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Host Institution: Instituto de Física Teórica - UNESP

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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 São Paulo as a collaboration between the São Paulo Research Funding Agency (FAPESP), the International Centre for Theoretical Physics (ICTP-Trieste) - a category 1 institute of UNESCO, the São 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 its twelve years of existence, the ICTP-SAIFR has already established itself as the premier institute for theoretical physics in South America. Its international schools and workshops for graduate students and researchers are selected from online proposals every year by the ICTP Scientific Council and attract the top students and lecturers from all over the world to São Paulo. Since the creation of ICTP-SAIFR, the graduate physics department of IFT-UNESP has been awarded the highest rating from the national agency CAPES despite its relatively small size. And with the help of a world-class scientific council and international search committee, ICTP-SAIFR has been able to reverse the brain drain and attract the top candidates to its faculty and postdoctoral positions. Its faculty currently include **Director Nathan Berkovits**, winner of the 2009 TWAS Physics Prize for his research in string theory and the 2021 John Wheatley Award for ICTP-SAIFR's role in South America, **Vice-Director Rogério Rosenfeld**, member of the Dark Energy Survey collaboration and president of the Brazilian Physical Society from 2019-2021, **Pedro Vieira**, joint professor at Perimeter Institute and winner of the 2018 Sackler Physics Prize and 2020 New Horizons in Physics Prize for his research in quantum field theory, **Ricardo Sturani**, member of the LIGO-Virgo collaboration which was recently awarded the Nobel Prize for the detection of gravitational waves, and **Ricardo Martínez-García**, winner

of a Serrapilheira grant for his research in mathematical ecology, coauthor of the December 2020 cover of Science, and elected in 2020 as an affiliated member to the Brazilian Academy of Science. Pedro Vieira is originally from Portugal and spends 6 months per year at IFT-UNESP with a FAPESP São Paulo Excellence Chair, and Riccardo Sturani and Ricardo Martinez-Garcia came to Brazil from Italy and Spain as FAPESP Young Investigator Fellows and began their permanent positions at IFT-UNESP in February 2022 as soon as the Covid-19 hiring restrictions were relaxed.

Simons-FAPESP "tenure-track" professors and FAPESP postdocs with temporary positions at ICTP-SAIFR are annually selected through an online application process involving hundreds of applicants. For the postdoctoral positions, a final short list of candidates are interviewed by the ICTP-SAIFR faculty and associated researchers in the research area of the candidates. And for the Simons-FAPESP group leader positions, the final short list of candidates are invited to present seminars and are interviewed by members of the ICTP-SAIFR Scientific Council and International Search Committee consisting of distinguished professors including Nobel Prize winners. These ICTP-SAIFR fellowships have attracted many outstanding researchers to return or to immigrate to Brazil, reversing the brain drain. In 2024, two new Simons-FAPESP "tenure-track" professors will be selected in the areas of theoretical physics and biological physics.

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, minicourses, workshops and programs for doctoral students and researchers in all areas related to 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. Over the next years, the ICTP-SAIFR intends to build on these recent accomplishments and continue to improve its research and organizational activities and consolidate its status as the premier theoretical physics institute in South America.

Accomplishments in the Period

During the third year of the grant from December 1, 2024 - November 30, 2025, ICTP-SAIFR further advanced its role as the premier hub for theoretical physics in South America. As will be explained below, this progress heavily relied on financial support from the private non-profit institution Amigos do SAIFR due to financial restrictions imposed by FAPESP during this period, and was achieved through hiring talented junior physicists from around the world, through the training of South American graduate students and postdocs with international advanced schools and workshops and new monthly research group meetings for the São Paulo physics community, and through the preparation of the next generation of scientists by organizing various types of outreach activities for high-school students and teachers, as well as the general public.

