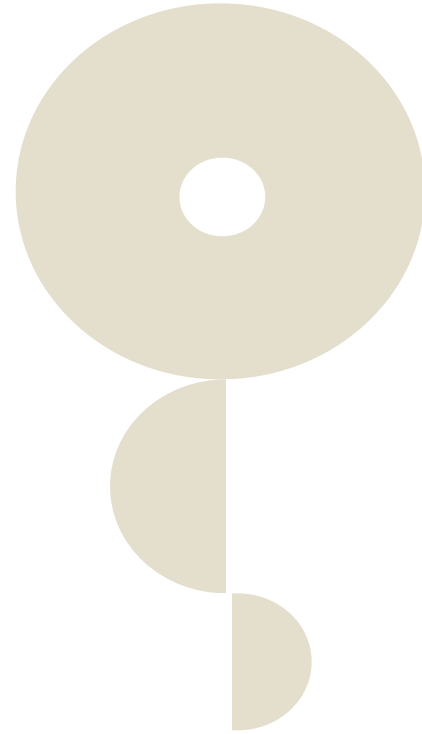




Instituto de Física Teórica (IFT)
Institute for Theoretical Physics
<http://www.ift.uam-csic.es>



IFT Report of Activities

2015



The Instituto de Física Teórica (IFT) is a joint research center belonging to the Spanish National Research Council (CSIC) and the Autonomous University of Madrid (UAM). The IFT UAM-CSIC began operation in 1996, but was not officially established until 2003. It is the only Spanish center dedicated entirely to Theoretical Physics. The IFT members develop research of excellence in the frontiers of Elementary Particle Physics, Astroparticle Physics and Cosmology, in order to understand the fundamental keys of Nature and the Universe. They are also leading many research projects, both at the national and international level. The IFT is part of the strategic line "Theoretical Physics and Mathematics" of the Campus of International Excellence (CEI) UAM+CSIC. Besides purely scientific activity, in the IFT is also conducted intensive training tasks of young researchers and professionals through the graduate program in Theoretical Physics with mention of excellence from the CEI and the Ministry, as well as knowledge transfer to the society through several outreach programs. Since 2012, the IFT is a Severo Ochoa Center of Excellence.

The functioning of the IFT is regulated by its Statutes. The main management boards are:

- The **Director** (Carlos Muñoz until September 3rd 2015, Angel Uranga afterwards), who is renewed every three years. The Director is assisted in his task by the Institute Board and reports to the Scientific Assembly (see below).

- The **Deputy Director** (Margarita García until September 3rd 2015, Luis Ibáñez afterwards) assists the Director in the operation of the Institute and substitutes the Director when necessary.

- The **Institute Board (Junta)** is in charge of the day-to-day operation of the Institute. It consists of the Director, Vicedirector and four members: Chairmen of the Theory departments (Ángel Uranga until September 3rd 2015, José L.F. Barbón afterwards) and Phenomenology and Cosmology department (Juan García-Bellido) and two Representatives of the personnel (Jesus Moreno and Karl Landsteiner).

- The **Scientific Assembly (Claustro)** formed by all members with a permanent of junior staff (5 or more years) positions. The Director chairs the Assembly.

-The **Scientific Advisory Committee** formed by highly reputed scientists that advise the Director and the Institute Board on the progress of the Institute. The latter inform the Assembly about the recommendations given by the Advisory Committee. Current members of the Committee are:

- *Luis Alvarez-Gaumé (CERN),
- *Daniel Amati (SISSA & INFN/Trieste),
- *Sheldon L. Glashow (Boston University),
- *Luciano Maiani (Univ. Roma La Sapienza & INFN)
- *Miguel A. Virasoro (Univ. Roma La Sapienza)

To ensure a proper operation of the Severo Ochoa Program of Excellence obtained in 2012, a Steering Committee of the program was formed. This is constituted by the Scientific Director, Luis Ibañez, the members of the Institute Board, and the Director of the Department of Theoretical Physics UAM (also IFT member) due to the strong scientific and institutional links between the IFT and the department. An Advisory Committee was also formed to advise about the progress of the program. It is constituted by the following reputed scientists:

- *Fernando Quevedo, Director of the ICTP, Trieste
- *Savas Dimopoulos, Stanford University
- *Geneviève Belanger, LAPTh, Annecy
- *Ignacio Cirac, Director, Max-Planck-Institut für Quantenoptik
- *Fabiola Gianotti, ATLAS Spokesperson, CERN
- *Blas Cabrera, CDMS Spokesperson, Stanford University

Several committees to handle several matters are also necessary for the running of the Institute. These include:

- **Cluster Administration.** This committee is responsible of all the duties necessary to administer the IFT HPC clusters. This includes system administration, allocation of resources to users, management of the queue system, software installation, back-ups, handling hardware and software incidences, cluster webpage administration, monitorization of use, etc. The chairman of the committee is Carlos Pena. For more information visit the webpage <http://www.ift.uam-csic.es/node/4633>

- **Outreach.** This committee is responsible of transmitting our knowledge, organizing activities addressed to general public and also to high-school students and teachers or undergraduate students. They include: formation courses, public talks, participation in media, publication of books, etc. Members of this committee are Ángel Uranga, José L.F. Barbón, Alberto Casas and Germán Sierra, with the administrative responsible Susana Hernández.

- **Postdoctoral Positions.** This committee is in charge of the organization of all activities related to the recruitment of postdoctoral scientists. In particular, this includes advertising openings at the most important international boards in the field, handling the relevant data to select the most adequate candidates, and organizing and chairing the meetings where decisions are taken. Currently, Jesus Moreno, Ángel Uranga, Juan García-Bellido and Belén Paredes are the members of this committee.

