PLAN NACIONAL DE I+D+I (2008-2011)

Perturbative and non-perturbative studies of the Standard Model and its extensions

Programme: Fundamental Research

Thematic Area: Particle Physics (FPA)

Principal Researcher: Vicent Giménez Gómez
Departament de Física Teòrica
Universitat de València

MEMBERS OF THE PROJECT

Local researchers:

- Vicent Giménez Gómez (PI)
  Assistant Professor (TU). EDP=1
- Arcadi Santamaría Luna
  Full Professor (CU). EDP=1
- Armando Pérez Cañellas
  Assistant Professor (TU). EDP=0.5
- Jorge Vidal Perona
  Assistant Professor (TU). EDP=0.5

MEMBERS OF THE PROJECT

Local researchers (pre- and postdocs):

- Arlene Cristina Aguilar
  MEC Postdoc EDP=0.5
- David Palao Pomares
  Predoc (Becario FPI) EDP=1
- Alberto Aparici Banages
  Predoc (Becario “Cinc Segles” UV) EDP=1

MEMBERS OF THE PROJECT

External researchers:

- Stefano Bertolini
  Full Professor. SISSA
- Vittorio Lubicz
  Assistant Professor. Università di Roma III
- Gabriel González-Sprinberg
  Assistant Professor. U. de la República.
- Alejandro Romanelli
  Assistant Professor. U. de la República.
- Mari Carmen Bañuls
  Postdoc. Max-Planck-Ins. für Quantenoptik

TEAM BACKGROUND

Previous research projects:

- 1998-2000 Ayuda para proyectos emergentes
  DGIC Generalitat Valenciana
  PI: Arcadi Santamaría Luna
  We were able to develop some new research lines autonomously.
- 2002-2005 Project of the Plan Nacional de I+D+I
  MCyT. Reference BFM2002-00568.
  Amount of the grant: 50.160 €
  It allowed us to acquire experience and participate in other projects (GoG)

TEAM BACKGROUND

Previous research projects

- 2005-2008 Project of the Plan Nacional de I+D+I MCyT. Reference FPA2005-00711. Amount of the grant: 59.500 €
  It has allowed us to consolidate and extend our previous project. Moreover, thanks to it, he have had our own voice in important national and internationational collaborations.(SPQcDR, ETMC)
- 2008-2011 We apply for a new project to continue our research and start some new lines.

TEAM BACKGROUND

Research ability

- We think our research capacity is beyond question:
  - 93 publications between 2003 and 2008
  - Published in prestigious international journals
  - Excluding external members: 28 articles with more than 50 cites, 9 of them with more than 100 in SPIRES-HEP.
  - Including external members: 69 articles with more than 50 cites and 25 with more than 100 cites in SPIRES-HEP.
  - Total number of cites of local members: > 5.000
  - Number of cites including external members: > 11.000
  - Two local members (AS and VG) have more than 1.800 cites and a Hirsch index h=25.
  - Arcadi Santamaría has recently become full professor.

TEAM BACKGROUND

Education and Training

- All senior members of our group are university professors and in the last 5 years have supervised:
  - 2 PhD thesis (Sobresaliente Cum Laude)
  - 1 dissertation (Sobresaliente)
  - David Palao Pomares, predoc FPI, is preparing his PhD thesis, supervised by V. Giménez, on QCD numerical simulations with the Wilson twisted mass lattice action. Defense date: March 2010.
  - Alberto Aparici Banages, predoc "Cinc Segles" of the UV, will carry out his thesis with A. Santamaría on models of neutrino masses and their effects in the LHC and low energy experiments.

TEAM BACKGROUND

Administrative and management capacity

- The senior members of our group have proved to have a high administrative ability:
  - A. Santamaría was the IP of the projects: GV98-80-1 (1998-2000) and BFM2002-00568 (2002-2005).
  - V. Giménez is the IP both of this application and of our present project FPA2005-00711 (2005-2008).
  - J. Vidal has been the head of the Departament of Theoretical Physics of the UV during 4 years and also the secretary of our department.
  - A. Pérez has been the vice-director of the IFIC.
  - V. Giménez has co-organized an international conference in Valencia in 2002 and some workshops.

TEAM BACKGROUND

Degree of objective fulfillment

- This application should be considered as a natural continuation of our present grant FPA2005-00711.
- We think the compliance with the objectives proposed in our present project is very high:
  - We have participated in the birth of a new large international collaboration: the ETMC (European Twisted Mass Collaboration) whose objective is to perform realistic QCD numerical simulations with the Wilson twisted mass lattice action.
  - We have obtained more than 2.000.000 Cpu hours on both the BSC's MareNostrum and the UV's Tirant.
  - Performed simulations with 2, and soon 4, sea quarks.

TEAM BACKGROUND

Degree of objective fulfillment

- We have performed stable simulations with pion masses as low as 280 MeV with two degenerated sea quarks.
- Determination of some chiral lagrangian low energy constants, quark masses, chiral condensate, B_K parameter and meson decay constants (f_pi and f_K) with two sea quarks.
- Extension of these studies to four sea quarks (tuning stage)
- Study of the experimental implications in the LHC and the ILC of models in which the neutrino masses are radiatively generated.
- Study of the possibility of the induction by right-handed neutrinos of a magnetic moment in light neutrinos.