On April 23, 2025, I received a message from the FAPESP diretorship that because of problems with previous financial reports of ICTP-SAIFR grants 2021/14335-0 and 2016/01343-7, I would need to remove my participation from all 36 projects with FAPESP that I currently coordinate. This was entirely unexpected since all financial and scientific reports had been submitted on time, and I had been informed via SAGe and via conversations with the auditors that they were all either approved or in analysis. After discussing with the directorship, I was allowed to continue my coordination of projects and was given until September 3, 2025 to provide additional documentation on the financial reports to address the unresolved complaints of the auditors.

The main two complaints were that the "diárias" of visitors included accommodations paid directly to the hotel instead of being paid to the visitor's bank accounts, and that perdiem paid to visitors was passed first to our accountant who withdrew the money in cash from her personal account. In our response submitted to SAGe on September 3, we explained the reasons for this procedure (many of our visitors are foreigners without bank accounts in Brazil, and cash withdrawal from the FAPESP bank account has a limit of 1000 reais per day) and provided fiscal invoices for all visitors at the hotel.

I have not yet received the analysis of the auditors to our response submitted on September 3, but the FAPESP directorship decided independently of this analysis to freeze all FAPESP payments to the 2021/14335-0 grant after September 3, 2025. Furthermore, FAPESP has not yet given me access to the referee´s evaluation of the previous 2024 scientific report nor the referee´s response to the previous request of additional postdoctoral funding. In November 2025, FAPESP set up an alternative project (2025/24203-5) via the university foundation Fundunesp to temporarily fund ICTP-SAIFR activities until the financial complaints of 2021/14335-0 have been resolved. However, the funds for this alternative project have not yet been received by Fundunesp. So since September 3, 2025, all ICTP-SAIFR activities have been financed by the private non-profit institution Amigos do SAIFR. Nevertheless, as will be described below, ICTP-SAIFR has continued to grow despite these unfortunate developments concerning FAPESP funding.

In 2025, ICTP-SAIFR was awarded a renewal for the fourth time of a prestigious "Targeted Grant for Institutes" from the privately funded Simons Foundation (USA). Only 12 out of 90

proposals were approved by the Simons Foundation in 2025, and this grant finances two generous Simons fellowships which are combined with FAPESP Young Investigator fellowships to attract top researchers to ICTP-SAIFR. In December 2025, the international ICTP-SAIFR search committee formed of world-leading researchers including Nobel laureate David Gross analyzed the applications of hundreds of candidates and selected 7 candidates for the short list who will be interviewed in person in January 2026.

Previous awardees of this Simons-FAPESP fellowship at ICTP-SAIFR are the Italian physicist Dario Rosa working in quantum chaos and the American physicist Jaron Kent-Dobias working in statistical mechanics and machine learning. Dario Rosa came to ICTP-SAIFR from a group leader position in South Korea in January 2024, and passed a concurso for a permanent position at IFT-UNESP in October 2025. Jaron Kent-Dobias came to ICTP-SAIFR in January 2025 after postdoctoral positions in Paris and Rome. Over the next two years, IFT-UNESP plans to open 4 new permanent positions in different research areas and Dr. Kent-Dobias will be a very strong candidate for one of these positions.

In addition to the two tenure-track fellowships, the new Simons grant includes fumding of an interchange agreement with the Bhaumik Institute for Theoretical Physics of the University of California at Los Angeles (UCLA). Bhaumik Institute has promised funding of a joint faculty member in gravitational wave physics who will spend 9 months per year at ICTP-SAIFR and 3 months per year at UCLA, and the Simons Foundation will fund students and postdocs who will interact with the joint faculty member. This new agreement with the Bhaumik Institute of UCLA will be similar to ICTP-SAIFR´s agreement with the Perimeter Institute for Theoretical Physics in Canada which funds the joint faculty member Pedro Vieira who spends 6 months per year at ICTP-SAIFR and 6 months per year at Perimeter.