- **Postgraduate Studies.** This committee is responsible of running, in collaboration with the Department of Theoretical Physics UAM, the Master Program in Theoretical Physics. It is also in charge of the organization of all activities related to the recruitment of Master and Ph.D. students. In particular, this includes advertising openings at the most important international boards in the field, handling the relevant data to select the most adequate candidates, and organizing and chairing the meetings where decisions are taken. Members of this committee are Carlos Pena, María José Herrero, Jesus Moreno and Esperanza López.

- **Workshops and Programs.** This committee is in charge of the activities related to the organization of specialized workshops on the topics of our research program, and of scientific long-term programs. In particular, this includes handling the proposals from IFT members and external researchers, select the best ones, and organizing and chairing the meetings where decisions are taken. José L. F. Barbón and Juan García-Bellido are the members of this committee.

- **Seminars and Colloquia.** This committee is in charge of planning the program of seminars and organization of IFT colloquia. This task includes that of selecting topics and speakers according to scientific interest and timeliness, and taking into account the suggestions made by the research groups of the institute. It is chaired by José L. F. Barbón, other members being Sven Heinemeyer, Esperanza López and Michele Maltoni,

- **Scientific Reports.** This committee is responsible for carrying out the institute's scientific reports, such as the biannual Activity Report, the preparation of the Action Plan, etc. The chairman of this committee is Karl Landsteiner.

- **Library.** This committee is responsible for the purchase of specialized and text books for the library, which are necessary for the development of research and for postgraduate classes, respectively. Enrique Álvarez and Jose Luis Fernández Barbón are the members of this committee.

Finally, we would like to remark that all previous committees are run by scientists (permanent and RyC members) that put their efforts into helping in the organization of the Institute. More detailed information can be obtained by visiting our webpage <http://www.ift.uam-csic.es>

Currently, December 2015, the scientific staff of the IFT consists of 20 permanent members, 1 Professor UAM-CEI, 6 Ramón y Cajal (RyC) tenure tracks, 24 postdocs, and 46 Ph.D. students, i.e. a total number of about 97 researchers, where 43% are foreigners.

The scientific staff at the IFT is composed of internationally renowned experts in Theoretical Physics, leading international research projects, and participating in international advisory committees. For instance, Belén Gavela belongs to the CERN Scientific Policy, Luis Ibáñez belongs to the Europea Committee for Future Accelerators (ECFA) and the High Energy Board of the European Physics Society, and Alfredo Poves is member of the Academy of Europe. The IFT staff includes four editors of the Journal of High Energy Physics, the most prestigious in the field; no other institute in Europe gathers this number of JHEP Editors.

The scientists at the IFT are:

- Permanent:

Enrique Álvarez, José L. F. Barbón, Alberto Casas, Margarita García Pérez, Juan García-Bellido, Belén Gavela, César Gómez, Antonio González-Arroyo, María José Herrero, Luis Ibáñez, Karl Landsteiner, Esperanza López, Michele Maltoni, Carlos Muñoz, Tomás Ortín, Carlos Pena, Alfredo Poves, Agustín Sabio, Germán Sierra, Ángel Uranga.

- Ramón y Cajal, or CEI:

Enrique Fernández, Gregorio Herdoíza, Fernando Marchesano, Vicent Mateu, Savvas Nesseris, Belén Paredes, Francisco Prada

- Long-term visitors (*residencia eventual*):

Isabel Campos, Sven Heinemeyer

- Postdocs:

Paolo Benincasa, Francesco Caporale, Grigorios Chachamis, Johan Comparat, Valentina De Romeri, Florian Domingo, Patrick Fritsch, Hirotaka Hayashi, Jong Soo Kim, Yan Liu, Pedro Machado, Elisabetta Majerotto, Luca

Merlo, Viviana Niro, Francisco Pedro, Miguel Peiró, Krzysztof Rolbiecki, Alberto Salvio, Juan José Sanz Cillero, Wieland Staessens, Yawn Sun, Marco Taoso, Cedric Weiland, Clemens Wieck

- PhD. students:

Franco Albareti, Santiago Ávila, Thomas Biekötter, Sjoerd Bielleman, Ilaria Brivio, Pablo Cano, Federico Carta, Emilia da Silva, Rocío del Rey, Dagoberto Escobar, José María Ezquiaga, Ginevra Favole, Pedro Fernández, Carlos García, Eduardo García-Valdecasas, Laura Gil, Sergio González, David Gordo, Josu Hernández, Mario Herrero, Essodjolo Kpatcha, Aitor Landete, Iñaki Lara, Oscar Lasso, Xabier Marcano, Javier Martín, Víctor Martín, Iván Martínez, Miguel Montero, Sebastián Montes, Nicolo Piazzalunga, David Preti, Pablo Quílez, Javier Quilis, Giovanni Ramírez, Ander Retolaza, Sandra Robles, Sergio Rodríguez, Jose Ángel Romero, Sara Saa, Ana Salvador, Sebastian Schwieger, Doris Stoppacher, Francisco Torrentí, Manuel Trashorras, Gianluca Zoccarato.

The administrative and technical staff of the IFT is the following. The Administration Service has four staff members: the Head of the Service (Isabel Pérez) and several Assistants (Sonica Campos, Mónica Encinas, María Hortal, Tiina Timonen, Mónica Vergel). The Communication and Outreach Service has one staff member (Susana Hernández). The Computing and Information Technology (CIT) Service has three staff members, the Head (Andrés Díaz-Gil) and two technicians (Marcos Ramírez and Emilio Ambite).

