, A_0^2, B_0^2}$$

$$\Rightarrow \; m_h = 114.7 \pm 3\,\text{GeV}, \; \Delta = 15, \; \Omega_{DM} : \text{WMAP}$$

$$\Rightarrow \; m_h = 115.9 \pm 3\,\text{GeV}, \; \Delta = 17, \; \Omega_{DM} : 3\sigma\text{WMAP}$$

2. Beyond MSSM with effective operators: $\mathsf{L}=\mathsf{L}_{\rm MSSM} + \mathsf{L}_{(d=5)} + \mathsf{L}_{(d=6)}$,

> 20 operators for Higgs sector: correlation $\delta m_{\rm Higgs} \leftrightarrow$ neutralino DM Ω_{DM}

$\Rightarrow$ overlaping constraints: large $\&$ small distance physics $\Rightarrow$ predictions m_h, Ω_{DM}

Ghilencea et al, JHEP 1105(2011)120; NPB 848(2011)1; NPB 835(2010)110; NPB 841(2010)157

Financial issues

- Unstable and unattractive funding for HEP-theory
- Too large overhead rates for HEP-theory research grants funded by the National Research Authority.
- National grants impose a minimal spending (10 – 20 %) for logistics $\rightarrow$ not appropriate for HEP-theory
- Romanian participation in experiments at CERN well supported by national authorities – however no support for participation in theory programs (small costs, improves visibility and publication record)

Conclusions and recommendations

- Good potential for HEP-theory in Romania
- Scattered subjects and no strong groups: Stimulate group formation + hire specialized researchers to create research groups in the leading domains in HEP-theory (in particular BSM phenomenology – people on leave)
- Small number of PhD students: attract more students for physics in general and for HEP in particular (e.g. increased PhD grants)
- Reduce overhead rate for HEP-theory projects supported by the Natl. Res. Authority
- HEP research evaluation – should be based on SPIRES instead of Web of Science

  – distinct criteria for HEP-theory and HEP-exp
- Obtain national financial support for HEP-theory group participation in programs at CERN similar to that for HEP-Exp groups.
- allow Romanian researchers to be considered as CERN member-country applicants when applying for CERN funded programs (months per researcher quota allocated ?)

Other proposals

- HEP-theory project evaluators research record comparable to that of applicant HEP-theory project evaluators not required to have a research record (Relative Influence Score) better or comparable to that of the applicant, but only a minimal (v. modest) threshold required to actually compete. Undermines the quality of refereeing.

- Distinction between hep-theory and hep-ex projects for ranking and evaluation criteria. Latest evaluation of Romanian research projects considers all authors of a hep-ex paper as principal authors when ranking a project (so a hep-theorist competes against the papers of whole ATLAS collaboration, etc....). Unfair advantage for hep-ex projects relative to hep-th, while competing for same allocated funding

- Use Spires in HEP-theory research evaluation SPIRES is more complete, works well with arXiv, is FREE

- Paid "on leave/sabbatical" for HEP-theorists while at CERN, for up to one year, with minimal results expected (numbers of publications/year: 3 ?). Currently possible only if funded from external research projects.