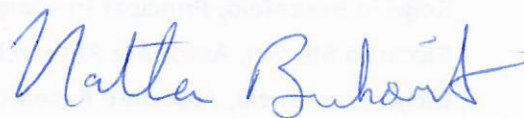


ICTP Instituto Sul-Americano para Pesquisa
Fundamental: um Centro Regional para Física
Teórica



Project Coordinator: Nathan Jacob Berkovits

Host Institution: Instituto de Física Teórica-UNESP

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3. Summary of the Project's main goals

Fundamental research in theoretical physics has historically led to developments in all areas of science. In addition to producing technological applications coming from a better understanding of the physical laws of the universe, fundamental research in theoretical physics has led to new methods of problem-solving which has revolutionized areas of mathematics, biology, computer science, economics, and other areas of study.

Throughout the world, the importance of this research has led to the creation of theoretical physics institutes which focus on research, on the training of graduate students and postdocs, and on the organization of schools and workshops. Although these theoretical physics institutes have different structures and many are connected with public universities, they are all disconnected from undergraduate physics departments and have independent hiring policies and academic responsibilities from the rest of the university. Because of this autonomy, these theoretical physics institutes are able to attract the best researchers to their faculty. And because of the prestigious faculty and the organization of schools and workshops, these institutes are able to attract highly qualified graduate students and postdocs. As a result, the academic and research programs at these autonomous theoretical physics institutes increase the international impact of their host universities.

To fulfill the need for such a theoretical physics institute in South America, the ICTP South American Institute for Fundamental Research (ICTP-SAIFR) was created in 2011 in Sao Paulo as a collaboration between the Sao Paulo Research Funding Agency (FAPESP), the International Centre for Theoretical Physics (ICTP-Trieste) - a category 1 institute of UNESCO, the Sao Paulo State University (UNESP), and the Instituto de Física Teórica (IFT-UNESP) in whose building it is located. The ICTP- SAIFR in South America was the first regional center of ICTP created outside of Trieste, and because of its success, the ICTP-Trieste has now

created regional centers in the continents of Central America (Mexico), Africa (Ruanda), and Asia (China).

In this UNESP-ICTP-FAPESP collaboration, the role of UNESP is to provide the infrastructure of the IFT-UNESP building including an auditorium, a computer lab, and first floor office space, as well as provide the salaries of their two secretaries, one accountant, one computer technician, and up to five tenured research professors. The role of ICTP-Trieste is to provide organizational support to the secretaries, and financial support for visitors from other South American countries. And the role of FAPESP is to provide financial support for visitors, postdocs, and Young Investigators, and for the organization of schools and workshops.

Despite its brief existence, the ICTP-SAIFR has already established itself as a leading institute for theoretical physics. With the help of a world-class scientific council and international search committee, ICTP-SAIFR has been able to sign exchange agreements with the other leading theoretical physics institutes around the world and attract the top candidates for its faculty and postdoctoral positions. In addition to its permanent faculty members who are hired through IFT-UNESP, ICTP-SAIFR has a joint faculty member with Perimeter Institute (Waterloo) and two tenure-track faculty members who are funded by a donation from the Simons Foundation (New York) together with FAPESP Young Investigator fellowships. Furthermore, ICTP-SAIFR has obtained a private donation called the "Isaias Raw Chair" which will supplement the salary of a future professor, and a donation from the Instituto Serrapilheira to finance outreach activities and two outreach coordinators.

Its postdocs and Young Investigators are selected from thousands of applications received through an online application process. Almost all received their PhD's at institutions outside Brazil, and many of these postdocs have already secured permanent faculty positions at other Brazilian institutions. So ICTP-SAIFR has been very successful at reversing the "brain drain" and attracting talented young physicists to Brazil. The main role of a theoretical physics institute is to foster the interchange of information between visiting and local researchers, and the ICTP-SAIFR has an active visiting program with over 150 visitors per year spending between one week and two months at the institute. There are weekly seminars and journal clubs in various subareas of theoretical physics, and the complete list of visitors and research seminars can be found on the ICTP-SAIFR webpage www.ictp-saifr.org. Research seminars are frequently recorded and made available online using equipment installed with the guidance of the Perimeter Institute and ICTP Trieste audiovisual departments.

In addition to the research conducted by its members and visitors, the ICTP-SAIFR regularly organizes schools, mini-courses, workshops and programs for doctoral students and researchers in all areas of theoretical physics. The success of these activities has allowed the IFT-UNESP masters and doctoral programs to attract the top students in theoretical physics from all of South America, and to receive the top ranking of Brazilian graduate physics programs since 2011.

During the next five-year period, the ICTP-SAIFR intends to build on these recent accomplishments and continue to improve its research and organizational activities. Through its new agreement with Perimeter Institute involving a joint faculty member and a joint master's program, these activities will have an expanding impact and include outreach activities for high-school students and teachers, as well as for the general public. In addition to the support it receives from public institutions such as FAPESP and UNESP, ICTP-SAIFR is actively pursuing support from private institutions to consolidate its status as the premier theoretical

physics institute in South America.

4. Accomplishments in the period

Although the number of current ICTP-SAIFR researchers is relatively small and the economic crisis has made it difficult for UNESP to open new permanent positions, ICTP-SAIFR is probably the leading center for high-energy theoretical physics in Latin America and its tenure-track Simons-FAPESP Young Investigator fellows are promising young physicists who are leading research groups in new areas. In addition, the large number of visitors and associated researchers at ICTP-SAIFR allows it to organize activities and conduct research in a wide range of subareas. All activities are recorded and posted on the ICTP-SAIFR webpage, and with the technical assistance of Perimeter Institute and the institutional "reserva tecnica" of FAPESP, the quality of the ICTP-SAIFR recording equipment was considerably improved in 2019 and the ICTP-SAIFR videos are now of similar quality to the Perimeter Institute videos.

The ICTP-SAIFR director and vice-director are Nathan Berkovits and Rogério Rosenfeld who perform research in the areas of string theory and cosmology, and the two permanent ICTP-SAIFR researchers are Pedro Vieira and Eduardo Ponton who perform research in the areas of quantum field theory and particle physics. These areas are especially strong at ICTP-SAIFR, and three separate "journal clubs" meet weekly in the areas of string theory, particle physics and cosmology and attract students and researchers from the various universities in Sao Paulo. In July 2019, Rogério Rosenfeld was elected president of the Brazilian Physical Society. And in November 2019, Pedro Vieira was awarded the prestigious 2020 New Horizons in Physics Prize by the Breakthrough Prize Committee "for profound contributions to the understanding of quantum field theory." In June 2019, Eduardo Ponton unfortunately passed away after a courageous 2-year battle with an anti-immunological disease and will be greatly missed.

The two previous Simons-FAPESP Young Investigators, Rafael Porto and Fabio Iocco, finished their fellowships in 2018-2019 and are now professors at universities in Europe (Rafael Porto at the Univ. of Hamburg and Fabio Iocco at the Univ. of Napoli). Following the recommendations of an international search committee led by William Bialek (Princeton), Simon Levin (Princeton) and Marcus Aguiar (Unicamp), the Spanish researcher Ricardo Martinez-Garcia was selected in February 2019 as the newest Simons-FAPESP Young Investigator fellow. Ricardo Martinez-Garcia performs research in the area of complex systems applied to biodiversity and arrived in September 2019 to ICTP-SAIFR after a four-year postdoctoral position at Princeton University. He will work together with Roberto Kraenkel (ICTP-SAIFR associated member at IFT-UNESP) and the ICTP-SAIFR Fapesp postdoc Gabriel Maciel who will arrive in January 2020. Also, during the period of January - September 2020, the co-director of the NSF Center for Theoretical Biological Physics, Jose Nelson Onuchic, will be on sabbatical as a visiting researcher at ICTP-SAIFR.

The second Simons-FAPESP Young Investigator fellow is the Brazilian condensed matter physicist Aline Ramires who works in superconductivity and joined ICTP-SAIFR in September 2018 after an international search led by Peter Goddard (IAS Princeton), Juan Maldacena (IAS Princeton), David Gross (KITP Santa Barbara) and Belita Koiller (UFRJ). Aline published an October 2018 cover article in Physical Review Letters, a single-author paper on critical phenomena in Nature Physics in September 2019, and is currently on leave at the Max Planck Institute for the Physics of Complex Systems in Dresden. In 2020, the ICTP-SAIFR Fapesp postdoc

Krissia Zawadski will arrive to work with her and with Alexandre Reilly Rocha (ICTP-SAIFR associate member at IFT-UNESP).

In these interdisciplinary fields of complex systems applied to biology and condensed matter physics, several ICTP-SAIFR activities are planned in 2020 including 5 international schools and 5 workshops, as well as an annual school on Machine Learning organized in collaboration with the new Advanced Institute for Artificial Intelligence (AI2) of UNESP.

In July 2019, ICTP-SAIFR organized the fourth version of Journeys in Theoretical Physics for the top undergraduate students from Latin America. At the end of this one-week minischool, the top-scoring students in an exam are invited to participate in a joint Master's program with one year at ICTP-SAIFR/IFT-UNESP and one year at either Perimeter Institute or the Princeton/CUNY Center for the Physics of Biological Function. 16 students have already entered this program, and the first four students accepted in 2016 have just finished their joint Master's degree and are currently enrolled in PhD programs at Caltech, Perimeter, Stanford and Uppsala.

Between December 2018 and November 2019, the number of ICTP-SAIFR schools and workshops increased over the previous years. The ICTP-SAIFR organized 8 international schools on the topics of data science, mathematical biology, physics applied to biology, theoretical physics, statistical physics, observational cosmology, high energy astrophysics and cold atoms, and 9 workshops on the subjects of QCD, nonlinear dynamics, american monsoons, S-matrix bootstrap, diversity, quantum symmetries, dark universe, relativity and a memorial symposium for Eduardo Ponton.

In its February 2019 meeting, the ICTP-SAIFR scientific council approved 8 international schools to be held in 2020 on the topics of mathematical biology, ecology, biophysics, socio-econophysics, particle physics, theoretical condensed matter physics, few-body physics, data science and machine learning, and 12 workshops on the topics of sociophysics, particle physics, string theory, quantum field theory, electromagnetic effects of multiparticle physics, unconventional superconductors, few-body systems, biophysics, dark matter and observational cosmology. On the ICTP-SAIFR steering committee, Luiz Davidovich (current president of the Brazilian Academy of Sciences) replaced Jacob Palis (ex-president of the Brazilian Academy of Sciences), and on the ICTP-SAIFR scientific council, chairman Peter Goddard (IAS Princeton) retired for health reasons and the new chairman will be Michael Green (University of Cambridge, former Lucasian Professor of Physics).

In addition to these research activities, ICTP-SAIFR considerably expanded its outreach activities in 2019 with the help of a generous donation from the private Serrapilheira Institute to hire two outreach coordinators. The main outreach activity involves a partnership with the Perimeter Institute for Theoretical Physics in Canada and is aimed at high-school physics teachers and students.