The management team (gerencia) is shared between the two institutes, IFT and ICMAT, constituting the CFTMAT service center.

The IFT is structured for scientific organization purposes into two departments: "Theory" and "Phenomenology and Cosmology". The first one includes the researchers working in formal or mathematical aspects of our field (Particle Physics and Cosmology) and has 11 permanent staff members, while the second includes the researchers more directly related with experimental or observational data and has 9 permanent staff members. [These departments include a small but very active group working in Quantum Information (1 staff member plus 1 RyC and PhD students), and another in Nuclear Physics (1 staff member plus PhD students)].

There are four research lines, with sub-lines, all of which have experienced a sustained development during the last years. They are:

-Quantum Fields, Gravity and Strings:

- 1-Holography, strings and applications of the AdS/CFT correspondence
- 2-Gravitation
- 3-String phenomenology
- 4-Lattice field theory

-The Origin of Mass:

- 1-Higgs physics, beyond the standard model physics and LHC
- 2-Flavour and neutrino physics.

-The Origin and Composition of the Universe:

- 1-Early universe cosmology
- 2-Dark energy
- 3-Astroparticle physics and dark matter.

-Theoretical Condensed Matter and Quantum Information.

During 2015 the IFT continued experiencing a qualitative jump in many of the aspects related to our Severo Ochoa Grant, enhancing its status as institute of international excellence. We organized about a dozen specialized programs, workshop and schools attended by several hundred scientists. We published 175 papers collecting several thousand citations.

Among our main achievements, organized according to research line, we list:

Quantum Fields, Gravity and Strings:

- The explicit computations showing the existence of delayed thermalization processes in holographic systems.
- The discovery of the existence of infrared hair in the corpuscular model of quantum black holes.
- The first application of the duality between quantum complexity and volume in holographic models of comological singularities.
- The publication of the second edition of the book “Gravity and Strings” by Tomás Ortín, with Cambridge University Press.
- The explicit construction of axion monodromy inflation models, in particular those involving the Higgs field as inflaton candidate, and study of their interplay with the LHC results.

The Origin of Mass:

- Detailed study of the instability of the Higgs field potential in the SM, its possible microscopic origin and implications for new physics.
- The analysis of possible signals in the LHC of the new supersymmetric model proposed by the group, the so-called $\mu\nu$ SSM, in particular nonstandard on-shell decays of W and Z bosons.
- General study of the effective action of a light Higgs from operator analysis, and its applications to the search of new physics.

- Production and extensive application of a new code CheckMate for testing new physics models from LHC data.

- Complete study of leptonic CP-violation from present neutrino data, and description of implications for future observables.

The Origin and Composition of the Universe:

- The exquisite precision of Planck measurements allowed the determination of the cosmological parameters of the Standard Model of Cosmology with few permil precision.

- The discovery with the Dark Energy Survey of 18 new dwarf faint galaxies which goes in the direction of resolving the long standing substructure problem of Cold Dark Matter.

- The proposal that Dark Matter is made of primordial black holes, which could also act as seeds for galaxies at high redshifts.

- First light of the Physics of the Accelerated Universe Camera (PAUCam), a state of the art Camera to measure the acceleration of the universe with 42 narrow band filters, built exclusively by a Spanish group (ICE, IFAE, CIEMAT, PIC and IFT) and set in the focal plane of the William Herschel Telescope in La Palma.

- A stochastic background of Gravitational Waves with a characteristic spectrum could be the signature for the violent conversion of energy into radiation and matter at the Big Bang. If the Higgs field is present during inflation, it could have specific signatures in the spectrum.

- The IFT has been member during this period of the SuperCDMS collaboration for direct DM searches, contributing to the data taking and analysis. Several WIMP searches from the CDMS II and second CDMSlite run have been published.

- Members of the IFT continued with their participation in the BOSS collaboration and the DESI project for the search of dark energy. In October, DESI CD-2 has been approved.

Theoretical Condensed Matter and Quantum Information:

- The first experimental observation of a Weyl fermion semimetal in a single crystal material of tantalum arsenide (TaAs) confirmed a theoretical prediction by the IFT group, done in 2014.

- Application of ultra-cold atoms in optical lattices to study many body phenomena, appearance of collective phenomena and new phases of strongly coupled systems.

SEV-2012-0249, ACREDITACIÓN CENTRO DE EXCELENCIA SEVERO OCHOA, MINECO, IP: Luis Ibáñez, 4.000.000 euros, 2013-2017

ERC-2012-ADG-20120216, String Phenomenology in the LHC Era, European Union, IP: Luis Ibáñez, 1.496.000 euros, 2013-2017

EU120353_01 - FP7-ERC-2013-ADG - 010168, UV- Completion through Bose-Einstein Condensation: A Quantum Model of Black Holes, European Union, IP: César Gómez, 304.825,20 euros, 2014-2019

PITN-GA-2011-289442, Invisibles, European Union, IP (Coordinator): Belén Gavela, 3.823.903 euros, 2012-2016

CSD2009-00064, Multimessenger Approach for Dark Matter Detection, MICINN, IP: Carlos Muñoz, 3.200.000,00 euros, 2009-2015

FPA2012-31880, Física de partículas elementales, MINECO, IP: Enrique Álvarez, 347.490,00 euros, 2013-2015

FPA2012-32828, Teoría de campos y cuerdas: teoría y fenomenología en la frontera de la física de partículas, MINECO, IP: Ángel Uranga, 314.730,00 euros, 2013-2015

FPA2012-31686, Dinámica de acoplo fuerte en la frontera de la física de partículas, MINECO, IP: Margarita García Pérez, 127.530,00 euros, 2013-2015