2025 was declared the International Year of Quantum Science and Technology (IYQ) by the United Nations, and ICTP-SAIFR was the primary South American center for organizing quantum-related activities. Together with ICTP in Trieste and the Lincei Academy in Rome, ICTP-SAIFR organized in May one of 25 "IYQ Global Events" including roundtable discussions with representatives from Latin American countries. This event led to creation of the Latin American Quantum Alliance (LAQuA) hosted by ICTP-SAIFR, and the organization of regional group meetings of the São Paulo community in quantum research. For researchers, ICTP-SAIFR organized in March a joint satellite meeting with the American Physical Society (APS) with one hour of seminars from the APS Global Physics Summit in Anaheim and one hour of seminars from the IFT-UNESP auditorium, two 2-week intensive programs in June and September on quantum information/condensed matter physics and quantum many-body dynamics, and two 1-week conferences in July and September on quantum matter and quantum materials. For advanced graduate students, ICTP-SAIFR organized two-week schools in October and November on quantum optics and non-equilibrium quantum many-body systems. For the general public, ICTP-SAIFR created a multimedia platform describing the achievements of quantum research during the past 100 years and Brazil´s contributions, organized public lec-

tures by Subir Sachdev (Harvard) and Brazilian researchers, and organized informal discussions on seminars, books and movies. For high-school teachers, ICTP-SAIFR organized weekly online courses certified by the São Paulo Board of Education showing how to introduce quantum mechanics into the curriculum, as well as an intensive one-week workshop in January in both Portuguese and Spanish.. And for high-school students, ICTP-SAIFR organized a one-week intensive course in July on quantum science and technologies, as well as Saturday minicourses on quantum mechanics and other subjects.

In addition to these activities related to quantum science, ICTP-SAIFR continued its activities related to the research areas of biological physics, statistical mechanics, data science, cosmology, astrophysics and field theory. In biological physics, ICTP-SAIFR organized in March a workshop on the Physics of Life which led to the creation of the Physics of Life South American Network (PolSAN), chaired by IUPAP president and ICTP-SAIFR visiting researcher Silvina Ponce Dawson, which organizes hybrid seminars hosted by ICTP-SAIFR. And for advanced graduate students, ICTP-SAIFR organized schools in 2025 on synchronization (Feb. 3-14), origins of life (March 10-21), physics of life (March 24-28), biomolecular simulations (April 14-19) infectious disease dynamics (May 12-18), and biological physics (Nov. 10-14).

In statistical mechanics and data science, ICTP-SAIFR organized a São Paulo School of Advanced Science on Disordered Systems with special funding from FAPESP, a workshop on soft matter, and a school on data science and machine learning. In cosmology and astrophysics, ICTP-SAIFR organized the two-week V Joint ICTP-Trieste/ICTP-SAIFR School on Cosmology, the CLAF/ICTP-SAIFR Latin-American Astroparticle Physics School, a school and workshop on multi-neutron clusters in nuclei and stars, and monthly research group meetings of the São Paulo community And in field theory, ICTP-SAIFR organized a 4-week program from July 21 - August 15 on the Simons Collaboration Boostrap and Fundamental Aspects of String Theory. This 4-week program included over 100 researchers and was completely funded by the Simons Foundation. In addition, ICTP-SAIFR organized a 2-week school on holography and gravity, and a 1-week school and 1-week conference on applications of QCD to gravity.

These accomplishments and others are all described in the bimonthly scientific bulletins at `https://www.ictp-saifr.org/scientific-bulletins/`.

Subsections 4.1 - 4.3 below will describe the research publications, visitors and activities during this period, and subsection 4.4 will repeat the request for additional postdoctoral fellowships which was submitted with the previous 2024 report but a response has not yet been received.

4.1 Research Related to Publications

The research conducted at ICTP-SAIFR during this period included various subareas of theoretical physics and its applications, ranging from high-energy physics and string theory, to condensed matter, gravity and cosmology, complex sytems and quantum physics. The publi-

cations involved research performed by principal and associated researchers, postdoctoral and direct-doctoral fellows, and visitors of ICTP-SAIFR. Several ICTP-SAIFR researchers are also members of international experimental collaborations such as the CMS particle detector at the LHC in Switzerland, the LIGO gravitational wave detector in the USA, and the Dark Energy Survey telescope in Chile. In this period, ICTP-SAIFR researchers had a total of 170 publications, with some of the main research outcomes that will be briefly described in the following sections.

