

Theoretical–research summer: For a new generation of experts on high energy physics

Saúl Ramos-Sánchez

Instituto de Física, Universidad Nacional Autónoma de México, POB 20-364, Cd.Mx. 01000, México

E-mail: ramos@fisica.unam.mx

Abstract. Motivated by the need to strengthen the comprehensive training of young Mexican physicists interested in theoretical high energy physics, the *Theoretical–research summer on high energy physics* program was conceived. This program, that celebrates its sixth anniversary, consists in a yearly, nationwide challenging contest in which a board of experts identify the best undergraduate contestants to support them during short research stays in high–energy–theory groups of prestigious international institutions. Out of 80 contestants, the eight awarded students have demonstrated their skills, producing highly advanced (and publicly available) reviews on particle physics, field theory, cosmology and string theory, and a published paper.

1. The origins

During more than 30 years, the (experiment–oriented) *Verano Científico en Laboratorios Extranjeros* program has had great success and acceptance among young students interested in becoming experts on experimental high energy physics. Unfortunately, targeting a different population, many talented undergraduate students devoted to theory could not be supported by that program.

Looking for a mechanism to identify the future generation of theoretical high energy physicists, in 2010 the *Theoretical–research summer on high energy physics* contest was conceived by a group of Mexican high energy researchers, with support of the Division of Particles and Fields of the Mexican Physical Society (DPyC) and the CONACyT National Network on High Energy Physics (RedFAE). The main purpose of the program is to promote the integral professional training of future researchers on theoretical high energy physics, by encouraging international contact in early stages of their education. Evidently, reaching this goal shall lead to an even more successful new generation of Mexican experts on theoretical high energy physics.

In this program, talented Mexican students contest to earn the opportunity to contribute to the development of theoretical research in highly recognized institutions in a foreign environment. The best contestants are awarded with a full two–month scholarship for a research stay at the theoretical high energy physics departments of the International Centre for Theoretical Physics (ICTP) or the Thomas Jefferson National Accelerator Facility (JLab).

The first call for applications took place on 2011 and, since then, its success has demonstrated the need of such a program. During the short life span of this program, not only top–quality reviews and reports have been produced, but also a published article and a rich exchange of ideas and collaborations as well as the seeds for future research have been the result of the



effort of the successful contestants. Furthermore, since the awarded students are motivated to share their experience and knowledge after their stays with the younger generations, the new applicants can profit from the discussions that take place during the contest.

2. The selection process

The call for applications of the contest is published nationwide every year in summer, through posters and emails that are shared among the Mexican experts on high energy physics and directors of scientific institutions. Applicants are expected to be young students, attending lectures of the last two semesters of their B.Sc. or the first two semesters of their M.Sc.. That is, contestants should be between 20 and 25 years old. They should also have demonstrated in their career a clear tendency towards theoretical physics. Beside knowledge on particle physics and its mathematical and conceptual basics (quantum mechanics, relativity, differential geometry, group theory, etc.), contestants should have some skills on analytical and numerical calculation methods.

The applications should include *i)* the full CV of the applicant, *ii)* her/his academic transcript, *iii)* a concise statement of interests and scientific prospects, and *iv)* two letters of recommendation (to be sent independently by the referees). The complete applications are submitted by the end of November through the electronic portal

<http://stringpheno.fisica.unam.mx/veranosteoricos/>

which contains many details of the program as well as a historic overview of its progress.

The applications are evaluated by a selection committee composed by five to eight members, who vary from year to year in order to incorporate different perspectives into the examination process. The selection committee comprises recognized scientists, including some experimentalists, of various disciplines within high energy physics. Some of the members of previous selection committee are A. Aguilar (UNAM), J. Barranco (Guanajuato U.), A. Bashir (UMSNH), K. Caballero-Mora (Chiapas U./MCTP), E. Castellanos (Chiapas U./MCTP), J. Erler (UNAM), A. García-Zenteno (UNAM), A. Güijosa (UNAM), I. Huet (Chiapas U./MCTP), R. Linares (UAM-I), M. Mondragón (UNAM), G. Murguía (UNAM), L. Patiño (UNAM), M. Tejada-Yeomans (Sonora U.), G. Toledo (UNAM), and L. Valencia-Palomo (Chiapas U./MCTP).