In 2019, ICTP-SAIFR translated into Portuguese over half of the pedagogical material prepared by Perimeter Institute for high-school teachers to use in their classrooms. This material is available for free on the Perimeter and ICTP-SAIFR websites (<http://outreach.ictp-saifr.org/traducoes-para-sala-de-aula/>) and uses modern physics discoveries such as black holes, the Higgs boson, quantum information, and expansion of the universe to teach basics physics concepts to high-school students.

With courses taught by the Perimeter outreach director and by the two ICTP-SAIFR

outreach coordinators, ICTP-SAIFR organized nine 2-day workshops in 2019 for high-school teachers in which they were shown how to use this material in their classrooms. Five of the nine workshops were held in Sao Paulo, two in Rio de Janeiro, one in Brasilia, and one in Sertaozinho in the interior of Sao Paulo state.

For high-school students, ICTP-SAIFR organized minicourses on modern physics topics on 34 different Saturdays in 2019. The minicourses consisted of 3-hour lectures in the morning taught by ICTP-SAIFR faculty which were followed by discussions on the lectures in the afternoon with a high-school teacher. Topics of the minicourses included electromagnetism, relativity, quantum mechanics, particle physics, sound and light waves, cosmology, big data, mathematical physics and applications to biology. ICTP-SAIFR also organized monthly visits of its faculty to different public high schools in São Paulo to discuss with students the research and career choices of a physicist.

In addition to these outreach activities for high-school students and teachers, ICTP-SAIFR continued its outreach activities for the general public including monthly informal discussions in a bar called "Papos de Física", distinguished public lectures by internationally recognized physicists, and a collaboration with the Instituto Moreira Salles museum in downtown São Paulo involving monthly discussions between a physicist and an artist in the museum on a topic of common interest called "Ciência em Diálogo".

The activities of ICTP-SAIFR in 2019 will be described below in more detail including:

- (a) research related to publications;
- (b) research related to visitors;
- (c) organization of schools, workshops, minicourses, outreach activities, meetings and seminars.

a. Research related to publications

The research conducted at ICTP-SAIFR during this period includes diverse areas of theoretical physics, as indicated by the publication list in item 8. Among the different subjects are string theory, field theory, integrability, condensed matter, particle physics, cosmology, general relativity, astrophysics, complex systems, and mathematical biology. These publications involved research performed by associated researchers, postdoctoral fellows and visitors of ICTP-SAIFR. Various ICTP-SAIFR researchers are members of state-of-the-art international collaborations, such as the CMS detector at the LHC, the LIGO and the Dark Energy Survey collaborations. In this period, ICTP-SAIFR had a total of 213 publications involving our associates including 25 publications in Physical Review Letters. Some of them will be highlighted below.

a1. String theory, Field Theory and Integrability

Manifestly supersymmetric theories are covariantly described in the pure spinor formalism, including supergravity and superstring theories. The $D=11$ pure spinor superparticle and its vertex operators are described using this formalism in Ref [18], and half-BPS vertex operators of the $AdS_5 \times S^5$ superstring are constructed using this formalism in Ref [19]. In Ref [20], the pure spinor formalism is used to sketch a proof of the conjecture of Maldacena for the duality between $N=4$ $d=4$ super-Yang-Mills and the $AdS_5 \times S^5$ superstring.

Advances in N=4 Super Yang-Mills theory integrability were achieved regarding four-point correlation functions in Ref [213] and octagons were used as proxies for combinatorics and non-planar resummations in Ref [210]. In Ref [63] a supergeometrical interpretation is presented for linearized beta-deformations in N=4, and Ref [208] studies deformations of the circular Wilson loop and spectral dependence in this model.

In Ref [210], pion scattering amplitudes are analyzed through bootstrapping QCD to evaluate its place in the space of consistent S matrices. The S-matrix bootstrap is also used to explore the space of consistent two-dimensional QFTs in Ref [209].

a2. Condensed Matter

Graphene is a growing field of research with multiple interdisciplinary applications. A theoretical DNA chip using electronic graphene-based substrates is proposed in Ref [191], showing that such a device could have high sensitivity towards the presence of DNA and good selectivity towards specific nucleotide sequences. Further applications of graphene for DNA sequencing are presented in Ref [188].

After the observation of trapped Bose-Einstein Condensate (BEC) in the laboratory, rotating trapped condensates have been produced and studied. The formation of dynamically stable vortex lattices are addressed in rotating [6], harmonically-trapped [7] and box-trapped [8] settings. The effect of quenched disorder in a dilute BEC confined in a hard walls trap is discussed in Ref [38]. In Ref [9] efficient OpenMP versions of C and Fortran programs are presented for solving the Gross-Pitaevskii equation for a rotating trapped BEC in two and three spatial dimensions.

S-duality, entropy function and transport in AdS₄/CMT₃ is reviewed in Ref. [64], using Abelian vector plus scalar holographic gravity models for 2+1 dimensional condensed matter transport along with the effect of S-duality on them.

a3. Particle and Astroparticle Physics

The Standard Model (SM) of particle physics is being tested at the LHC, and ICTP-SAIFR members participate in the CMS collaboration which has produced several results in 2019 [71 - 170]. The most important contributions include publications regarding the following searches: the Higgs boson decaying to two muons in proton-proton collision [71]; dark matter particles produced in association with a top quark pair [72]; narrow H_y resonances in proton-proton collisions [73]; pair production of second-generation leptoquarks [74]; long-lived particles decaying into displaced jet in proton-proton collisions [75]; the search for supersymmetric partners of electrons and muons [76]; the search for heavy Majorana neutrinos [77]; and several measurements of Higgs boson couplings in proton-proton collisions [78]. With the end of the second run of the LHC, no evidence of new physics beyond the SM has been found yet. Within this context, the prospects of new physics in double Higgs production at e+e- colliders are presented in [195].

Two-Higgs Doublet Models (2HDM) are popular standard model extensions and some work on discussing neutrino masses has been done by ICTP-SAIFR associate members. Neutrino masses in a U(1) gauge symmetry model using type I and type II seesaw mechanisms are discussed in [174], whereas [175] proposes a 2HDM where the stability of dark matter, neutrino masses and the absence of flavour changing interactions are explained by promoting baryon and lepton

number to gauge symmetries. In [176], collider bounds are explored in 2-Higgs doublet models with U(1) gauge symmetries.

A combined analysis of LHC and electroweak precision data was performed in [30] to put constraints on physics beyond the Standard Model parameterized by dimension-6 effective operators.

a4. Cosmology and Gravity

SAIFR researchers are working in important international efforts such as the Laser Interferometer Gravitational-wave Observatory (LIGO) [197-207], the Dark Energy Survey (DES) [43-61], the Javalambre Photometric Local Universe Survey (J-PLUS) [1] and the Large Synoptic Survey Telescope (LSST) collaborations.

LIGO has finished its first (O1) and second (O2) observational runs and several new results were obtained in 2019. Alerts were issued for 14 candidates in O2, 6 of which have been confirmed as gravitational-wave events associated with the merger of black holes or neutron stars, as described in [206]. The search for a correlation between gravitational wave events in O1 with high energy neutrino sources obtained from other experiments such as Antares and IceCube was conducted in [197] but unfortunately none was found. New bounds on a given type of tidal instabilities were obtained from a detailed analysis of the neutron star merger event GW170817 in [198] as well as more detailed properties of this event were estimated in [203]. Searches for short and long-duration gravitational-wave transients were reported in [199] and [200] respectively. A null search for gravitational waves from 222 pulsars using O1 and O2 data was conducted in [202] whereas in [204] a narrow-band search using LIGO O2 data for the continuous wave emission of 33 pulsars is described that also showed no evidence and also no evidence of gravitational waves from four magnetar bursts were found in [205].

One of the most interesting results was a joint LIGO/Virgo/DES analysis [207] that used GW170817 with its optical counterpart to measure the Hubble constant for the first time from gravitational waves (and hence with large errors) obtaining in $H_0 = 75^{+40}_{-32}$ km/s/Mpc.

An important theoretical result obtained in [201] using Effective Field Theory is the computation of gravitational interaction between two compact bodies up to the sixth power in Newton's constant in the static limit, which was published in Physical Review Letters.

The DES collaboration has finished its planned 5 years observations in January 2019 and it is working on the analysis of the first 3 years of data. Several results using Y1 data were published in 2019 [43-61]. The measurement of the galaxy angular power spectrum [51] was led by the group in São Paulo and the paper [59] studying extensions of the standard cosmological model received an important contribution from MSc student Andresa Campos in the analysis of the Λ CDM model. In addition, a paper showing the DES results including galaxy clustering, weak lensing and supernovae was published in Physical Review Letters [61].

The first J-PLUS data release was published in [1] and Fisher forecasts for interacting dark matter using J-PAS characteristics [4] and for the redshift space distortion parameter using Euclid characteristics [5] were performed.

Finally, [196] present a review on the state-of-the-art and upcoming research on dark matter and dark energy.

a5. Astrophysics

The nature of dark matter (DM) is one of the greatest mysteries of modern particle physics, astrophysics and cosmology. [29] reviews the interplay of the LHC and non-LHC dark matter search and estimates the potential of the future LHC runs to probe dark matter parameter space. [33] addresses how to handle uncertainties in the Galactic Dark Matter distribution when looking for DM. [177] investigates a dark matter detection method based on spectroscopic measurements of neutron stars whereas [35] develop a new Bayesian methodology to infer the distribution of DM within the Milky Way using rotation curve data.

A unified setup for dark matter, inflation, and baryon asymmetry generation through neutrino mass seesaw mechanism is proposed by [178], in a paper published in PRD.

The Cherenkov Telescope Array (CTA) is a major next-generation observatory for ground-based high-energy gamma-ray astronomy, a project with the collaboration of ICTP-SAIFR associate members. The goals and current status of the project are discussed on Ref [25] whereas, in Ref [24], the optimized and final telescope arrays are presented, based on Monte Carlo optimization, along with the foreseen performance of the observatory.

The controls on the magnetic field strength and cycle period in solar-type stars were studied in [26].

a6. Complex Systems

The use of networks to model complex systems has proven to be a difficult yet insightful approach. Ref [36] investigates causal links between climate as environmental drivers and malaria cases in Argentina, showing a relationship between increased extreme weather events and risks of malaria spreading.

Multistability is characterized by a large number of coexisting attractors, a phenomenon addressed in many different approaches. In Ref. [21] a Josephson-junction-based electrical circuit is designed, reporting extreme multistability.

a7. Mathematical Biology

Evolution studies have benefited from mathematical modelling, which attempts to constrain the mechanisms responsible by speciation. In Ref [12], a lattice model is used to explore how populations with different ecological outcomes are connected across large landscapes. The authors conclude that neither spatial distribution of phenotypes nor the spatial differences in magnitude and direction of selection alone dictate coevolutionary dynamics. In [13], speciation mechanisms through microevolutionary processes are modelled in phylogenetic patterns.