4.1.1 High Energy Physics

String Theory

The research outcomes in string theory have mostly focused on the holographic correspondence of AdS/CFT, the conformal bootstrap program, and the study of the so-called pure-spinor formalism for the quantization of superstring theory.

In the realm of the AdS/CFT correspondence, historically a major role has been played by the celebrated duality between the $\mathcal{N} = 4$ super Yang-Mills (SYM) and type IIB string theory on $\mathrm{AdS}_5 \times S^5$, given the high analytical control at disposal on both sides of the correspondence. In [1], the authors have addressed the problem of describing, from the gauge theory side of the correspondence, the correlation functions of three $1/2$ BPS *huge* operators, *i.e.* operators having large conformal dimension. Operators of this kind are particularly interesting since, unlike operators with small conformal dimension, they are dual to gravitational sources that heavily backreact on the gravitational backgrounds, and thus they cannot be described within a framework involving a gravitational probe in a fixed background. In this paper, the authors have been able to show that this set of correlation functions can be mapped to some matrix model representations, which in certain cases can be handled analytically. Moreover, these matrix model representations can be mapped to some $1+1$ dimensional integrable hydrodynamic fluid problems, which therefore highlight a new integrable corner of the AdS/CFT correspondence. Remaining in the realm of $N = 4$ SYM, in [2] the authors have tested the prediction of the Conformal Regge Theory, according to which the conformal field theory data, for a given conformal field theory, should organize in families that can be described by analytic functions in the complex spin. However, this description seems at odds with the known fact that there are many more large spin operators compared with small spin operators. The authors, working mostly with $N = 4$ SYM as an explicit playground, have provided a coherent physical picture for this puzzle, showing that operators do actually organize into analytic families, but the continuation of the higher families develop zeros in their structure operator product expansion constants for lower integer spins, thus terminating the trajectory at finite values of the spin.

Remaining in the field of AdS/CFT, but moving away from the realm of $N = 4$ SYM, in [3] the authors have worked on the spectrum of half-BPS single-particle operators of the

D1-D5 system, which, via AdS/CFT, is dual to he spectrum of Kaluza-Klein modes of tensor and graviton multiplets in $AdS_3 \times S^3$. The main achievement of the research has been to provide *simple* formulas for all four-point correlators of scalar half-BPS primary operators in the spectrum, at tree level. The key insight to reach this result has been the use of the *generalized Mellin space*, a generalization of the Mellin space that includes a discrete Mellin transform on the R-symmetry coordinates. In this way, the resulting Mellin amplitudes had been written in terms of a small set of building blocks with manifest properties under a six-dimensional symmetry.

In the field of the S-matrix bootstrap, the authors of [4] have introduced the notion of branon jets, which are states of collinear flux tube excitations. Arguing for the analyticity, crossing and unitarity of the multi-particle scattering of these jets, the authors have placed bounds on a set of finite energy *multi-particle* sum rules. These results are important in that they delve for the first time into amplitudes of the form $2 \to n$; thus going beyond the standard S-matrix bootstrap, in which only $2 \to 2$ amplitudes are considered and constrained.

Finally, in the field of the pure-spinor formalism for the quantization of the superstring, a major achievement has been obtained in [5] where, within the framework of the pure-spinor formalism, it has been introduced a new prescription for superstring amplitude computations. The advantage of this new prescription is that it is related, via a $U(5)$-covariant field redefinition, to the Ramond-Neveu-Schwarz amplitude prescription. In this way, the two main formalisms for computing the superstring amplitudes, the Ramond-Neveu-Schwarz formalism and the pure-spinor formalism, are manifestly shown to be equivalent. Another result concerns the possibility of writing a theory for the heterotic string fields using the hybrid formalism. In [6], the authors have achieved a first step in this direction, by constructing the quadratic term in the heterotic string field theory action while keeping manifest $N = 1$, $d = 4$ super-Poincaré invariance in terms of three string fields.