FPA2012-34694, Astropartículas en el universo, MINECO, IP: Carlos Muñoz, 121.680,00 euros, 2013-2016

FPA2012-35043-C02-01, Gravedad, supergravedad y supercuerdas, MINECO, IP: Tomás Ortín, 97.110 euros, 2013-15

FPA2013-44773-P, Fenomenología más allá del Modelo Estándar e implicaciones, MINECO, IP: Jesús Moreno, 72.000,00 euros, 2014-2016

FIS2012-33642, Materia cuántica topológica: en la frontera entre materia condensada, óptica cuántica e información cuántica, MINECO, IP: Belén Paredes, 98.280,00 euros, 2013-2015

FPA2013-47986-C03-03, Física Fundamental y Cosmología con Cartografiados Extagalácticos, MINECO, IP: Juan García-Bellido, 72.600,00 euros, 2014-2016

AYA2014-60641-C2-1-P, Descubriendo el lado oscuro del universo con los grandes cartografiados espectroscópicos, MINECO, IP: Francisco Prada, 90.750 euros, 2015

PCIG10-GA-2011-304023 FUSS, European Union, IP: Fernando Marchesano, 87.500,00 euros, 2012-2015

FP7-PEOPLE-2011-IRSES-295234, European Union, IP: Germán Sierra, 28.600 euros, 2012-2016

INTERNATIONAL AGREEMENTS

We have continued weaving our international collaboration network, both at the level of individual researchers, and at the institutional level through the signature of agreements with leading institutions world-wide.

In particular in 2015 the IFT has signed an agreement with

- SISSA (Trieste)
- ICTP-SAFIR South American Inst. For Theoretical Physics.

These add up with similar agreements signed in earlier years with ICTP-Abdus Salam (Trieste) and Kavli Inst. for Theoretical Physics (Beijing).

The IFT has continued supporting a strong strategy of organization of international conferences, workshops and programs (extended workshops), increasing its international visibility and fostering the collaboration with visitors from top research institutions worldwide. The list of such activities in 2015, which have attracted over 1.000 visitors, is:

Programs:

- Identification of Dark Matter with a cross-disciplinary approach 27 April - 15 May 2015 (47 participants) <https://workshops.ift.uam-csic.es/IDMCDA>
- eNLarge Horizons
18 May - 5 June 2015 (77 participants) <https://workshops.ift.uam-csic.es/NLHIFT>

Workshops and International Conferences:

- Entangle this: Spacetime and matter, 2-4 March 2015 (57 participants)
<https://workshops.ift.uam-csic.es/entanglethat>
- LHC Working Group on Forward Physics and Diffraction 21-25 April 2015 (32 participants) <https://workshops.ift.uam-csic.es/LHCFPWG2015>
- String Phenomenology 2015, 8-12 June 2015 (130 participants)
<https://workshops.ift.uam-csic.es/stringpheno15>
- Invisibles '15 Workshop, 27th June 2015 (179 participants)
<http://indico.cern.ch/event/351600/>
- SDSS-IV Collaboration Meeting, 20-23 July 2015 (157 participants),
<https://workshops.ift.uam-csic.es/sdss4madrid>
- Dark Energy Survey Collaboration Meeting, 5-9 October 2015 (140 participants),
<https://workshops.ift.uam-csic.es/desmeetingmadrid>
- Windows on Quantum Gravity, 28-30 October 2015 (47 participants)
<https://indico.cern.ch/event/373935/>
- IV Postgraduate Meeting on Theoretical Physics, 18-20 November 2015, (73 participants)
<http://www.ift.uam-csic.es/es/events/iv-postgraduate-meeting-theoretical-physics>

- IBS-MultiDark Joint Workshop on Dark Matter and 13th MultiDark Consolider Workshop, 23-28 November 2015, (87 participants)

<http://www.ift.uam-csic.es/es/events/ibs-multidark-joint-workshop-dark-matter-and-13th-multidark-consolider-workshop>

- XXI Christmas Workshop, 9th-11th December 2015,

<http://www.ift.uam-csic.es/es/events/xxi-christmas-workshop>

Schools:

- Invisibles '15 School, 15th - 19th June 2015 (84 participants)

<http://indico.cern.ch/event/341178/>

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A characteristic tract of leading research centres is the existence of a program of seminars and visits. Our activity has been and continues to be very high in this aspect, as demonstrated by the list that we will present. We underline that two thirds of the total number of visitors belong to foreign institutes and research centres.

Within the framework of the Severo Ochoa grant, we established the ‘Distinguished Visiting Professors’ program which have been allocated and used by renowned scientists: L. Maiani, L. Randall, I. Cirac, A. Linde, R. Kallosh, V. Mukhanov, etc. We received around almost 200 regular visitors, and several visits within the ‘Associate Researchers’ program which includes high-level physicists like J. Vermaseren, G. Shiu, D. Ross, S. Pascoli, M. Okawa, J.R. Espinosa, etc.