The selection process has three stages. In the first stage, after the candidates have submitted their documents and recommendation letters, the selection committee evaluates them and, based on this information, must decide who may be the most qualified students. The successful candidates in this first stage are the finalists, who are then invited to participate in the next stages, which are hosted at a Mexican institution, where theoretical high energy physics is developed.

In the second stage, the candidates attend a couple of crash courses on essential topics (such as quantum field theory, QCD and QED particle physics, relativity, cosmology and string theory) and talks held by previously awarded students and experts of the area. The language of lectures and seminars is English; questions and discussions are encouraged. After these sessions, which may take up to three days, students are examined in a three-hour-long written test, partly based on the topics discussed on the crash courses and the talks, and also on elementary concepts of high energy physics.

The third and last stage gives the selection committee the opportunity to gain an overall perception of the students' skills to have an academic discussion. In this stage, the experts interview the best candidates about their previous knowledge and experiences in theoretical high energy physics, their research interests, and their expectations at the research center where they would like to make a stay. Some questions should invite the candidate to exhibit the

technical abilities (s)he has in her/his favorite research topic. The interviews are personal and conducted in English.

All examination elements acquired during the contest let easily identify the best candidates. The names of the awarded contestants are announced in the closure ceremony, where all finalists also receive their certificates.

The *Theoretical–research summer on high energy physics* program has received about 100 applications from which over 60 students have excelled in the first stage of the contest. The selection committees have made difficult decisions to identify among them the best qualified contestants. Until the summer of 2016, eight exceptional students have been awarded with a full scholarship to develop a self–contained project on theoretical physics. The topics they have investigated range from low–energy meson and baryon physics to higher–order corrections of string theories. They have led to works of remarkable quality [1] and even to published papers.

The ICTP and the JLab have provided financial support and academic guidance to the awarded contestants. Scientists of all levels, including e.g. the director of the ICTP, have participated advising the projects of the students. Besides, students have been assigned an office and have been incorporated in the group activities. Particularly, they were included in seminars, workshops and schools organized at the institutions, such as the Hampton University Graduate School (HUGS) at the JLab and the various summer schools at the ICTP.

After their research stays, the successful candidates are invited to report the main results of their work and to share their achievements in public seminars, attended by the new contestants and active researchers of the area. The goal of these activities is twofold. First, the seminars and reports motivate young students who often see the research topics of the awarded students for the first time in there, and find out that they could be presenting similar findings, should they pull ahead in the contest. Second, holding professional talks before a critical academic audience is a limestone of a comprehensive training as a scientist, complementing thereby the purpose of the program.

3. Awarded students

In the following, we summarize some of the achievements of the eight awarded young scientists.

Lucía Gómez Córdova

In December of 2011, Lucía (21y) was a 7th semester B.Sc. student at the University of Guanajuato, campus León, working under the supervision of Oscar Loaiza-Brito. During her stay at the ICTP, in the summer of 2012, she developed the project *Moduli stabilization and inflation in type IIB supergravity*, supervised by Michele Cicoli. Now, she is a Ph.D. student, supervised by Pedro Vieira and Robert Myers, at the Perimeter Institute for Theoretical Physics. She works on quantum field theories and has published three papers.



David Theurel Lambert

In December of 2012, David (24y) was an undergraduate student at the UNAM, working on his B.Sc. thesis on an attempt towards quantum gravity. During his stay at the ICTP, in the summer of 2013, he was supervised by Gabrijela Zaharijas and Emiliano Sefusatti on the project *A bound on the short-wavelength extrapolation of the dark matter power spectrum*, that led to the publication of the paper entitled *Extragalactic gamma-ray signal from dark matter annihilation: an appraisal* [2]. Since

2013, he is a Ph.D. student at the MIT, where till 2015 he studied non–geometric theories of gravity; he is now working on computational neuroscience.