Other publications related to string theory are [7–10].

Particle and Astroparticle Physics

The Standard Model (SM) of particle physics has by now been tested to great precision at LHC, and active investigations (both theoretical and experimental) are looking for phenomena going beyond the predictions of the SM. Also, the over- whelming astrophysical evidence for the existence of dark matter points to the incompleteness of the SM. The researchers of ICTP-SAIFR have actively worked on all these important subjects.

Results from the CMS collaboration working at the LHC were reported in [11–58]. Some highlights of the main outcomes are listed below:

1. In [39], the collaboration has reported the results of a search for the rare decay $D^0 \to \mu^+\mu^-$, by means of proton-proton collision events at $\sqrt{s} = 13.6$TeV, collected by the CMS detector during the period 2022–2023, finding no significant excesses. This search

has utilized, for the first time, a newly developed inclusive dimuon trigger, which has expanded the scope of the CMS flavor physics program.

2. In [42], a measurement is presented of the cross section in proton-proton collisions for the production of two W bosons and one Z boson. The measurement is based on data recorded by the CMS experiment at the CERN LHC at center-of-mass energies $\sqrt{s} = 13$ and 13.6 TeV. The analysis reports both nonresonant WWZ production and ZH production, with the Higgs boson decaying into two W bosons. This is the first time that the two processes are measured separately in a simultaneous fit.

3. In [27] the collaboration has reported the first search for a heavy neutral spin-1 gauge boson (Z') with nonuniversal fermion couplings produced via vector boson fusion processes and decaying to tau leptons or W bosons. The analysis has been performed by means of the data collected at LHC by the CMS experiment at $\sqrt{s} = 13$TeV from 2016 to 2018. The results are in perfect agreement with the standard model predictions.

4. [52] reports a study on the bound states of charm and anticharm quarks, known as charmonia. These states have a rich spectroscopic structure that can be used to probe the dynamics of hadron production in hadron collisions. Using the data collected by the CMS detector, the cross section ratio of excited ($\psi(2s)$) and ground state (J/ψ) vector mesons is measured, as a function of the charged-particle multiplicity in proton-lead collisions at a center-of-mass energy per nucleon pair of 8.16 TeV.The ratio is measured separately for prompt and nonprompt charmonia. The prompt measurements are compared with a theoretical model which includes interactions with nearby particles during the evolution of the system. These results provide additional constraints on hadronization models of heavy quarks in nuclear collisions.

Departing from the CMS collaboration results, in [59] the authors present a renormalizable $SO(10)$ grand unified theory with a minimal Yukawa sector (which includes 19 parameters) where CP violation has a spontaneous origin. In this framework, the authors show that the model is capable of simultaneously reproducing the observed fermion masses and mixings, including neutrino oscillations, as well as the baryon asymmetry of the universe via thermal leptogenesis. These results demonstrate that a minimal and predictive $SO(10)$ scenario with spontaneous CP violation can simultaneously address several outstanding puzzles in particle physics and cosmology.

In [60] the authors focus their attention on the phenomenon of neutrino oscillation, which constitutes an unambiguous evidence of physics beyond the Standard Model. Experiments have by now established that neutrinos have tiny masses and that they oscillate among different flavors. However, the origin of such tiny masses remains unknown (together with other questions regarding the neutrino sector). In this paper, the authors investigate minimal scalar leptoquark models that dynamically generate neutrino masses at the one-loop level. It is shown that these

models can produce viable neutrino masses, consistent with neutrino oscillation and cosmological data. Moreveor, by using leptoquark couplings fixed by neutrino data, the investigation predicts additional contributions to neutrinoless double-beta decays.

Additional research results in the area are [61–87].