Distinguished Professor visits 2015:

Ignacio Cirac (6/3/15), Alexei Smirnov (8-23/4/15), Dmitri Kharzeev (12-26/5/15), Andrei Linde (6-17/6/15), Renata Kallosh (6-17/6/15), Lisa Randall (23-29/6/15), Herbert Neuberger (11/5/15-11/6/15)

Associate Researcher visits 2015:

Gerardo Aldazábal (1/6/15-2/7/15), Mattias Blennow (22/6/15-22/7/15), Maxim Chernodub (4-7/5/15 and 12-18/7/15), Antonio Delgado (7-9/1/15 and 6-10/4/15 and 1-3/7/15), Anamaria Font (2-14/6/15), José M. Gracia Bondía (20/4/15-16/6/15), Sven Heinemeyer (18/2/15 and 25/2/15 and 23-24/6/15 and 22-25/9/15 and 15/10/15-15/1/16), Pilar Hernandez (7-10/4/15), Alejandro Ibarra (28-30/1/15), Patrick Meessen, Olga Mena (5-7/5/15), Frederic Nowacki (15-25/2/15), Masanori Okawa (27/5/15-7/6/15 and 16-30/9/15), Silvia Pascoli (9-11/3/15 and 5-13/9/15 and 21-28/11/15), Mariano Quirós (2-16/5/15), Douglas Ross (16/3/15-1/4/15 and 6-18/9/15), Miguel Angel Vázquez Mozo (6/2/15-6/3/15), Jos Vermaseren (29/4/15-1/6/15).

Other visitors:

J.A. Aguilar (8-11/9/15), D. Alonso (10-15/9/15), F. Alcaraz (1-25/7/15), J. Alfaro (31/8/15-2/9/15), M. Asorey (2-3/7/15), M. Ata (28/7/15-4/8/15), G. Ballesteros (19/1/15-20/3/15), I. Bandos (14-17/1/15), C. Bauer (27/11/15-4/12/15), I. Bena (10/5/15), V. Berezin (11-14/5/15), E. Bergshoeff (10-14/5/15), J. Bergstrom (6-12/2/15), A. Bernevig (16-20/8/15), J. Betancort (16-26/11/15), A. Bondel (2/9/15), M.E. Cabrera (20/5/15-9/7/15), I. Campos (24-26/2/15 and 22-25/9/15 and 5/10/15-), S. Caron-Huot (9-13/11/15), A. Casatela (1/2/15-30/4/15), F.G. Celiberto (28/9/15-27/2/16), D. Correa (9-26/6/15), D. Croton (21/9/15), L. del Debbio (17-18/12/15), N. Desai (8-10/9/15), V. Domcke (25/5/15), F. Domingo (27/10/15-31/12/15), J. Dukelsky (3/7/15), J. Edelstein (15-18/1/15), M. Escudero (5/7/15), D. Espriu (17-18/12/15), J. Farrow (6/7/15-31/8/15),

A. Fernández Soto (16/12/15), F. Ferreira (4-13/12/15), D. Figueroa (18-23/12/15), M. Fornasa (15-28/11/15), J. Furtado Valle (25-27/11/15), M. García (4-8/5/15), M.P. García del Moral (21-25/9/15), G. Gómez Santos (3/7/15), S. Gottloeber (21/9/15), A. Guarino (8-12/6/15), Z. HaiQing (8-11/11/15), B. Herwerth (18-24/10/15), H. Horch (8-12/15), C. Hoyos (6-10/4/15), E. Jenkins (30/9/15-31/10/15 and 11/11/15-12/12/15), R. Jiménez (20-22/1/15), M. Kaminski (12-15/7/15), Z. Komargodski (25-28/11/15), A. Kronefeld (22-15/11/15), D. López Fogliani (31/8/15-21/9/15), F. Lacasa (5-9/10/15), J. López Pavón (9-14/1/15 and 18-29/5/15), M. Lucente (2-6/2/15), Y.-Z. Ma (9-12/9/15), J.D. Madrigal (25/10/15-5/11/15), A. Manohar (30/9/15-31/10/15 and 11/11/15-12/12/15), C. Manuel (25/5/15), A. Marrani (13-19/4/15), O. Mattelaer (6-10/9/15), D. Mayani (5-6/2/15), E. Megías (13/9/15-4/10/15), K. Mimasu (26-30/1/15), M. Minakata (6/5/15-5/6/15), J. Molina (14-16/12/15), R. Morales (18-19/11/15), M. Morudo Prado (1/6/15), F. Muia (2/6/15-22/7/15), B. Murdaca (8/1/15-26/2/15 and 21/4/15-20/5/15), G. Murray (13-17/9/15), S. Nampuri (26-30/1/15), J.M. No (26-30/1/15), S. Patiri (15/11/15-4/12/15), R. Pérez Marco (10-30/9/15), S. Pilipenko (15-29/11/15), A. Ramos (6-7/7/15), F. Riccioni (10-16/5/15), J. del Río (27-28/10/15 and 25/11/15), V. de Romeri (2-6/2/15), J. Sánchez (13-17/9/15), I. Sachs (22-25/2/15), M.A. Sánchez-Conde (19-22/4/15 and 17-19/5/15 and 14-18/12/15), V. Sanz (26-30/1/15), J.-F. Schaff (12/11/15), C. Shabhazi (4-12/3/15 and 18-29/5/15), I. Shapiro (23-27/2/15), P. Soler (8-26/6/15), D.T. Son (29/6/15), K. Sousa (18-21/1/15), C. Steinwachs (28/10/15-3/11/15), V. Swasti (15-20/3/15), M. Taoso (28/10/15-23/12/15), M. Tytgat (14-17/11/15), R. Valandro (16-27/3/15), D. Valls (3-5/2/15), E. Vernier (27-30/1/15), J. Virto (19-20/2/15), M.A. Vozmediano (29/6/15), C. Wieck (31/5/15-12/6/15), Q. Yang (23/11/15-7/12/15), M. Zumalacárregui (7-9/1/15 and 22/5/15-1/6/15),

We also established two special collaborations with IFT alumni in two strategic areas, supported by visits of the relevant researchers.

- Dark Matter Lab:

The purpose of the Dark Matter Lab is to sustain the interaction of the IFT with the CDMS collaboration through collaboration and visits of the researcher David G. Cerdeño, Ramón y Cajal researcher at the IFT in 2001-2014, and now staff member at the Institute for Particle Physics Phenomenology at Durham Univ. UK. (Visit dates 26/3/15-12/4/15, plus participation in the MultiDark workshops in November).