The structure of ecological interactions is commonly approached through analysis of interaction networks. However, sampling biases are important misleading factors, limiting the accuracy of the models. In order to assess these biases and produce more accurate interaction network models, researchers from SAIFR developed the software EcoNetGen [14]. The software constructs and samples networks with predetermined topologies, allowing researchers to explore large-scale ecological networks.

a8. Quantum information

Exploring potential applications of quantum information and intrinsic quantum mechanics properties, such as entanglement and superposition, is an important growing area of research. Published on Nature Machine Intelligence, Ref [17] combines machine learning algorithms with quantum information. They demonstrate a scalable machine learning procedure that can be used for reconstructing pure and mixed states, including states in quantum information and ground states of local Hamiltonians relevant to condensed matter, cold atomic systems and quantum simulators.

b. Research related to visitors

Between December 2018 and November 2019, the ICTP-SAIFR hosted 52 short-term visitors who stayed less than four days, 208 middle-term visitors who stayed between five and fourteen days, and 24 long-term visitors who stayed more than two weeks. The complete list of visitors to ICTP-SAIFR can be found on the webpage <https://www.ictp-saifr.org/ictp-saifr-visitors-2019/>. The research of some of the visitors is described below:

Yang Bai – University of Wisconsin-Madison, USA (01/15 – 02/12)

During my visit, I had started a new project with Eduardo Ponton and Bithika Jain. We want to know whether the simple Higgs-portal dark matter can generate a soliton-like state of dark matter from the early universe physics. The soliton state of dark matter could be macroscopic and have its detection possibility different from a simple dark matter particle. We will try to work out in more detail about the properties of the dark matter soliton state.

Dmitry Melnikov – International Institute of Physics (UFRN) (08/21 – 08/30)

During my visit I gave a seminar titled "Knots and complexity in topological theories" and discussed a possible collaboration project with the group of Prof. Horatiu Nastase. We found a project of common interest and plan to convert it into a paper within the next few months.

Bahati Mukeru - University of South Africa (02/18 – 04/17)

During my visit to ICTP-SAIFR, I performed, with my host (Prof. L. Tomio) some fusion calculations. We combined two different methods, namely the "continuum-discretized coupled channels" and the critical angular momentum methods to study complete fusion in the $^8\text{Li}+^{208}\text{Pb}$ reaction. We established that below the critical angular momentum, the total fusion cross section is insignificantly dependent on variation of the ground state binding energy. This critical angular momentum was determined using the complete fusion experimental data. We have therefore attempted to validate the critical angular momentum approach to complete fusion, using a more quantum mechanically proven method. The results have been submitted for publication in the journal of Nuclear Physics A.

Alessandro Georgoudis - Uppsala University (03/25 – 03/29)

During my visit at ICTP I presented my previous work, in collaboration with V. Goncalves, on obtaining propagator type integrals from constraints coming from conformal invariance. With V. Goncalves we continued working on the topic in order to obtain the full list of Master Integrals appearing at 5 loops, more precisely we are trying to obtain the non planar contributions in momentum space.

Johan Martinez – Universidad de Los Andes (03/07 – 04/06)

We worked together with the ICTP members to expand our future research lines the physics of complex systems in the field of prediction of epileptic seizures by using nonlinear dynamics, statistical physics and graph theory in collaboration with Dr. Hilda Cerdeira. We also finished a manuscript about novel methodologies to better understand the evolution of time series by means of directed and weighted graphs extracted from finite collection of samples of aggregated data of Dengue, Malaria and Influenza as well as artificial model of linear and nonlinear time series.

c. Organization of activities

Between December 2018 and November 2019, the ICTP-SAIFR organized eight São Paulo International Schools for Theoretical Physics, nine workshops, one minicourse, one Program, forty-seven outreach events, and weekly seminars, colloquia and journal clubs. The complete list of 2019 activities is on the webpage <https://www.ictp-saifr.org/2019-activities/>, the list of weekly seminars, colloquia and journal clubs is on the webpage <https://www.ictp-saifr.org/2019-research-seminars-and-activities/>. Activities, seminars and colloquia of December 2018 are described on “Past research seminars and activities” at <http://www.ictp-saifr.org/other-years-research-seminars-and-activities/>. Most of the activities were filmed and the videos are available online on the associated webpages.

c1. São Paulo International Schools

The eight São Paulo International Schools were on the subjects of data science (Dec. 3-14, 2018), mathematical biology (Jan. 14-20), physics applied to biology (Jan. 21-26), theoretical physics (Feb. 11 - 15), statistical physics (July 1-6), observational cosmology (July 22-Aug. 2), high energy astrophysics (Aug. 5-16) and cold atoms (Sept. 16-27). The schools were for mostly master’s and PhD students, and those students not from São Paulo were housed in a hotel in shared rooms. The students were asked to anonymously evaluate the schools, and the links to view their evaluations are:

<http://bit.ly/survey-codata2018>
<http://bit.ly/survey-mathbio8>
<http://bit.ly/survey-evolution19>
<http://bit.ly/survey-dutchbr19>
<http://bit.ly/survey-StatPhys2019>
<http://bit.ly/survey-Cosmos2019>
<http://bit.ly/survey-astro2019>
<http://bit.ly/survey-atom2019>

All lectures of the schools were filmed and the videos are available online on the school webpage.

c1A. CODATA-RDA School of Research Data Science (Dec. 3-14, 2018)

The International School on Data Science (Dec. 3-14) is described on the webpage <https://www.ictp-saifr.org/2018-codata-rda-school-of-research-data-science/> and involved 6 lecturers and 31 students. This activity covered various topics including the principles of Open Science, research data management and curation, large scale analysis, statistics, visualisation, modeling techniques, automation and scripting.

Lecturers:

- Raphael Cobe (NCC, Brazil)
- **Marcela Alfaro** (Universidad de Costa Rica, Costa Rica)
- **Raphael Cobe** (NCC, Brazil)
- **Steve Diggs** (University of California, USA)
- **Filipe Fernandes** (NOOA/IOOS & Software Carpentry, Brazil)
- **Robert E Quick** (Indiana University, USA)
- **Natália da Silva** (Universidad de La República, Uruguay)

c1B. VIII Southern-Summer School on Mathematical Biology (Jan. 14 - 20)

The VIII Southern-Summer School on Mathematical Biology (Jan. 14 – 20) is described on the webpage <https://www.ictp-saifr.org/viii-southern-summer-school-on-mathematical-biology/> and involved 1 lecturer and 64 students. The school was aimed at students in Physics, Mathematics, Ecology and Epidemiology, having at least a basic knowledge of calculus and differential equations. Lectures covered the basics of population dynamics and are supplemented with modelling exercises addressing mainly problems in ecology, epidemiology and evolution.

Lecturers and Topics:

- **Roberto Kraenkel** (IFT-UNESP, Brazil): Introduction to Population Biology

c1C. Joint ICTP-SAIFR/ICTP-Trieste School on Mathematical Models of Evolution (Jan. 21 – 26)

The School on Physics Applications in Biology (Jan. 22-27) is described on the webpage <https://www.ictp-saifr.org/school-on-mathematical-models-of-evolution/> and involved 4 lecturers, 4 speakers and 62 participants. This activity included minicourses, discussion sessions and group exercises on topics including the evolution of population genetics, individuality, immune systems, ecology and viruses.

Lecturers and Topics:

- **Luca Peliti** (SMRI, Italy): Population genetics and evolution
- **Paul Rainey** (IAS – Massey University, New Zealand): Evolution of individuality
- **Curtis Callan** (Princeton University, USA): The evolution of immune systems
- **Joshua Weitz** (Georgia Institute of Technology, USA): Ecology and evolution of viruses

Speakers and Topics:

- **Danilo Liarte** (Cornell University, USA): Geometry and Disorder of Soft Matter: Smectics, Martensites and Jamming
- **Ricardo Martinez-Garcia** (Princeton University, USA): Self-organized patterns: linking behavior with ecological and evolutionary processes
- **John Realpe-Gomez** (Xanadu Quantum Technologies Inc, Canada): Human cooperation as a selfishness/prosociality balance near criticality
- **Daniel Schultz** (Geisel Medical School at Dartmouth, USA): Gene Regulation and Dynamical Efficacy in Antibiotic Responses

c1D. 4th Joint Dutch-Brazil School on Theoretical Physics (Feb. 11-15)

The 4th Joint Dutch-Brazil School on Theoretical Physics was jointly organized with the Dutch Research School of Theoretical Physics (DRSTP) (Feb. 11-15), is described on the webpage <https://www.ictp-saifr.org/4th-joint-dutch-brazil-school-on-theoretical-physics/>, and involved 3 lecturers and 120 participants.

Lecturers and Topics:

- **Ronald Kleiss** (Radboud U, The Netherlands): Monte Carlo Theory and Techniques
- **Zohar Komargodski** (Simons Institute, Stony Brook, USA): Quantum Field Theories in 2+1 Dimensions: Duality, Confinement, Topological Phases, Criticality, and Symmetry Breaking

- **Juan Maldacena** (IAS Princeton, USA): Toy models for black holes

c1E. Preparatory School for StatPhys 2019 (July 1-5)

Preparatory School for StatPhys 2019 (July 1-5) is described on the webpage <https://www.ictp-saifr.org/preparatory-school-for-statphys-2019/> and involved 5 lecturers and 81 participants. This activity introduced graduate students and young researchers to concepts in modern Statistical Physics and prepared them for StatPhys 2019 in Buenos Aires

Lecturers and Topics:

- **Pablo Balenzuela** (University of Buenos Aires, Argentina): Multi-agent models in complex networks
- **William Bialek** (Princeton, USA): Physical limits to biological function/ Statistical physics for real biological networks
- **Mauro Copelli** (UFPE, Brazil): Criticality, with applications to neuroscience
- **Maxi San Miguel** (IFISC, Spain): Statistical physics: state of the art (I and II)
- **Gabriel B. Mindlin** (University of Buenos Aires, Argentina): Introduction to nonlinear dynamics

c1F. III Joint ICTP-Trieste/ICTP-SAIFR School on Observational Cosmology (July 22 – Aug. 2)

The III Joint ICTP-Trieste/ICTP-SAIFR School on Observational Cosmology (July 22 – Aug. 2) is described on the webpage <https://www.ictp-saifr.org/iii-joint-ictp-trieste-ictp-saifr-school-on-observational-cosmology/> and involved 7 lecturers and 61 participants. The school aimed at providing students with the necessary tools for understanding the current issues in modern cosmology and to familiarize them with how recent observations can be used to constrain different cosmological models and parameters.

Lecturers and Topics:

- **Mehrdad Mirbabayi** (ICTP-Trieste, Italy): Introduction to Inflation
- **Cora Dvorkin** (Harvard University): Introduction to CMB Theory
- **Raul Abramo** (IF-USP, Brazil) & **Rogério Rosenfeld** (IFT-UNESP&ICTP-SAIFR, Brazil): Introduction to Large Scale Structure
- **Marko Simonović** (CERN, Switzerland): Advanced Topics in LSS
- **Alessandra Silvestri** (Leiden University, The Netherlands): Beyond LCDM
- **Tim Eifler** (University of Arizona, USA): From observations to models

c1G. School on High Energy Astrophysics (Aug. 5-16)

The School on High Energy Astrophysics (Aug. 5-16) is described on the <https://www.ictp-saifr.org/school-on-high-energy-astrophysics/> and involved 9 lecturers and 55 participants. This school presented lectures on a range of topics including the processes involved in gamma-ray, charged cosmic-ray, and neutrino high energy astrophysics.