Cosmology, Astrophysics and Gravity

ICTP-SAIFR researchers are taking part in international collaborations to explore the cosmos, such as the Dark Energy Survey (DES), Dark Energy Spectroscopic Instrument (DESI), Cherenkov Telescope Array (CTA), the Rubin Observatory's Legacy Survey of Space and Time (LSST), the Javalambre Physics of the Accelerated Universe Survey (J-PAS) and the related S-PLUS and MiniJ-PAS surveys, the Laser Interferometer Gravitational-wave Observatory (LIGO), KAGRA and Virgo Collaborations.

Results from DES and LSST are described in [88, 89]. The key insights are as follows:

1. [88] presents cosmological constraints from the joint analysis of the three important (and complementary) probes used to investigate the large-scale structure of the universe: Cosmic shear, galaxy clustering, and the abundance of massive halos. The results consider the cosmological correlation between the different tracers, and they account for the systematic uncertainties that are shared between the large-scale lensing correlation functions and the small-scale lensing-based cluster mass calibration. The obtained results have a high level of precision, thus highlighting the benefits of multiwavelength multiprobe cosmology. This analysis paves the way for upcoming joint analyses of next-generation datasets.

2. [89] presents the joint tomographic analysis of galaxy-galaxy lensing and galaxy clustering in harmonic space, using galaxy catalogues from the first three years of observations by the Dark Energy Survey. The paper presents, for the first time within the DES, results from a combination of two angular power spectra in harmonic space, namely the two-point correlation of galaxy positions and the cross-correlation of galaxy positions and shapes. This new methodology is tested for internal consistency and robustness, and the results are compared to the ones obtained from the configuration space analyses on the same dataset. This work represents an important milestone, since it probes the robustness of the different analyses of DES data, being a completely independent data reduction to a different set of summary statistics. Researchers expect the methodology presented in this work to pave the way for and incentivize future harmonic space analyses of significantly larger datasets from next-generation Stage-IV imaging programs.

Results from CTA are in [90, 91] and they are summarized below:

1. In [90], the collaboration presents forecasts of the sensitivity of the forthcoming Cherenkov Telescope Array Observatory (CTAO) to annihilating or decaying dark matter signals in

dwarf spheroidal galaxies (dSphs) orbiting the Milky Way. These are considered prime targets for the search for indirect dark matter signatures in the GeV-to-TeV γ-ray range. To this goal, an original selection of candidates is performed from the current catalogue of known objects. For each of those objects, the expected content of dark matter is derived, using the most comprehensive photometric and spectroscopic data available. This approach enables the derivation of novel astrophysical factor profiles for indirect dark matter searches, which are then compared with results from the literature.

2. In [91], the collaboration explores the feasibility of detecting new Galactic transients with the Cherenkov Telescope Array Observatory, and the prospects for studying them with Target of Opportunity observations. The analysis shows that CTAO will likely detect new sources in the TeV regime, such as the massive microquasars in the Cygnus region, low-mass X-ray binaries with low-viewing angle, flaring emission from the Crab pulsar-wind nebula, among others.

Moving to the LIGO, KAGRA, Virgo collaboration, in [92] are reported the results of a search for continuous gravitational wave emission from a set of 45 known pulsars in the first part of the fourth LIGO–Virgo–KAGRA observing run. Continuous gravitational waves (CWs) emission from neutron stars carries information about their internal structure and equation of state, and it can provide tests of general relativity. By conducting a targeted search for each pulsar, using three independent analysis methods considering single-harmonic and dual-harmonic emission models, researchers found no evidence of a CW signal. The analysis also found no evidence of nonstandard polarizations as predicted by the Brans–Dicke theory.

Other results in the broad area of cosmology, astrophysics, and gravity include [93–116].

4.1.2 Complex Systems

Biological and Ecological Systems, Statistical Physics

The research activity in this field has been highly diversified, with results ranging from ecology to the physics of proteins, passing through optimization problems of relevance for AI applications and results in statistical physics.