- Quantum Information Lab:

The purpose of the Quantum Information Lab is to sustain the interaction of the IFT group on Theoretical Condensed Matter and Quantum Information group with the researcher Belén Paredes, Ramón y Cajal researcher at the IFT from 2012 until May 2015, and at present at the Max Planck Institute in Munich. This provides an important support for an emerging strategic line at the IFT, and bridges several collaborative lines with Prof. I. Cirac. (IFT Severo Ochoa Distinguished Professor) (Visit by B. Paredes, 1-30/9/15).

The IFT sustains an stimulating scientific atmosphere through the organization of weekly seminars and discussion sessions, as well as occasional colloquia by world-experts in Theoretical Physics, or even in other fields of Science. The programme in 2015 included:

Colloquia:

- I. Cirac “Quantum Simulations”, March 6th, 2015
- A. Casas and L. Labarga “Neutrino oscillations, a Nobel prize winning discovery”, organized jointly with the Department of Theoretical Physics, UAM, December 16th, 2015

Journal Clubs:

- SPLE Club: For researchers interested in aspects of String Phenomenology. Every two Tuesdays at 11,30h
- Holoclub: For researchers interested in aspects of Holography in String Theory. Every two Tuesdays at 11,30h
- PhenoCoffee Club: For researchers interested in particle physics phenomenology beyond the Standard Model, and Dark Matter. Every Friday at 11,30h.
- PhD Forum: Organized by PhD students to explain each other their current research projects.

Webinars:

Online seminars on topics related to the ITN “Invisibles”:

- “Neutrino masses from cosmological intergalactic data”, M. Viel, Jan. 27th, 2015
- “Higgs inflation as a mirage”, J.L.F. Barbón, February 10th 2015
- “Robust collider limits on heavy-mediator dark matter”, A. Wulzer, Feb. 24th 2015
- “Dibosons at the LHC: symmetry restored?”, J. Kopp, November 24th

Seminars:

- “Causality Constraints on Corrections to the Graviton Three-Point Coupling”, J. Edelstein, January 15th, 2015
- “Perturbative Stability along the Supersymmetric Directions of the Landscape”, K. Sousa, January 19th 2015
- “Life in the Universe”, R. Jiménez, January 22nd 2015

- “Inflation in the Time of Mixing Axions”, W. Staessens, January 26th 2015
- “Hot Attractors”, S. Nampuri, January 29th 2015
- “Just enough inflation: power spectrum modifications at large scales”, F. Pedro, February 2nd 2015
- “CERN: the next 60 years and 100 kilometers”, A. Blondel, February 9th 2015
- “Flavoured Conspiracies and Conundrums”, J. Virto, February 20th 2015
- “The running coupling and B-physics from lattice QCD computations”, P. Fritsch, February 23rd 2015
- “Renormalization and stability in higher derivative models of quantum gravity”, I. Shapiro, February 26th 2015
- “Let us talk about particle physics phenomenology”, G. Chachamis, March 2nd 2015
- “Can universality be extended to Potts antiferromagnets?”, J. Salas, March 12th 2015
- “TBA”, V. Niro, March 9th 2015
- “TBA”, M. Pietroni, March 23rd 2015
- “TBA”, A. Smirnov, April 16th 2015
- “Spherically symmetric conformal gravity and "gravitational bubbles", M. Berezin, May 11th 2015
- “TBA”, T. Minakata, May 18th 2015
- “TBA”, V. Domcke, May 25th 2015
- “Is the composite fermion a Dirac particle?”, D.T. Son, June 30th 2015
- “Anomalous hydrodynamics kicks neutron stars”, M. Kaminski, July 13th 2015
- “Delta Gravity, Dark Energy and the accelerated expansion of the Universe”, J. Alfaro, September 1st 2015
- “Where are baryons in the Universe?”, Y.-Z. Ma, September 10th 2015
- “Ultra-large-scale cosmology with future surveys”, D. Alonso, September 14th 2015
- “Correlated worldline theory of quantum gravity: low-energy consequences & table-top tests”, P.C.E. Stamp, September 22nd 2015
- “Lifshitz dynamics in the UV”, M. Herrero, October 1st 2015
- “The Standard Model EFT and Dimension 6 operators”, A. Manohar, October 15th 2015
- “Inflation and moduli backreaction in string-effective supergravities”, C. Wieck, October 19th 2015
- “Gravitational perturbations of the Higgs field”, A. Maroto, October 26th, 2015
- “Towards a realistic astrophysical interpretation of the Galactic center excess”, M. Taoso, October 29th 2015
- “High Energy Scattering in QCD: Putting Together All the Main Ingredients”, J.D. Madrigal, November 2nd, 2015

- “Vortex in holographic two-band superfluid/superconductor”, H.Q. Zhang, November 10th 2015
- “Beyond unitarity: new on-shell representations for loop amplitudes”, S. Caron-Huot, November 12th 2015
- “Signatures of scalar dark matter”, M. Tytgat, November 16th 2015
- “Phenomenology of semileptonic B -meson decays with form factors from lattice QCD”, A. Kronfeld, November 23rd 2015
- “Comments on Disordered Conformal Field Theories”, Z. Komargodski, November 26th 2015
- “GENEVA: an NNLO / NNLL event generator”, C. Bauer, December 3rd 2015
- “Searching for P-odd effects in heavy ion collisions”, D. Espriu, December 17th 2015.