TEAM BACKGROUND

Degree of objective fulfillment

- Exploration of a method to obtain quadratic divergencies, and higher orders, in QFT with dimensional regularization
- Study of quantum computing algorithms, specifically quantum walks based on a time dependent coin, and their experimental realization.
- Solution of a system with 100 qubits using the matrix product state technique.
- Calculation of the neutrino emission of Cooper pairs in neutron stars.
- Study of the experimental advantages of longitudinal polarized electrons in Super B factories, specially in the measure of the electric dipolar moment of the tau.

PHYSICS OBJECTIVES

Generic objectives

- A range of research lines to
  - help to completely verify current physics theories of the origin of matter and its interactions, included and described by the Standard Model, by means of a quantitative understanding of experimental results obtained in B and D factories, the Tevatron and the LHC.
  - propose extensions of the SM which solve some open questions like the origin of the neutrino masses and mixings, and also describe new phenomena that could be verified experimentally.
  - help to design the future quantum computers and prepare efficient algorithms, what will help us very much due to our large need of computer resources.

PHYSICS OBJECTIVES

Specific objectives

- Non-perturbative QCD: Lattice QCD.
  - Tuning to the maximal twist of the Wilson twisted mass action for four sea quarks, Nf=2+1+1.
  - Production of gauge configurations on MN, BGL, APE.
  - Precisely measure the mesonic and baryonic spectrums.
  - Determination of some χPT low energy constants.
  - Non-perturbative computation of all bilinear RC.
  - One-loop perturbative calculation of RC including O(a).
  - Determination of light quark masses (u, d and s).
  - Non-perturbative computation of four-quark RC.
  - Determination of the BK parameter and the mesonic decay constants.

PHYSICS OBJECTIVES

Specific objectives

- Non-perturb. QCD: Schwinger-Dyson equations.
  - Study of the gluon and ghost propagators by using the Schwinger-Dyson equations.
  - Study of the chiral symmetry breaking by means of the Schwinger-Dyson equations.
  - Numerical simulation study of the propagators of the gluon and the ghost in lattice QCD.
  - Study of models in 5 dimensions to describe the strong interactions in the limit of large number of colours.

PHYSICS OBJECTIVE

Specific Objectives

- Perturbative QCD
  - Study of the possibility of determining the b quark mass at the scale of the Higgs boson, if it is found in the LHC and its predominant decay is to b quarks.
  - Using the result above, and other already obtained, verify the running of the quark masses.
  - Study of the strong corrections to the production and decay of the top quark and the effect of the widths.

PHYSICS OBJECTIVES

Specific objectives

- New Physics: neutrinos, unification, extra dimen.
  - Analysis of models of the neutrino masses generated radiatively and their implications in the LHC, ILC and low energy experiments.
  - Magnetic moments of right-handed neutrinos.
  - Magnetic and electric dipolar moments of the tau lepton and top quark.
  - Fermion and neutrino masses in broken SO(10).
  - Study of the production and possible detection of Kaluza-Klein modes in extra dimensions.
  - Study of a possible Higgsium production in the LHC.
  - Numerical simulations with extra dimensions.

PHYSICS OBJECTIVES

Specific objectives

- Astroparticles and cosmology.
  - Momentum distribution of cosmic background neutrinos.
  - Astrophysical and cosmological effects of a possible magnetic moment of the neutrinos.

PHYSICS OBJECTIVES

Specific objectives

- Quantum information and its applications to physical systems.
  - Study of open quantum mechanical systems. Application to the search algorithm (both adiabatic and non-adiabatic) and to the quantum walk.
  - Development of numerical simulations of the behaviour of systems with a large number of entangled states.
  - Design of quantum mechanical algorithms applicable to some complex problems like lattice QCD.

BUDGET

Marginal cost budget

- Personnel costs:
  - Salary bonus — 34.650 € — 2.100 €/EDPY
- Execution costs:
  - Small equipment — 13.781 € — 835€/EDPY
    - 3 desktop computers
    - 3 laptops
  - Consumables — 6.000 € — 364€/EDPY
    - Toners, streamer tapes, HD, DVDs, memory, cards, paper
  - Travelling expenses — 54.000 € — 3.273€/EDPY
    - 1 weak stay per year
    - 3 year x 12 members x 1500 €

BUDGET

Marginal cost budget

- Execution costs: Miscellaneous
  - Books and journals 1.000 € 61€/EDPY
  - Invited seminars 4.200 € 255€/EDPY
    - 4 seminars per year
    - 3 years x 4 seminars x 350 €
  - Equipment maintenance 4.000 € 242€/EDPY
    - Cluster repairs. Replacement and upgrading of electronic components.
  - Thesis publication expenses 1.000 € 61€/EDPY

TOTAL Miscellaneous 10.200 € 618€/EDPY

BUDGET

Marginal cost budget

- Direct costs:
  - Personnel costs 34.650 € 2.100€/EDPY
  - Execution costs 83.981 € 5.090€/EDPY

  TOTAL direct 118.631 € 7.190€/EDPY
- Indirect costs:

  TOTAL indirects 24.913 € 1.510€/EDPY

  21% direct costs

  TOTAL grant 143.544 € 8.700€/EDPY

CONCLUSIONS

- We are a small but very active and productive group with good collaborators.
- We need students and, at least, one postdoc to keep developing state-of-the-art physics.
- Our request budget is, in our view, modest.