The paper [117] addresses a well-known problem in data-driven approaches to physical modeling (which collectively aim in deriving the evolution equations directly from experimental data), which is the task of finding a balance between reproducing the experimental data and avoid overfitting features. In the context of dynamical systems, the data are represented by the trajectories, whose temporal evolution is modeled by differential equations (deterministic or stochastic). In this paper, the authors have established a rigorous framework, using extreme value statistics for model selection, to compare stochastic models and guide data-driven methods. The authors have shown and tested extensively that the method they developed is robust and efficient.

In [118], the author has considered the problem of finding N-dimensional configurations which simultaneously satisfy a set of M non-linear constraints while living on a $(N-1)$-dimensional sphere. This constitutes a standard setup in constraint satisfaction problems, which form a basis for thinking about problems as diverse as neural networks, granular materials, ecosystems, and confluent tissues. When solutions to this problem exist, they form a manifold. The author has computed the average Euler characteristic of this manifold in the limit of large N, and found different behaviors depending on the values of the parameters defining the specific problem. The analysis has shown that this behavior splits into five different phases, with different implications for the topology of the solution manifold.

In [119] the authors have studied the behavior of the chromosome structure across the cell cycle. It is known that, during the cell division, chromosomes change folds and assume different shapes. The authors have combined a maximum entropy approach with polymer physics to model an ensemble of chromosomal structures consistent with Hi-C data during mitosis, thus generating an effective energy landscapes for chromosomal structures at different stages during the cell cycle. The modeled chromosomes show hierarchical helical ordering at two scales: high-periodicity turns at local regions, and low-frequency turns spanning larger segments. The results of the analysis suggest the importance of the liquid-crystalline properties of chromatin during cell cycle rearrangements.

In the paper [120] (which shows huge overlaps with the research performed in quantum physics described below), the authors explore the possibility of using quantum simulation to study open-system molecular dynamics in non-perturbative regimes. In this work, the authors present the first trapped-ion simulation of charge and exciton transfer in a multi-mode linear vibronic coupling model. The relevance of the work resides in that itestablishes a scalable and hardware-efficient route to simulate many-mode vibronic processes with engineered environments, guiding the design of next-generation organic photovoltaics and molecular electronics.

Other works in this area include [121–147].

Condensed Matter Theory

An important research line in condensed matter has been in investigating and characterizing the properties of materials known as metal trihalide perovskites. These materials are emerging as extremely important in the field of sustainable energy, since they offer exceptional light absorption and cost-effective production. In [148], it has been presented a method to determine exciton binding energy and reduced effective mass in bulk halide perovskites, while considering polarization effects due to carrier interactions with longitudinal optical phonons. The method estimates the exciton-polaron binding energy from optical absorption measurements, using a recently developed Elliott-based band fluctuations (EBF) model. The reduced effective mass is then obtained via the integration of this EBF model with the Pollmann–Büttner exciton-polaron model. Based on the results of this investigation, researchers have concluded that the

Pollmann–Büttner model provides an effective approach for determining the reduced effective mass in metal trihalide perovskites. Remaining in the field of characterizing materials, another research line has regarded the characterization of hexagonal ice, denoted by I_h, *i.e.* the most common structure of ice. Notably, although this is the common ice structure, it still exhibits a variety of fascinating properties, for which a comprehensive theoretical description remains lacking. In this context, deep potentials have been recently introduced to investigate the properties of ice I_h, aiming to match the accuracy of ab initio simulations with the simplicity and scalability of classical molecular dynamics. In [149], authors have used machine learning potentials to simulate the structural and vibrational properties of ice I_h. Through this approach, they have shown that most functionals overestimate the density of ice compared to experimental results. Furthermore, a quantum treatment of the nuclei leads to even further distancing from experiments.