The IFT runs an English-taught one-year 60 ECTS M.Sc. degree that aims at providing a solid foundation for prospective PhD students in theoretical physics, as well as valuable skills for other careers. The program has obtained several excellence awards from the Spanish Ministry of Education and from the Campus of International Excellence UAM +CSIC. It has been ranked among the top Excellence Groups in Physics by the Centre for Higher Education Development (CHE).

The number of M.Sc. students per academic year is about 30, a large fraction of them being foreigners, either European or overseas. We also have around 5 European Erasmus students each year which attend some of the lectures. With the SO program, we have co-financed the organization of the UAM PhD Program in Theoretical Physics, offering predoctoral positions, together with courses on advanced research topics in Particle Physics and Cosmology to the students enrolled in the program. Most of our PhD students obtain postdoctoral positions in the international postdoc market. In this sense, we make a strong effort on training young researchers, supervising a substantial number of PhD theses.

PhD Courses 2014-15

2014-15, <http://members.ift.uam-csic.es/cpena/phdcourses.html>

- Lectures on Supersymmetry and Supergravity in Curved Spaces and Superspaces, by I Bando (IKERBASQUE and UPV/EHU, Bilbao), October 2014
- Introduction to Supersymmetry, by D. López-Fogliani (U. Buenos Aires, Argentina), January-February 2015
- Anomalies, by MA Vázquez Mozo (U. Salamanca), February 2015
- Supersymmetry Phenomenology, by S Heinemeyer (IFCA, Santander), Febr.-March 2015
- Introduction to String theory, by A. Uranga (IFT), April 2015
- Calculating Particle Interactions, by J Vermaseren (NIKHEF, Amsterdam), May 2015

PhD Thesis:

- Pablo Bueno Gómez, “Supergravity, black holes and holography”, supervisor: Tomás Ortín, 20th May 2015
- Amadeo Jiménez Alba, “Broken symmetries and transport in holography”, supervisor: Karl Landsteiner, 21st May 2015
- Irene Valenzuela, “The Higgs sector, Susy breaking and inflation in string theory”, supervisor: Luis Ibáñez, 15th June 2015.
- Giovanni Ramírez, “Quantum entanglement in random and inhomogeneous spin chains”, supervisor: Germán Sierra, 3rd July 2015

The IFT carries out the important task of transferring knowledge to society through outreach activities. For more information, see <http://projects.ift.uam-csic.es/outreach>.

Science & Art at the Thyssen Museum:

In collaboration with the Thyssen-Bornemisza Museum (Madrid). Activities included:

- Special exhibition of selected paintings in the context of the connection between art and science "Invisibles-Thyssen".
- Outreach "Art and Science - Invisible World" session, June 24th. Presentations by: Carlos Frenk, Michelangelo Mangano, Álvaro de Rújula and an art expert. Followed by a joint round table.
- Outreach "Art and Science" session June 26th. Presentations by: Antonio Córdoba, Fabiola Gianotti, Mario Livio, Lisa Randall and art expert Linda Henderson. Followed by a joint round table.

<https://indico.cern.ch/event/351600/page/3516-outreach-and-social-activities>

- A. de Rújula in the digital newsletter of the Thyssen Museum

<http://pdigital.museothyssen.org/index.html?revista=139657263&pagina=24849>

- News in “El País”

http://elpais.com/elpais/2015/06/19/ciencia/1434731116_385257.html

Outreach Conferences:

- Conference Day in the occasion of the 100th Anniversary of General Relativity, at CSIC Main Auditorium, 8/5/2015, <https://workshops.ift.uam-csic.es/RG100>

“Relatividad General para principiantes”, J.L.F. Barbón,

<https://www.youtube.com/watch?v=iSiHBK1c-Fg>

“Tests experimentales de la Relatividad General: ¿Tenía razón Einstein 100 años después?”, Carlos F. Sopena, ICE

<https://www.youtube.com/watch?v=XpFRVjOypc4>

“Relatividad general y cosmología”, J. García-Bellido

<https://www.youtube.com/watch?v=AYBrMBPvjls>

“Astrofísica relativista y agujeros negros: observando lo invisible”, A. Alberdi, IAA

https://www.youtube.com/watch?v=jRkF1_Yfzyc

“Relatividad General y Mecánica Cuántica”, E. Álvarez.

<https://www.youtube.com/watch?v=7FoCL-QuLWY>

- Conference “Luz y universo. La luz y el origen de la materia”, by A. Casas at MUNCYT, National Museum of Science and Tehcnoogy, 11 June 2015.

https://www.youtube.com/watch?v=CTrX_JBNEu

- Conference "El papel de la ciencia en la regeneración y el futuro de España", por Tomás Ortín, at the Opening Ceremony for Academic Year 2015-16, Universidad Popular de Palencia.

- Conference “100 años de Cosmología Relativista”, J. García-Bellido, in the Madrid Planetarium, 1/10/2015

- Conference Series on Fundamental Physics at Residencia de Estudiantes CSIC during Madrid Science Week 2015:

El misterioso vacío de la física cuántica y la cosmología, A. González-Arroyo, 5/11/2015

Neutrinos: la luz invisible: M. Maltoni, 5/11/2015

¿Qué sabemos del Big Bang?, E. Álvarez, 6/11/2015

El líquido perfecto al comienzo del universo, K. Landsteiner, 6/11/2015

Las fronteras teóricas del universo, T. Ortín, 12/11/2015

La fuerza de las interacciones fundamentales, G. Herdoíza, 12/11/2015

Desenredando la teoría de cuerdas, A. Uranga, 13/11/2015

LHC más allá del bosón de Higgs, Pablo García-Abia, 13/11/2015

- Conferences at MUNCYT, the National Museum of Science and Technology, during Madrid Science Week 2015:

Los límites del espacio y el tiempo, 100 años después de Einstein, J. L. F. Barbón, 8/11/2015

Los retos de la física de partículas en la nueva etapa del LHC, M. J. Herrero, 15/11/2015

Videos

We actively support the publication of videos for some of the above outreach conferences, at the IFT Youtube channel with a very successful number of views. Our Youtube channel has over 14.000 suscribers and over 250.000 views.