Lectures and topics:

- **Pasquale Blasi** (GSSI, L'Aquila, Italy): *Acceleration mechanisms*
- **Fabio Cafardo** (IAG-USP, Brazil) & **Rodrigo Nemmen** (IAG-USP, Brazil): *Fermi-LAT Gamma-ray Telescope: Hands-on Activity*

- **Carlos Arguelles Delgado** (MIT, USA): *HE neutrino detection*
- **Fabio Iocco** (ICTP-SAIFR, São Paulo, Brazil): *Indirect DM searches*
- **Johannes Knapp** (DESY Zeuthen, Germany): *Measuring astroparticles*
- **Dmitriy Kostunin** (DESY Zeuthen, Germany): *Astroparticle Experiments in the Baikal region*
- **Kohta Murase** (Pennsylvania State University, USA): *Physics of HE sources; HE neutrino production*
- **Rodrigo Nemmen** (IAG-USP, Brazil): *Active galactic nuclei and blazars*
- **Pasquale D. Serpico** (LAPTh, Annecy, France): *High energy physics processes in astrophysics*

c1H. School on Interaction of Light with Cold Atoms (Sept. 16-27)

The School on Interaction of Light with Cold Atoms (Sept. 16-27) is described on the webpage <https://www.ictp-saifr.org/school-on-interaction-of-light-with-cold-atoms/> and involved 8 lecturers and 67 participants. The school aimed at students studying a STEM subject, and those who were interested in gaining entrepreneurial skills with the view to commercialize scientific ideas or inventions.

Lecturers and topics:

- **Eric Akkerman** (Technion, Israel): Mesoscopic physics of photons
- **Mikhail Baranov** (IQOQI, Innsbruck, Austria): Fermions
- **Michel Brune** (ENS, France): From cavity QED to quantum simulations with Rydberg atoms
- **Philippe W Courteille** (IFSC-USP, Brazil): Introductory course (atom-light interaction and basic applications)
- **Roberto Serra** (UFABC, Brazil): Quantum information
- **Georgiy Shlyapnikov** (CEA-CRNS, France): Dipolar gases
- **Juliette Simonet** (University of Hamburg, Germany): Optical lattices and Artificial Gauge Fields
- **Jook T. M. Walraven** (University of Amsterdam, The Netherlands): Quantum gases

c2. Workshops

ICTP-SAIFR organized 9 workshops on the subjects of QCD, nonlinear dynamics, American monsoons, S-matrix bootstrap, diversity, quantum symmetries, dark universe and relativity and a memorial symposium. The purpose of these workshops was to discuss status, recent progress and perspectives in each of the fields mentioned. Additionally, one conference and one roundtable on large collaborations and one memorial symposium in honor of ICTP-SAIFR Prof. Eduardo Pontón were organized.

c2A. ICTP-SAIFR/FAIR Workshop on Mass Generation in QCD (Feb. 25 - March 1)

The workshop was jointly organized by German and Brazilian researchers. The main goal of the workshop is to involve Brazilian physicists in experiments at the new Facility for Antiproton and Ion Research (FAIR) in Germany. The webpage of the workshop is <https://www.ictp-saifr.org/ictp-saifr-fair-workshop-on-mass-generation-in-qcd/> and speakers included:

- Anna Bakhausen (DAAD São Paulo, Brazil): Funding opportunities from the DAAD
- Fábio Braghin (Universidade Federal de Goiás, Brazil): Pion and constituent quark effective interactions and constituent quark mass

- Fábio Köpp Nobrega (Universidade Federal do Rio Grande do Sul): Heavy quark hadroproduction within dipole framework at FAIR
- Tassos Belias (GSI, Darmstadt, Germany): The PANDA detector
- Marco Bregant (IF-USP, Brazil): Instrumentation Lab of HEPIC@IFUSP
- Kai-Thomas Brinkmann (Giessen University, Germany): Photon spectroscopy at PANDA and elsewhere
- Chen Chen (IFT-UNESP, Brazil): Structure of the nucleon's low-lying excitations
- Mauro Cosentino (UFABC, Brazil): Simulation for high energy physics detectors
- Evgeny Epelbaum (Ruhr-University Bochum, Germany): Hadronic molecules from effective field theory
- Christian Fischer (Giessen University, Germany): QCD phase transition from Dyson- Schwinger equations
- Tobias Frederico (Instituto Tecnológico da Aeronáutica, Brazil): Minkowski space dynamics for hadrons
- Tord Johansson (Uppsala University, Sweden): Prospects for hyperon physics with PANDA
- Takeshi Kodama (UFRJ, UFF/INCT-FNA, Brazil): The National Institute for Nuclear Physics and Applications
- Rubens Lichtenthäler (USP, Brazil): Selected ongoing projects at RIBRAS
- Frank Maas (HIM/Mainz University, Germany): Nucleon structure studies with the PANDA experiment
- João Pacheco Melo (UNICSUL, Brazil): Extraction of the Electromagnetic Form Factors for Spin-1 Particles on the Light-Front
- Marcelo Munhoz (IF-USP, Brazil): Heavy-Flavor Hadrons as a Probe of the Quark-Gluon Plasma
- Fernando Navarra (IF-USP, Brazil): Heavy quarkonium in a hadron gas
- Marina Nielsen (USP, Brazil): Recent developments on the X, Y and Z states
- Jorge Noronha (USP, Brazil): Out-of-equilibrium phenomena at finite density
- Klaus Peters (GSI, Darmstadt, Germany): Status and progress of FAIR / Experimental status and outlook of the XYZ mystery
- Gilberto Ramalho (UNICSUL, Brazil): Octet baryon double ratios GE/GM in a nuclear medium
- Fernando Serna (UNICSUL, Brazil): Interplay of dynamical and explicit chiral symmetry breaking effects on a quark
- Tobias Stockmanns (FZ Jülich, Germany): PandaRoot — the simulation and reconstruction framework of PANDA
- Alinka Lépine Szily (USP, Brazil): RIBRAS — Radiative Beams in Brazil
- Giorgio Torrieri (UNICAMP, Brazil): Quarkyonic matter. What is it and how to (maybe) detect it.
- Kazuo Tsushima (UNICSUL, Brazil): In-medium properties of the low-lying bottom baryons in the QMC model
- Marcio Weichert (DWIH): Introduction to the German Centres for Research and Innovation
- Ulrich Wiedner (Ruhr-University Bochum, Germany): Glueballs – fundamental, exciting and elusive
- Katrin Winkler (DFG Latin America): Funding opportunities from the DFG

c2B. Latin American Strategy Forum for Research Infrastructure (April 30 – May 1)

The forum brought together scientists from all of Latin America to discuss large-scale long-term science collaborations. The webpage of the workshop is <https://www.ictp-saifr.org/workshop-on-the-latin-american-strategy-forum-for-research-infrastructure/> and speakers included:

- **João Luiz Azevedo** (President of CNPq, Brazil): Roundtable
- **Xavier Bertou** (CNEA/CONICET, Argentina): ANDES
- **Lidia Brito** (Director of UNESCO Montevideo Office): UNESCO perspectives
- **Marcela Carena** (Fermilab & University of Chicago, USA): Conclusion
- **Benjamín Marticorena Castillo** (CONICYT, Peru): Roundtable
- **Carlos Henrique Brito Cruz** (Science Director of FAPESP & UNICAMP, Brazil): FAPESP Strategy for Research Infrastructures
- **Sebastián Eslava** (Director of Innovation and Technological Development, Colciencias, Colombia): Roundtable
- **Nigel S. Lockyer** (Director of Fermilab): Fermilab and the P5 Process
- **Andres Lopez** (National Contact Point of CONICYT, Chile): Roundtable
- **Luciano Maiani** (Università di Roma, Italy): European-Latin American cooperation
- **Salvatore Mele** (CERN, Switzerland): CERN and the European Strategy in Particle Physics

- **Claudia M. Guerrero Monteza** (Director of Cooperación Internacional of SENACYT, Panama): Roundtable
- **Oscar Cobar Pinto** (General Secretary of Guatemala Funding Agency and Programa Ibero-Americano de Ciência e Tecnologia para o Desenvolvimento – CYTED, Guatemala): Roundtable
- **Fernando Quevedo** (Director of ICTP-Trieste, Italy & Cambridge University, UK): Introduction to LASF4RI
- **Antonio José Roque da Silva** (Director-General of National Center for Research in Materials and Energy-CNPq, Brazil): The Sirius Synchrotron Light Source: an open research infrastructure
- **Martha Rosas** (Acting Director for International Cooperation in CONACYT, Mexico): Roundtable
- **Rogério Rosenfeld** (IFT-UNESP/ICTP-SAIFR, Brazil): Introduction
- **Giorgio Rossi** (Universita di Milano, Italy): ESFRI Strategy for Research Infrastructures
- **Ronald Shellard** (CLAF / CBPF, Brazil): Roundtable
- **Jorge Tezon** (Development Manager of CONICET, Argentina): Roundtable
- **Mark Thomson** (Executive Chair of Science and Technology Facilities Council-STFC, UK): STFC and GSO Strategy for Research Infrastructures

c2C. Conference on Perspectives in Nonlinear Dynamics (July 16-19)

This workshop included various aspects including computational neuroscience, climate dynamics, social networks and urban computing. The webpage of the workshop is <https://www.ictp-saifr.org/conference-on-perspectives-in-nonlinear-dynamics/> and speakers and topics included:

- **José S. de Andrade Jr.** (Universidade Federal do Ceará, Brazil): Self-organization and Nonuniversal Anomalous Scaling in Non-Newtonian Turbulence
- **Raul P. Aristides** (UFPR, Brazil): Non-local coupling among oscillators mediated by fast travelling waves
- **Paulo Artaxo** (USP, Brazil): Scientific challenges in regional and global climate change
- **Murilo Baptista** (University of Aberdeen, UK): Exploiting the spatial signatures of causality to understand social crisis in Brazil
- **Ginestra Bianconi** (Queen Mary University, UK): Emergent Hyperbolic Network Geometry and Frustrated Synchronization
- **Bruno R.R. Boaretto** (UFPR, Brazil): Protocol for suppression of phase synchronization in Hodgkin-Huxley-type networks
- **Stefano Boccaletti** (CNR, Italy / Northwestern Polytechnical University, China): Collective organization of networked phase oscillators: explosive synchronization and Bellerophon states
- **Fernando S. Borges** (UFABC, Brazil): Firing patterns in networks of adaptive exponential integrate-and-fire neuron model
- **Roberto C. Budzinski Neto** (UFPR, Brazil): Phase synchronization and intermittent behavior in healthy and Alzheimer affected human brain based neural network
- **Javier Martín Buldú** (Complex Systems Group & GISC – URJC, Spain): Connecting Networks
- **Iberê Luiz Caldas** (IFUSP, Brazil): Shearless Invariants in Non twist Symplectic Maps
- **Ricardo E. Carvalho** (UNESP-RC, Brazil): Transport barriers with shearless attractors
- **Mario Chavez** (Hôpital de La Pitié-Salpêtrière, France): Ordering and ranking of complex high-dimensional data
- **Americo B. Cunha Jr.** (UERJ, Brazil): Bifurcation analysis and control of chaos on bistable piezoelectric energyharvesting systems
- **Nivedita Deo** (University of Delhi, India): Evolution and Dynamics of World Currency Network
- **José L. H. Diestra** (ICTP-SAIFR/IFT-UNESP, Brazil): Estimation of dengue's burden in Venezuela using neighboring and internet-source data.
- **Bruno Eckhardt** (Philipps-Universität Marburg, Germany): Individual and collective bacterial motions
- **Fabiano Ferrari** (Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brazil): Suppression of Synchronization due to Delayed Feedback Signals in Neural Networks
- **Silvio C. Ferreira Jr.** (Universidade Federal de Viçosa, Brazil): Quantifying echo chamber effects in information spreading over political communication networks
- **Ulrike Feudel** (Oldenburg University, Germany): Transient chaos in networked systems: Desynchronization and real-time vulnerability
- **Neelima Gupte** (IIT Madras, Chennai, India): Microtransitions in hierarchical and Climate networks
- **André Gusso** (Universidade Federal Fluminense, Brazil): Robust chaos induced by two-frequency excitation
- **Ricardo Gutiérrez** (Universidad Rey Juan Carlos, Spain): Targeting the dynamics of ecological networks

- **Kelly Iarosz** (USP, Brazil): Mathematical model of brain tumour
- **Babatunde Idowu** (Lagos State University – Ojo, Nigeria): A New Chaotic Finance System: Its Analysis, Control and Synchronization
- **Jürgen Kurths** (Potsdam Institute for Climate Impact Research, Germany): Complex network approach reveals global pattern of extreme-rainfall teleconnection
- **Emanuel F. Lima** (UFSCar, Brazil): Non-chaotic classical transitions
- **Alejandro López-Castillo** (UFSCar, Brazil): Turing Patterns Modulation by Chemical Gradient
- **Ricardo López-Ruiz** (University of Zaragoza, Spain): Inequality in Random Markets
- **Cristina Masoller** (Universitat Politècnica de Catalunya, Spain): Network-based tools for retina image classification and outlier detection
- **Ricardo Martínez-García** (Princeton University): Pattern formation in populations with density-dependent movement and two interaction scales
- **Pablo Mininni** (Universidad de Buenos Aires, Argentina): Low dimensional dynamics and invariant manifolds in stratified turbulence
- **Adilson Motter** (Northwestern University, USA): Symmetric States Requiring System Asymmetry: The Emergent Role of Heterogeneity in Network Dynamics
- **Tiago Pereira** (ICMC-USP São Carlos, Brazil): Stochastically driven hubs induce coherence resonance and synchronisation
- **Pedro Pessoa** (University at Albany/ State University of New York, USA): Entropic Dynamics on Statistical Manifolds
- **Samridhi Sankar Ray** (International Center for Theoretical Sciences, Tata Institute of Fundamental Research, India): Non-intermittent Turbulence: Lagrangian Chaos and Irreversibility
- **Alexandre R. Rocha** (IFT-UNESP, Brazil): Properties of Liquid water from atomistic simulations and neural networks
- **Camilo Rodrigues Neto** (EACH-USP, Brazil): Model for laws of scale in urban systems
- **Francisco A. Rodrigues** (IFSC-USP, Brazil): Structure and dynamics of networks: a machine learning approach
- **Kalel L. Rossi** (UFPR, Brazil): Effects of neural variability on the phase synchronization of neural networks
- **Nicolás Rubido** (Universidad de la República de Uruguay): What topological factors affect network inference?
- **Elena Surovyatkina** (Potsdam Institute for Climate Impact Research (PIK), Germany): Forecasting monsoon: insight from Nonlinear dynamics
- **Zoltán Toroczkai** (University of Notre Dame, USA): Computational Hardness as Chaos in an Analog Approach to Boolean Satisfiability Problems
- **Ricardo Viana** (UFPR, Brazil): Fractal structures in open Hamiltonian systems: examples in Plasma Physics

c2D. Large Collaborations in Astronomy and Cosmology (July 28)

This workshop aimed to bring the international community to discuss the scientific and organizational aspects of large-scale collaborations in astronomy and cosmology. The webpage of the workshop is <https://www.ictp-saifr.org/large-collaborations-in-astronomy-and-cosmology/> and panelists included:

- Luís Raul Abramo (IFUSP, Brazil)
- Beatriz Barbuy (IAG-USP, Brazil)
- Rennan Barkana (Tel Aviv Univ., Israel)
- Carlos Brito Cruz (FAPESP science director, Brazil)
- Tim Eifler (Univ. Arizona, USA)
- Roderik Overzier (Observatório Nacional-RJ, Brazil)
- Rogério Rosenfeld (ICTP-SAIIFR/IFT-UNESP, Brazil)
- Alessandra Silvestri (Leiden Univ., Netherlands)
- Marko Simonovic (CERN, Switzerland)
- Laerte Sodré (IAG-USP, Brazil)

c2E. Workshop on American Monsoons: progress and future plans (Aug. 19-24)

This external activity of ICTP Trieste brought together scientists and students to present and discuss current research on the American monsoons and their role in the global monsoon system. The webpage of the workshop is <https://www.ictp->

saifr.org/american-monsoons-progress-and-future-plans/ and speakers included:

- **Marcelo Barreiro** (Universidad de la Republica, Uruguay): Regional and remote controls of the South Atlantic Convergence Zone
- **Wenju Cai** (CSIRO, Australia): ENSO under greenhouse warming
- **Leila M.V. Carvalho** (University of California at Santa Barbara, USA):
 - Present and future of the South American Monsoon in a Warming Climate
 - Statistical methods to analyze climate variability in the South America Monsoon region
- **Iracema F. A. Cavalcanti** (CPTEC-INPE, Brazil): Main features and Life cycle –SAMS – model results
- **Tereza Cavazos** (CICESE, Mexico): Intercomparison of observed and simulated climatic trends in the North American Monsoon
- **Caio A. S. Coelho** (CPTEC-INPE, Brazil): Design and assessment of a Brazilian global sub-seasonal prediction system
- **Christopher Cuning** (CEMADEN, Brazil): Climate and weather extremes during the South American Monsoon season within the context of Disaster Risk Reduction – The CEMADEN Experience
- **Maria Assunção F. da Silva Dias** (Universidade de São Paulo (USP), Brazil): Diurnal and local variability of the South American Monsoon with possible effects of aerosol
- **Pedro L. da Silva Dias** (Universidade de São Paulo (USP), Brazil): Paleoclimatic aspects of the South American monsoon
- **Francina Dominguez** (University of Illinois at Urbana, USA): Main Features of the North American Monsoon
- **Rong Fu** (University of Texas at Austin, USA): Connections between South and North American monsoons
- **Manoel A. Gan** (CPTEC-INPE, Brazil): Main features and Life cycle –SAMS – Observations
- **Alice M. Grimm** (Universidade Federal do Paraná (UFPR), Brazil):
 - Subseasonal variability of the South American monsoon
 - Variability of the South American monsoon on interannual and decadal/ interdecadal time scales
 - Sub-seasonal prediction of South American summer monsoon active and break phases
- **Cecilia Hidalgo** (Universidad de Buenos Aires, Argentina): Collaborative processes in action: climate services and impact-based forecasts for southern South America
- **Mary Kayano** (CPTEC-INPE, Brazil): Pacific and Atlantic multidecadal oscillations: relations to the ENSO and effects on the South American rainfall

c2F. Workshop on S-matrix Bootstrap (Sept. 9-13)

The goal of this very informal workshop was to bring together specialists on different topics like the conformal bootstrap, 2D integrable S-matrices, lattice field theory, effective field theories and flux tubes, dispersion relations approaches and string theory amplitudes. The workshop was supported by the [Simons Bootstrap collaboration](#). The webpage of the workshop is <https://www.ictp-saifr.org/workshop-on-s-matrix-bootstrap/> and speakers included:

- Raul Briceno (Old Dominion Univ. and Jefferson Lab, USA)
- Sergey Dubovsky (New York University, USA)
- Barak Gabai (Harvard University, USA)
- Andrea Guerrieri (ICTP-SAIFR/IFT-UNESP, Brazil)
- Victor Gorbenko (Stanford University, USA)
- Eliot Hijano (University of British Columbia-Vancouver, Canada)
- Marton Lajer (Wigner RCP and ELTE, Hungary)
- Denis Karateev (EPFL-Lausanne, Switzerland)
- Shota Komatsu (IAS Princeton, USA)
- Martin Kruczensky (Purdue University, USA)
- Dominik Neuenfeld (University of British Columbia, Canada)
- José R. Pelaez (Universidad Complutense de Madrid, Spain)
- Alessandro Piloni (Jefferson Lab and ECT, USA)
- Ricardo Rattazzi (EPFL – Lausanne, Switzerland)
- Francesco Riva (EPFL – Lausanne, Switzerland)
- Matthew Schwartz (Harvard University, USA)
- Xiang Zhao (Durham University, UK)

c2G. Workshop on Determination of Fundamental QCD Parameters (Sept. 30 – Oct. 4)

The Workshop included seminars on state-of-the-art extractions of α_s and quark masses, theoretical developments and tools for α_s and quark-mass determinations, on the lattice and in the continuum, and the impact of QCD parameters in calculations within and beyond the SM. The webpage of the <https://www.ictp-saifr.org/workshop-on-determination-of-fundamental-qcd-parameters/> and speakers and topics included:

- **Attilio Cucchieri** (Instituto de Física de São Carlos – USP, Brazil): Alphas from QCD Vertices
- **Cesareo Dominguez** (University of Capen Town, South Africa): Determination of quark masses from QCD sum rules
- **Aida El-Khadra** (University of Illinois Urbana-Champaign, USA)
- **Jens Erler** (Universidad Nacional Autónoma de México, Mexico): Fundamental Parameters from Electroweak Fits
- **Daniel de Florian** (ICAS – Universidad Nacional de San Martín, Argentina): Precision QCD at the LHC
- **Shoji Hashimoto** (KEK – Tsukuba, Japan): Test of OPE on the Euclidean lattice
- **Christian Hoelbling** (Universität Wuppertal, Germany): Quark mass determinations from BMW collaboration
- **Yuichiro Kiyo** (Juntendo University, Japan): α_s determination from static QCD potential
- **Christopher Lee** (Los Alamos National Laboratory, USA): Probing the strong coupling and nonperturbative effects with angularities
- **Tomasz Korzec** (Universität Wuppertal, Germany): The Strong Coupling from Low Energy Physics
- **Andreas Maier** (DESY Zeuthen, Germany): Towards charm and bottom quark masses with five-loop accuracy
- **Kim Maltman** (York University, Canada & University of Adelaide, Australia): Use of recent high-precision $R(s)$ data in the determination of α_s
- **Pere Masjuan** (Universitat Autònoma de Barcelona, Spain): Heavy quark masses from QCD sum rules
- **Aditya Pathak** (University of Vienna, Austria): Precision determination of short distance top mass
- **Santiago Peris** (Universitat Autònoma de Barcelona, Spain): α_s from tau decay
- **Peter Petreczky** (Brookhaven National Laboratory, USA): Strong coupling constant and heavy quark masses in $(2+1)$ -flavor QCD
- **Antonio Pineda** (Universitat Autònoma de Barcelona, Spain): Charm and bottom quark masses from heavy quarkonium
- **Daniel Samitz** (University of Vienna, Austria): Infrared Parton Shower Dynamics and the Top Quark Mass
- **York Schroeder** (Universidad del Bío-Bío, Chile): From sum-integrals to continuum integrals and back
- **Johannes Weber** (Michigan State University, USA): Determination of the QCD coupling constant from the static energy and the free energy
- **Angelika Widl** (University of Vienna, Austria): Inclusive top quark pair production cross section at lepton colliders: Matching of threshold and continuum

c2H. Workshop on Skills for Young Scientists/Increasing Diversity in STEM (Oct. 7-11)

Both workshops were held at ICTP-SAIJR from Oct. 7-11. The Workshop on Skills for Young Scientists was aimed at women at early stages of their careers and intended to give them useful tools for a successful career development. The second workshop discussed the gender gap in science in Latin America, results obtained within the Global Gender Gap in Science Project. The webpage of the workshop is <https://www.ictp-saifr.org/workshop-on-skills-for-young-scientists-increasing-diversity-in-stem/> and speakers included:

- **Alice Rangel de Paiva Abreu** (UFRJ, Brazil)
- **Germana Barata** (UNICAMP, Brazil)
- **Alba Avila-Bernal** (UniAndes, Colombia)
- **Marcia Barbosa** (UFRGS, Brazil)
- **Henrique Cunha Jr.** (UFC, Brazil)
- **Silvina Ponce Dawson** (UBA, Argentina)
- **Díndara Galvão** (USP, Brazil)

- **Vania Ghirello Garcia** (Brazil)
- **Evelin Hasslinger** (Brazil)
- **Luciana Luna Anna Lomonaco** (IME-USP, Brazil)
- **Zelia Ludwig** (UFJF, Brazil)
- **Laura Merner** (AIP Statistical Research Center, USA)
- **Lilia Meza Montes** (BUAP, Mexico)
- **Katemari Rosa** (UFBA, Brazil)
- **Antonio Carlos Fontes dos Santos** (UFRJ, Brazil)
- **Alejandra Gonzalez Vasquez** (Universidad de Chile)

c2I. Workshop on Quantum Symmetries (Oct. 16-18)

The Workshop brought together specialists and young mathematicians to discuss several topics on mathematics applied to the study of quantum symmetries. The webpage of the workshop is <http://www.ictp-saifr.org/workshop-on-mathematical-modeling-of-infectious-disease-dynamics/> and speakers and topics included:

- **Nicolás Andruskiewitsch** (Universidad Nacional de Cordoba, Argentina): Examples of finite-dimensional pointed Hopf algebras in positive characteristic
- **Dirceu Bagio** (Universidade Federal de Santa Maria, Brazil): On Simple Modules Over a Lestrygonian Nichols Algebra
- **Yuly Billig** (Carleton University, Canada): Representations of Lie algebras of vector fields on algebraic varieties
- **Stephen Griffeth** (Universidad de Talca, Chile): Structure and character formulas for unitary representations of Cherednik algebras
- **Vesselin Gueorguiev** (Ronin Institute for Independent Scholarship, USA): q -analog of $A_{\{m-1\}} \oplus A_{\{n-1\}} \subset A_{\{mn-1\}}$
- **Reimundo Heluani** (IMPA, Brazil): Vertex algebras and arc spaces
- **Andrei Mikhailov** (IFT-UNESP, Brazil): Deformations, renormgroup, symmetries, AdS/CFT
- **Julia Pevtsova** (University of Washington, USA): Cohomology of finite dimensional Hopf algebras
- **Bárbara Pogorelski** (Universidade Federal do Rio Grande do Sul, Brazil): On the combinatorial rank of quantum groups
- **Luis Enrique Ramirez** (Universidade Federal do ABC, Brazil): Gelfand-Tsetlin modules for arbitrary characters
- **João Fernando Schwarz** (IME-USP, Brazil): Noncommutative Birational Equivalence and Applications
- **Dmitry Vasilevich** (Universidade Federal do ABC, Brazil): Index Theorems, Anomalies, and all that (IFT-Colloquium)
- **Cristian Vay** (Universidad Nacional de Cordoba, Argentina): Symmetries on modules over Drinfeld doubles

c2J. Dark Universe Workshop – Early Universe Cosmology, Baryogenesis and Dark Matter (Oct. 21-25)

The goal of the workshop was to establish collaborations between international research groups and the ongoing Brazilian efforts in cosmology and particle physics, with an emphasis on the multidisciplinary approach. The webpage of the workshop is <https://www.ictp-saifr.org/dark-universe-workshop-early-universe-cosmology-baryogenesis-and-dark-matter/> and speakers and topics included:

- **Rouzbeh Allaverdi** (New Mexico University, USA): Nonthermal Dark Matter and Baryogenesis
- **Yang Bai** (University of Wisconsin-Madison, USA): Primordial Extremal Black Holes as Dark Matter
- **Ronaldo Batista** (UFRN, Brazil): Describing Warm Dark Matter with the Reduced Relativistic Gas
- **Geneviève Bélanger** (Laboratoire de Physique Théorique – Annecy, France): Feebly interacting dark matter
- **Antonio Delgado** (Notre Dame University, USA): Higgsino DM from natural susy
- **Pasquale Di-Bari** (University of Southampton, UK): A unified model of neutrino masses, dark matter and leptogenesis testable at Neutrino Telescopes
- **Francesco D’Eramo** (Padua University, Italy): Displaced new physics at colliders and the pre-

- BBN universe
- **Sylvain Fichet** (ICTP-SAIFR/IFT-UNESP, Brazil & Caltech, USA): The warped dark sector
- **Jay Hubisz** (Syracuse U., USA): Cosmology of Brane Worlds From Symmetry Principles
- **Alejandro Ibarra** (Technische Universität München, Germany): Review on Dark Matter (IFT-Colloquium) / Astrophysical Uncertainties on Local Dark Matter Searches
- **Markus Luty** (University of California – Davis, USA): Almost Inert Higgs Bosons at the LHC
- **Adam Martin** (Notre Dame University, USA): Custodial Dark Pions
- **Mariano Quiros** (IFAE – Barcelona, Spain): Electroweak Baryogenesis and Dark CP violation
- **Diego Restrepo** (University of Antioquia, Colombia): Simplest Dirac scotogenic model
- **Tania Robens** (Ruđer Bošković Institute, Zagreb-Croatia): Constraining the Inert Doublet Model at current and future colliders
- **Riccardo Sturani** (II-P/UFRN, Brazil): Gravitational wave astronomy
- **Thiago Tomei** (NCC-UNESP, Brazil): Dark Matter Searches in CMS
- **Carlos Wagner** (Argonne Lab. & University of Chicago, USA): Higgs and Dark Matter physics in low energy Supersymmetry
- **Ivonne Zavala** (Swansea University, UK): Dark Energy and String theory
- **Alfonso Zerwekh** (Universidad Técnica Federico Santa María, Chile): Dark Matter and Vector fields in non-trivial representations of $SU(2)_L$

c2K. Eduardo Pontón Memorial Symposium (Oct. 28)

In honor of Eduardo Pontón's important contributions both in teaching and research, ICTP-SAIFR organized this symposium. The webpage of the symposium is <https://www.ictp-saifr.org/eduardo-ponton-memorial-symposium/> and speakers included:

- **Yang Bai** (University of Wisconsin-Madison, USA)
- **Cecilia Pontón Bayona** (Colombia)
- **Carlos Bautista** (IFT-UNESP, Brazil)
- **Nathan Berkovits** (ICTP-SAIFR/IFT-UNESP, Brazil)
- **Enrico Bertuzzo** (IFUSP, Brazil)
- **Gustavo Burdman** (IFUSP, Brazil)
- **Marcela Carena** (Fermilab and University of Chicago, USA)
- **Zackaria Chako** (University of Maryland, USA)
- **Sylvain Fichet** (Caltech, USA & ICTP-SAIFR/IFT-UNESP, Brazil)
- **Gero von Gersdorff** (PUC-Rio, Brazil)
- **Jay Hubisz** (Syracuse University, USA)
- **Fabio Iocco** (University of Napoli, Italy)
- **Gabriela Lichtenstein** (IF-USP, Brazil)
- **Markus Luty** (University of California – Davis, USA)
- **Ricardo Matheus** (IFT-UNESP, Brazil)
- **Luis Nasser** (Columbia College Chicago, USA)
- **Fernando Quevedo** (ICTP-Trieste, Italy /Cambridge University, UK)
- **Mariano Quirós** (IFAE Institute of High Energy Physics, Spain)
- **Rogério Rosenfeld** (ICTP-SAIFR/IFT-UNESP, Brazil)
- **Pedro Vieira** (Perimeter Institute, Canada/ICTP-SAIFR, Brazil)
- **Tim Tait** (University of California-Irvine, USA)
- **Carlos Wagner** (University of Chicago and Argonne National Laboratory, USA)

c2L. One-day Relativity Workshop (Nov. 15)

This one-day workshop included seminars on current topics in relativity. The webpage of the workshop is <https://www.ictp-saifr.org/one-day-relativity-workshop/>, and speakers and topics included:

- **John Friedman** (University of Wisconsin-Milwaukee, USA): Whispers from space: Remarkable implications of the neutron star merger GW170817
- **André Landulfo** (UFABC, Brazil): Unruh meets Larmor: Radiation, acceleration, and the surprising role of zero-energy Rindler modes
- **Maurício Richartz** (UFABC, Brazil): Analogue Gravity: an overview of recent experiments
- **Robert Wald** (University of Chicago, USA): The Particle and Energy Cost of Entanglement of Hawking Radiation with the Final Vacuum State

c3. Minicourses

In 2019, ICTP-SAIFR organized the Minicourse on Quantum Gravity from QFT perspective (April 1 – 5) with lectures by Ilya L. Shapiro, ICTP-SAIFR associate member and Professor at UFJF (Brazil). This course provided a short introductory and review course on perturbative Quantum Gravity. The website of this activity is <https://www.ictp-saifr.org/quantum-gravity-from-the-qft-perspective/>

c4. Program

In 2019 the Program on Particle Physics (<https://www.ictp-saifr.org/ictp-saifr-program-on-particle-physics/>, Sept 30 – Nov. 30) aimed to bring together top researchers working in the area of particle physics to discuss the theory and phenomenology of the most promising classes of theories beyond the Standard Model. Participants in the program include:

- **Geneviève Bélanger** (Laboratoire de Physique Théorique – Annecy, France): Oct. 14-25
- **Karim Benakli** (Sorbonne University-Jussieu-Paris, France): Nov. 12-22
- **Marcela Carena** (Fermilab & University of Chicago, USA): Oct. 20-29
- **Alexandra Carvalho** (NICPB-Tallinn, Estonia): Oct. 14-26
- **Francesco D’Eramo** (University of Padova, Italy): Oct 20 – Nov. 8
- **Antonio Delgado** (University of Notre Dame, USA): Oct. 20-25
- **Claudio Dib** (Universidad Técnica Federico Santa María, Chile): Oct 7-16
- **Diogo Franzosi** (Chalmers University of Technology, Sweden): Oct. 13- Nov. 8
- **Gero von Gersdorff** (PUC-Rio, Brazil): Oct. 27- Nov. 1
- **Maarten Golterman** (San Francisco State University, USA): Sep 30 – Oct. 19
- **Jay Hubisz** (Syracuse University, USA): Oct. 20 – Nov. 1
- **Alejandro Ibarra** (Technische Universität München, Germany): Oct. 22-27
- **Adam Martin** (University of Notre Dame, USA): Oct. 20-25
- **Eugenio Megias** (University of Granada, Spain): Oc. 31-Nov. 16
- **Germano Nardini** (University of Stavanger, Norway): Nov. 16-30
- **Matthias Neubert** (MITP/Johannes Gutenberg University, Germany): Oct. 24-29
- **Alexander Pukhov** (Lomonosov Moscow State University, Russia): Oct. 4-26
- **Diego Restrepo** (University of Antioquia, Colombia): Sept. 30-Oct. 26
- **Tania Robens** (Ruđer Bošković Institute – Zagreb, Croatia): Oct. 22 – Nov. 8
- **Alberto Tonero** (Carleton University, Canada): Nov. 18 – Nov. 30
- **Carlos Wagner** (University of Chicago, USA): Oct. 20-29
- **Alfonso Zerwekh** (Universidad Técnica Federico Santa María, Chile): Oct 6-27

c4. Outreach events

The ICTP-SAIFR organized ten outreach events in 2019 aiming at different audiences. The format, topics and webpages for these events are:

1) Papos de Física

Papos de Física is a monthly outreach program of ICTP-SAIFR introducing current topics in theoretical physics to the general public in an informal setting. The webpage for this program is <http://outreach.ictp-saifr.org/publico-leigo/papos-de-fisica/>. Topics covered during these meetings included:

- [7 de novembro – Daniel Stariolo \(UFF\) – Sistemas Complexos: o olhar da Física](#)
- [3 de outubro, 2019 – Ilana Wainer \(IO-USP\) – Efeitos Climáticos do oceano](#)
- [12 de setembro, 2019 – Eduardo Cypriano \(IAG-USP\) – Desafios da cosmologia observacional](#)
- [08 de agosto, 2019 – Fábio Iocco \(ICTP-SAIFR\) – Galáxias e Matéria Escura: Uma conexão íntima](#)
- [13 de junho, 2019 – Elisabete Dal Pino \(IAG-USP\) – Buracos Negros e Altas Energias](#)

- [20-22 de Maio, 2019 – Papos de Física no Pint of Science Brasil 2019](#)
- [04 de Abril, 2019 – Paulo Nussenzveig \(IFUSP\) – A natureza da luz](#)
- [14 de Março, 2019 – Celso Lima \(IFUSP\) – Mecânica Quântica: Características e Descaracterização](#)

2) Ciência em Diálogo no IMS: Física e Arte

This outreach program involves a monthly series of presentations at the IMS featuring one scientist and one non-scientist who discuss a topic of common interest. The webpage for the program is <http://outreach.ictp-saifr.org/dialogo/>. Topics covered during these meetings included:

- 1 de novembro: *Ordem e desordem*, com Ricardo Martinez-Garcia e Fabio Delduque (artista visual)
- 11 de outubro: *Cor*, com Marcia de Almeida Rizutto e Paulo Pasta (artista visual)
- 13 de setembro: *Computação*, com Pedro Vieira e Paula Perissinotto (artista plástica)
- 24 de agosto – REPRISE: *Música e som*, com Nathan Berkovits e Flo Menezes (músico)
- 2 de agosto: *Fotografia de partículas*, com Rogério Rosenfeld e Wagner Sousa e Silva (jornalista).
- 7 de junho: *Movimento e dança*, com Aline Ramires e Julia Abs (dançarina)
- 25 de maio – ESPECIAL: *Marc Ferrez e o eclipse de Sobral*, com Rodrigo Nemmen (IAG-USP), Rogério Rosenfeld e Cristina Barbosa (SBHC).
- 3 de maio: *Inteligência Artificial*, com Rodrigo Nemmen e Cesar Baio (artista)

3) ICTP-SAIFR distinguished Public Lectures:

The goal of this program is to bring outstanding scientists to give talks to the general public on relevant topics in physics. Topics covered in 2019 included perspectives on physics applied to biology and black holes and the structure of spacetime:

- [February 12: Juan Maldacena \(IAS Princeton\) - Black Holes and the Structure of Spacetime](#)
- [January 23: Curtis Callan \(Princeton University\) - The Biological Future of Theoretical Physics](#)

4) 4th IFT-Perimeter-SAIFR Journeys into Theoretical Physics (July 6-12)

The 4th edition of this school is described on the webpage <http://www.ictp-saifr.org/journeys> and involved 5 lecturers and 63 participants. The top students in this school were accepted to a joint master`s program where they will spend one year at Perimeter Institute (Waterloo) or at CUNY/Princeton Center for the Physics of Biological Function and one year at ICTP-SAIFR/IFT-UNESP. The students accepted to the joint program include Benjamin Garcia de Figueiredo (IF-USP, São Carlos), Leonardo Almeida Lessa (IF-USP, São Paulo), Siddhartha Emmanuel Morales Gúzman (UNAM, Cidade de México) and Marina Maciel Ansanelli (IF-USP, São Paulo)

Lecturers and Topics included:

- **William Bialek** (Princeton Univ.): Precision and emergence in the physics of biological systems
- **Cliff Burgess** (Perimeter Institute): What is the Universe made of?
- **Ricardo Martinez-García** (Princeton Univ./ICTP-SAIFR): Nonlinear phenomena in biology
- **Thiago Tomei** (NCC-UNESP/IFT-UNESP): Aspects of Experimental High-Energy Physics
- **Pedro Vieira** (Perimeter/ICTP-SAIFR/IFT-UNESP): Matrix Models

5) 2019 Prêmio IFT-UNESP/ICTP-SAIFR para Jovens Físicos (July 11)

ICTP-SAIFR organized in collaboration with IFT-UNESP a competition for undergraduate physics students held on July 11 in which winners were determined by a 3-hour exam. The webpage with the names of the 5 winners is <https://www.ictp-saifr.org/2019-ictp-saifr-competition-for-young-physicists/>

6) Minicourses for High-School Students:

This program involves several minicourses on topics of modern physics to high-school Students. The webpage for the minicourses is <http://outreach.ictp-saifr.org/ensino-medio/minicurso/> and topics covered include:

- March 16 – April 13 – Elementos de Eletromagnetismo e Relatividade – Pedro Vieira (ICTP-SAIFR & Perimeter Institute)
- April 27 to May 25 – Introdução à Mecânica Quântica – Pedro Vieira (ICTP-SAIFR & Perimeter Institute)
- June 1 – July 6 – Modelagem Matemática – Roberto Kraenkel (IFT-UNESP)
- August 10 – September 14 – Física do Universo: Cosmologia – Rogério Rosenfeld (ICTP-SAIFR/IFT-UNESP)
- September 21 – October 12 – Física das Ondas: Água, Som e Luz – Nathan Berkovits (ICTP-SAIFR/IFT-UNESP)
- October 19 – November 9 – Introdução à Física de Partículas – Ricardo D’Elia Matheus (IFT-UNESP)

Besides, Lucas David (Outreach coordinator) complemented these minicourses with additional theoretical classes on mathematical tools used in physics, electricity and magnetism and activities such as measuring Planck’s constant using LEDs and calculation of dark matter in a galaxy.

7) Workshops for High-School Teachers

This program presents classroom methods for teaching modern physics concepts to high-school teachers. In 2019 ICTP-SAIFR organized several activities in São Paulo and other states in Brazil, most of them covered by Ana Luiza Sério and Lucas David, ICTP-SAIFR outreach coordinators:

- [Nov. 30 – Dec. 1 – Special Edition: 2019 Nobel Prize – São Paulo](#)
- [Oct. 26 and 27 – Brasília](#)
- [Oct. 5-6 – Sertãozinho, Minas Gerais](#)
- [Sept. 14-15 - Cutting-edge In-class Physics Resources - Gregory Dick \(Perimeter I.\) and Laura Pankratz \(Perimeter I.\)](#)
- [Sept. 7 – Camp Serrapilheira – Rio de Janeiro](#)
- [May 19 – Special edition: 100 years of Sobral’s eclipse](#)
- [May 4-5 – Rio de Janeiro](#)
- [April 13-14 – São Paulo](#)
- [March 30-31 – São Paulo](#)

8) Physicists at the school

This outreach program involves visits of physicists to public high schools to discuss their research with the students and to answer questions about careers in physics. The webpage of the program is <http://outreach.ictp-saifr.org/fisicos-na-escola/> and visits organized in 2019 were:

- Nov. 29: ETEC Guaracy Silveira (R. Ferreira de Araújo, 527 – Pinheiros, São Paulo). Pedro Vieira (ICTP-SAIFR/Perimeter Institute)
- Nov. 4: ETEC de Sapopemba (R. Benjamin de Tudela, 155 – Fazenda da Juta, São Paulo). Nathan Berkovits (ICTP-SAIFR / IFT-UNESP)
- Oct. 21: ETEC Parque Belém (R. Ulisses Cruz, 85 – Belém, São Paulo). Roberto Kraenkel (IFT-UNESP)
- Aug. 26: Escola Estadual Doutor Américo Brasiliense (Praça IV Centenário, 7 – Centro, Santo

- André). Nathan Berkovits (ICTP-SAIFR / IFT-UNESP)
- June 7: Escola Estadual Alberto Torres (Av. Vital Brasil, 1260 – Butantã, São Paulo). Roberto Kraenkel (IFT-UNESP)
- May 13: ETEC Albert Einstein (R. Nova Granada, 35 – Casa Verde, São Paulo). Rogério Rosenfeld (ICTP-SAIFR & IFT-UNESP)
- April 24: Escola Estadual Professora Maria de Lourdes Aranha de Assis Pacheco (R. Ângelo Andrade, 51 – Cj. Residencial José Bonifácio). Roberto Kraenkel (IFT-UNESP)

c5. Weekly seminars, colloquia and journal clubs

Between December 2018 and November 2019, weekly seminars and colloquia were regularly organized. There were 134 seminars and colloquia and the complete list is on the webpage <https://www.ictp-saifr.org/2019-research-seminars-and-activities/>. The list of the seminars of December 2018 are shown at <http://www.ictp-saifr.org/other-years-research-seminars-and-activities/>. There were also weekly journal club meetings in string theory, particle physics and cosmology.

c6. Annual meeting of Steering Committee and Scientific Council

On February 4-5, 2019, the ICTP-SAIFR steering committee and scientific council met to evaluate the activities of 2018 and to discuss the future plans and activities for 2019. The program is on the webpage <https://www.ictp-saifr.org/2019-meeting-of-scientific-council-and-steering-committee-2/> and the council members are listed on the webpages <http://www.ictp-saifr.org/steering-committee/> and <http://www.ictp-saifr.org/scientific-council/>.