Juan Carlos De Haro Santos

In December of 2012, Juan Carlos (23y) was an undergraduate student at the University of Guanajuato, working on his B.Sc. thesis under the supervision of David Delepine. During his stay at the JLab, in the summer of 2013, he developed the project *Noether's theorem for dynamical symmetries*, supervised by José Goity. After defending successfully his M.Sc. thesis *Commissioning of CUORE Fast Cooling System* in 2016, he does now a Ph.D. at the U. Guanajuato, supervised by D. Delepine. He works on CP violation in mesons.



Mariana Carrillo González

In January of 2014, Mariana (22y) was an undergraduate student at the University of Morelos, working on her B.Sc. thesis, advised by Gabriel Germán. During her stay at the JLab, in the summer of 2014, she was supervised by José Goity on the project *Spin-flavor symmetry for large N baryons in a boosted frame*. After completing her M.Sc. at the Perimeter Institute in 2015, she became a Ph.D. student at the University of Pennsylvania under the supervision of Mark Trodden.

She works on particle cosmology and has published five papers.

Diego Vidal Cruz Prieto

In January of 2014, Diego (23y) was an undergraduate student at the UNAM, working on his B.Sc. thesis under the supervision of David Vergara. During his stay at the ICTP, in the summer of 2014, he worked on *D-brane action corrections through S matrix computations at disk level*, under the direction of Hesam Hatefi. In 2015, he started his M.Sc. studies at UNAM, supervised by D. Vergara.



Ricardo Espíndola Romero

In December of 2014, Ricardo (22y) was an undergraduate student at the UNAM, working on his B.Sc. thesis under the direction of Antonio García Zenteno. During his stay at the ICTP, in the summer of 2015, he was supervised by Leopoldo Pando Zayas and worked on *Localization in Field Theory and Matrix Models*. He is now an M.Sc. student at UNAM, working on field-theoretical aspects of the AdS/CFT correspondence with his B.Sc. advisor. He is co-author of a paper.

Marco Antonio Carrillo Bernal

In December of 2015, Marco (22y) was an undergraduate student at the University of Veracruz, working on his B.Sc. thesis with the advise of Carlos Vargas and Genaro Toledo. He had already co-authored three papers on different topics. During his stay at the JLab, in the summer of 2016, he worked on the project *Extracting the chiral anomaly from $\gamma\pi \rightarrow \pi\pi$ through lattice QCD*, under the direction of Raúl A. Briceño. In autumn 2016, he shall start his M.Sc. studies at UNAM, supervised by Wolfgang Bietenholz, specializing on the topics he developed at JLab.





Uriel Adrián Luviano Valenzuela

In December of 2015, Uriel (21y) was a 7th semester B.Sc. student at the UNAM. During his stay at the ICTP, in the summer of 2016, he was supervised by Luis Aparicio and Fernando Quevedo, who guided him in his research on α' corrections to supersymmetry breaking in type IIB string compactifications. He shall conclude his B.Sc. studies by the winter of 2016.

4. Outlook

The *Theoretical–research summer on high energy physics* program has identified gifted undergraduate students and ignited their development as future experts on theoretical high energy physics. However, there are various challenges that must be tackled in order to reach the final goal of our program. One of them is the possibility to offer scholarships at other prestigious institutions, such as FermiLab, DESY and IPMU. Discussions between the organizing committee of this program and the administration of those institutions are conducted and could well lead to enlarge the current program in few years.

Further, even though this program has achieved Mexican institutions with few or no experts on high energy physics, it is clear that the contest by itself cannot influence much the training process of future experts on theoretical high energy physics at those places. Perhaps, a coordination with other programs, such as the yearly *Escuela en física fundamental*, could facilitate the success of the candidates from those institutions.

Finally, the *Theoretical–research summer on high energy physics* program has welcome several talented students from large and small universities across the country, who unfortunately could not be awarded by the program. Besides, there are great institutions in Mexico with specialists on high energy physics, who could well host the brilliant students in similar nationwide research stays, to perform research of international quality. With this purpose and with the aid of this program, suitable candidates and institutions shall be identified and supported to achieve their common scientific goals.

A new generation of talented Mexican experts on theoretical high energy physics is in development. At this stage, it is not possible to know the achievements that they could bring, but we are confident that their effort and a proper guidance can let them reach the greatest of all purposes in physics: a better understanding of laws of Nature. Hopefully, this program contributes to fulfill this aim.

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