We have started a series of animated videos, in collaboration with the renowned Youtube channel “Quantum Fracture”. The first two have already been made public at the IFT Youtube channel, with an enormous success in the number of views

- “¿Qué es la materia oscura?”, <https://www.youtube.com/watch?v=F86nBOsGr5M>

- “¿Qué son las oscilaciones de neutrinos?”

<https://www.youtube.com/watch?v=MHcoFBV5z8s>

TV, Radio and Newspapers

- Contribution by A. de Rújula to the article “Más allá del bosón de Higgs”, in the newspaper “El Mundo”, 10/2/2015

<http://www.elmundo.es/ciencia/2015/02/10/54d91f21ca4741c14e8b4576.html>

- Contribution by A. Casas to the article “Materia oscura, supersimetría... Esto es lo que buscará el 'nuevo' acelerador LHC”, in the newspaper “El Confidencial”, 7/4/2015

http://www.elconfidencial.com/tecnologia/2015-04-07/lhc-cern-boson-higgs-materia-oscura_754865/

- Article by L. Ibáñez in the journal “Investigación y Ciencia”, foreword to the special number “Grandes físicos y grandes descubrimientos”, April/June 2015.

<http://www.investigacionyciencia.es/revistas/temas/numero/80/grandes-fsicos-y-grandes-descubrimientos-13234>

- The IFT in the TV program “Fábrica de ideas” of Spanish TV channel “La 2”, October 2015 (from minute 14:52 on)

<http://www.rtve.es/alacarta/videos/fabrica-de-ideas/fabrica-ideas-24-10-15/3333296/>

- Article “¿Viajaremos en el tiempo?”, by J.L.F. Barbón in the newspaper “El País”, 23/10/2015

http://elpais.com/elpais/2015/10/21/ciencia/1445427862_876412.html

- Interviewing J.L.F. Barbón in the program “El sol sale por el oeste” in Radio Canal Extremadura, 20/10/2015

<http://www.canalextramadura.es/alacarta/radio/audios/el-sol-sale-por-el-oeste-3h-201015>

- Article “¿Le debemos nuestra existencia a los neutrinos?”, by E. Fernández in the newspaper “El País”, 28/10/2015

http://elpais.com/elpais/2015/10/23/ciencia/1445615891_620511.html

- “La teoría general de la relatividad explicada en dos minutos”, J.L.F. Barbón for the newspaper “El País”, 19/11/2015

http://elpais.com/elpais/2015/11/19/ciencia/1447926957_854635.html

- Contribution by J. García-Bellido in the article “Regreso al futuro: Cómo construir una máquina del tiempo”, in the newspaper “El Mundo”, 23/11/2015.

<http://www.elmundo.es/ciencia/2015/10/20/56253e72ca4741ea628b457c.html>

- Article “¿Qué habían antes del Big Bang?”, by A. Casas, in the newspaper “El País”, 27/11/2015

http://elpais.com/elpais/2015/11/17/ciencia/1447754148_458128.html

- Contribution by J.L.F. Barbón to the article “Por qué ningún reloj, por sofisticado que sea, dará nunca la hora exacta”, in the newspaper “El País”, 12/12/2015

http://elpais.com/elpais/2015/12/10/buenavida/1449774669_498211.html

Activities related to High School Education

Outreach talks:

The IFT has a programme of outreach talks at High Schools in the Madrid area on topics of particle physics, cosmology. In 2015 our researchers delivered over 50 outreach talks. This activity is carried out mostly within the framework of the CPAN collaboration. It is also important to emphasize that it involves several of the younger IFT members, namely PhD students.

Courses for High School Teachers:

- Participation in the course “Introducción a la física de partículas para profesores de ciencias y tecnología”, in collaboration with the High School Teacher Program at CERN by Comunidad de Madrid, March 2015. <http://indico.cern.ch/event/375830/>

- Organization of the course “Física de partículas y cosmología: del Big Bang al bosón de Higgs”, within the framework of the collaboration CSIC - Comunidad de Madrid, April 2015. <https://workshops.ift.uam-csic.es/curso2015>

International Hands-on Particle Physics Masterclasses

This activity lies within the International [Hands on Particle Physics Masterclass](#), which involves 85 institutions worldwide, and is coordinated by the International Particle Physics Outreach Group ([IPPOG](#)). In 2015 we organized two sessions, with some 35 High School students each.

- March 27th 2015, at the IFT

<https://workshops.ift.uam-csic.es/iftw.php/ws/masterclass2015/home>

- November 3rd, 2015, within the Madrid Science Week, at IES Ramiro de Maeztu

4º ESO + empresa

A group of students from High Schools in the Madrid area spent three days of experience at the IFT, 24-26 March 2015

- Guided visits of IFT premises

In collaboration with “Centro de Intercambios Escolares” we organized two guided visits for High School students in exchange programmes.

- March 20th 2015: 20 High School students from Indiana, USA.

- June 9th 2015: 39 High School students from the Instituto Juan Ramón Jiménez, Rabat

Other activities

We also participated in the general outreach programs of our host institutions, UAM and CSIC, with activities in events like "La noche de los investigadores", and have had additional collaborations with other institutions.