5. Description of Institutional Support

The ICTP-SAIFR received support from both the Instituto de Física Teórica (IFT) and from the Universidade Estadual Paulista (UNESP). All professors and secretarial staff of the IFT have been extremely supportive of all ICTP-SAIFR activities, and the ICTP-SAIFR frequently uses the services of the IFT-UNESP driver and car.

The UNESP university is providing the salary for four ICTP-SAIFR secretaries including an executive secretary, an accountant, a computer systems manager and an executive manager. UNESP has also agreed to hire 5 permanent ICTP-SAIFR researchers, and the first permanent researcher (Eduardo Ponton) was hired in 2013 at the top researcher level.

Part of the institutional reserve técnica was used in 2019 to substantially upgrade the recording equipment in the IFT-UNESP auditorium following the guidance of the Perimeter Institute audiovisual department.

6. Activity Plan for 2020

In 2020, the ICTP-SAIFR will continue and expand its research, outreach and training activities in all areas of theoretical physics. Confirmed scientific activities in 2020 which will be organized by ICTP-SAIFR include international schools and workshops on topics including mathematical biology, ecology, biophysics, nonlinear systems, particle physics, theoretical condensed matter physics, few-body systems and data science and machine learning. The list of 2020 activities confirmed up to now are on the webpage <https://www.ictp-saifr.org/2020-activities/> and include the activities:

São Paulo International Schools on Theoretical Physics

[IX Southern-Summer School on Mathematical Biology](#)

January 12-18, 2020

[School on Community Ecology: from patterns to principles](#)

January 19-25, 2020

[School on Biological Physics: from Molecular to Macroscopic Scale](#)

March 9-14, 2020

[School on Applications of Nonlinear Systems to Socio-Economic Complexity](#)

April 14-18, 2020

II Joint ICTP-Trieste/ICTP-SAIFR School on Particle Physics

June 22 – July 3, 2020

School on DFT and Beyond: Electronic Structure Theory in the Era of Data-Driven Science

July 27 – August 7, 2020

School on Critical Stability of Few-Body Quantum Systems

October 5-16, 2020

2nd School on Data Science and Machine Learning

December 14-18, 2020

Meetings/Programs/Workshops

Meeting of ICTP-SAIFR Steering Committee and Scientific Council

February 3-4, 2020

[Workshop on Sociophysics: Social Phenomena from a Physics Perspective](#)

April 19-23, 2020

PHENOEXP 2020: Physics and Beyond

May 11-15, 2020

Workshop on Fundamental Aspects of String Theory

June 1-12, 2020

Workshop on Symmetry-Protected Topological Order: Theoretical and Numerical Approaches

July 20-24, 2020

Exact Results in QFT and the Bootstrap & IGS 2020

August 17-28, 2020

Workshop on Electromagnetic Effects on Multiparticle Systems

September 9-12, 2020

SCES 2020: Satellite Workshop on Unconventional Superconductors

September 28 – October 2, 2020

Workshop on Critical Stability of Few-Body Quantum Systems

October 5-16, 2020

Workshop on Current Topics in Biological Physics: Chromatin Structure and Protein Folding

October 19-23, 2020

3rd South American Dark Matter Workshop

November 30 – December 4, 2020

Workshop on New Trends in Dark Matter

December 7-12, 2020

Latin American Workshop on Observational Cosmology
December 14-19, 2020

Outreach

Papos de Física
March – November, 2020

Minicursos para Estudantes do Ensino Médio
March – November, 2020

Ciência em Diálogo: Física e Arte
March – November, 2020

Física Moderna para Professores do Ensino Médio
March-November, 2020

2020 IFT-Perimeter-SAIFR Journeys into Theoretical Physics
July 13-19, 2020

Prêmio Jovens Físicos 2020
July 18, 2020

7. Use of Reserva Técnica Funds

Between December 2018 and November 2019, the part of the reserva tecnica funds related to “Custos de Infraestrutura Direta do Projeto” was used for the following purposes:

- a) Advertisement of postdoctoral and tenure-track fellowships at Academic Jobs Online: R\$ 1,267.11
- b) Advertisement of postdoctoral and tenure-track fellowships at Physics Today Jobs: R\$ 2,426.63
- c) Design and printing of posters and pamphlets for announcement of school and workshop activities: R\$ 21,188.20
- d) Post office expenses – delivery of School/Workshop posters: R\$ 22,867.40
- e) Purchase of supports of banners and posters: R\$ 1,453.00
- f) Purchase of office chairs for researchers: R\$1,046.00
- g) Purchase of printer cartridge: R\$ 352.80
- h) Purchase of camera and camera lens for taking pictures of ICTP-SAIFR activities and posting photos online: R\$ 3,096.45
- i) Airfare for scientific visit at DESY Zeuthen (Berlin) of ICTP-SAIFR associate member Fabio Iocco. Fabio participated in meetings and collaborations of the Cherenkov Telescope Array on the determination of roadmap for the Consortium paper on the Large Magellanic Cloud: R\$ 5,182.54.
- j) Reinforcement of sound-proof windows for research offices: R\$ 5,455.00

And the part of the reserva tecnica funds related to "Benefícios Complementares" was used for the following purposes:

- a) Airfare for ICTP-SAIFR director Nathan Berkovits to Copenhagen (Denmark) to present a talk with the title "Sketching a proof of the Maldacena conjecture at small radius" at the meeting Simons Program on Amplitudes in String and Field Theory (March 18-22) at the Niels Bohr International Academy: R\$ 4,747.52
- b) Airfare and per diem for ICTP-SAIFR director Nathan Berkovits to Florence (Italy) to present a talk with the title "Sketching a proof of the Maldacena conjecture at small radius" at the meeting String Theory from a Worksheet Perspective (April 15-May 10) at the Galileo Galilei Institute for Theoretical Physics: R\$ 3,824.75
- c) Airfare for ICTP-SAIFR director Nathan Berkovits to Bariloche (Argentina) to present a talk with the title "Pure Spinor and the AdS₅×S⁵ Superstring" at the meeting Quantum Gravity in the Southern Cone VIII (December 16-20): R\$ 2,411.37
- d) Per diem for participation in the Workshop "Cosmo@AR (October 10-14, 2018) of ICTP-SAIFR vice-director Rogério Rosenfeld in Buenos Aires, Argentina. Rogério presented a talk entitled "The Dark Energy Survey": R\$ 2,790.15
- e) Airfare for ICTP-SAIFR director Nathan Berkovits to Rio de Janeiro to participate in the roundtable *Una Agenda para el Futuro del CLAF* at the meeting 40^a Reunião do Conselho Diretor do Centro Latino Americano de Física – CLAF (November 25-26) : R\$ 705.88

8a. Articles in refereed scientific journals

8a1. Articles by ICTP-SAIFR Associate Researchers – they are presented following the order of the Project Team (item 2d)

- [1] A. J. Cenarro *et al.* including L. R. Abramo, "J-PLUS: The Javalambre Photometric Local Universe Survey," *A&A*, vol. 622, p. A176, Feb. 2019.
- [2] R. C. C. Lopes, R. Voivodic, L. R. Abramo, and L. S. Jr, "Relation between the turnaround radius and virial mass in f(R) model," *J. Cosmol. Astropart. Phys.*, vol. 2019, no. 07, pp. 026–026, Jul. 2019.
- [3] G. Sato-Polito, A. D. Montero-Dorta, L. R. Abramo, F. Prada, and A. Klypin, "The dependence of halo bias on age, concentration, and spin," *Mon Not R Astron Soc*, vol. 487, no. 2, pp. 1570–1579, Aug. 2019.
- [4] A. A. Costa *et al.* including L. R. Abramo, "J-PAS: forecasts on interacting dark energy from baryon acoustic oscillations and redshift-space distortions," *Mon Not R Astron Soc*, vol. 488, no. 1, pp. 78–88, Sep. 2019.
- [5] L. R. Abramo and L. Amendola, "Fisher matrix for multiple tracers: model independent constraints on the redshift distortion parameter," *J. Cosmol.*

Astropart. Phys., vol. 2019, no. 06, pp. 030–030, Jun. 2019.

- [6] S.K. Adhikari "Phase-separated symmetry-breaking vortex-lattice in a binary Bose-Einstein condensate", *Commun Nonlinear Sci Numer Simulat*, vol. 71, pp. 212-219, 2019.
- [7] S.K. Adhikari, "Stable controllable giant vortex in a trapped Bose-Einstein condensate," *Laser Physics Letters*, vol. 16, no. 8, p. 085501, Aug. 2019.
- [8] S.K. Adhikari, "Vortex-lattice in a uniform Bose-Einstein condensate in a box trap", *J. Phys.: Condens. Matter*, Vol. 31, pp. 27540 1-10, 2019.
- [9] R.K. Kumar *et al. including S.K. Adhikari*, "C and Fortran OpenMP programs for rotating Bose-Einstein condensates", *Computer Phys. Comm.*, Vol. 240, pp 74-82, 2019
- [10] S. Gautman and S.K. Adhikari, "Limitation of the Lee-Huang-Yang interaction in forming a self-bound state in Bose-Einstein condensates", *Annals of Phys.*, Vol. 409, pp 16791-7, 2019
- [11] S. Gautman and S.K. Adhikari, "Weaking coupling to unitarity crossover in Bose-Fermi mixtures: Mixing-demixing transition and spontaneous symmetry breaking in trapped systems, *Phys. Rev. A*, vol. 100, pp 02362 6-10, 2019.
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8a2. Articles by ICTP-SAIFR Postdoctoral Associates

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8. First page of publications

See two annexed files for publications of professors and postdocs on ICTP-SAIFR research team.

9. Scientific reports of postdocs and direct doctoral student

See annexed file for scientific reports of Jose Luis Herrera Diestra, Leonardo Guerini, Andrea Guerrieri, Bithika Jain, Ekaterina Karukes, Martin de Los Rios, Diego Medrano, Antonino Troja, Lucas Nogueira de Sá Martins

10. Scientific reports of TT and JC

See annexed file for scientific reports of Malena Stariolo, Adrianna Virmond and Isabela Pereira

11. Scientific reports of visiting fellows

See annexed file for scientific reports of Fabio Iocco