Another line of research, in a sense at the boundary between condensed matter and quantum physics, has focused on finding protocols to effectively create useful qubit states in quantum many-body systems. In [150], the authors have been able to show that, starting from an interacting quantum impurity model (in this specific case, a spin $1/2$ transverse-field quantum Ising chain with an impurity at its edge), and acting with a local perturbation protocol, it is possible to engineer an X state at the edge of the system. The term X state refers to a class of special two-qubit states, which encompasses many interesting entangled two-qubit states like the Bell states and the Werner mixed states. The results of this paper are important because they show the possibility of building interesting states, useful for quantum information processes, by actively driving a quantum many-body impurity system and waiting for the relaxation of the spurious excitations.

One of the main challenges in strongly interacting systems is to disentangle the various types of excitations. One promising possibility that has gained attention in the past few years is shining trains of pulses onto the sample, in the so-called multidimensional spectroscopy. The term "multidimensional" refers to the multiple independent frequencies associated with arbitrary delays between the pumps and the probe. This approach has benefited from recent experimental advances in generating multiple coherent pulses in the terahertz regime, which matches the characteristic frequency scale of excitations in these systems. In [151], involving both experimentalists and theorists, the authors have explored novel features of multidimensional spectroscopy in superconductors. A key challenge in superconductors is to disentangle contributions from quasiparticles and the collective amplitude (Higgs) mode. This work shows that this is possible via a specific process in multidimensional spectroscopy, known as a *quantum echo*, which in the paper has been analyzed at energies equal to twice the superconducting gap.

Other papers in condensed matter include [152–158]

4.1.3 Quantum Physics

In quantum physics, the research efforts have been tailored towards a diversified set of problems. On one hand, research has focused on the study of quantum chaos in many-body systems, its violations, and how these effects can be used for applications in the growing fields of quantum technologies and quantum thermodynamics. Another line of research has been towards the study of quantum many-body effects in models of relevance for experimental applications, like in cavity QED architectures.

The paper [159] has analitically investigated the charging dynamics of Sachdev-Ye-Kitaev (SYK) models as quantum batteries, with a particular focus towards the possibility of obtaining super-extensive scalings (in the number of Majorana fermions) of the charging power, this being a critical indicator of the presence of a quantum advantage. By designing an innovative method, which recasts the charging process into an effective random walk problem in operator space, the researchers have established rigorous conditions for the quantum advantage in SYK batteries and they extended these insights to graph-based SYK models. The methods developed could be useful for broader implications in the study of quantum dynamics. The relevance and the international visibility of the research performed at ICTP-SAIFR in the field of quantum thermodynamics is further certified by the publication [160]. In this review, a group of international researchers have joined their efforts to envision the next challenges and steps in the quantum thermodynamics research, with the goal of paving the way towards future applications of these results.

The paper [161] addresses the important problem of developing new methodologies to describe the dynamics of dissipative quantum many-body systems. Finding efficient tools for studying this dynamical regime is of uttermost importance, since recent experiments with quantum simulators have demonstrated the potential of controlled dissipation as a tool for realizing correlated many-body states (an example of a similar phenomenon is represented by the results of [150] already mentioned in the condensed matter section). The authors have introduced an efficient nonperturbative framework that combines the superposition of Gaussian states variational ansatz with the quantum trajectory approach to simulate open systems featuring a dissipative impurity. In the field of cavity QED framework, the paper [162] explores the dynamics of two-dimensional Rydberg atom arrays coupled to a single-mode optical cavity, employing nonequilibrium diagrammatic techniques to capture nonlinearities and fluctuations beyond mean-field theory. Through this methods, the authors reported a novel prethermalization regime driven by the interplay between short-range Rydberg interactions and long-range photon-mediated interactions.

Other publications in the broad area of quantum physics include [163–170].

4.2 Research Related to Visitors

During this period, the ICTP-SAIFR hosted 80 long-term and 320 middle-term visitors whose names and affiliations are here. The research developed by some of these visitors, as well as a few comments about their stay, are presented below:

Sitender Pratap Kashyap: (Prague, Inst. Phys., Czechia) – (01/09/2025 - 01/12/2025)
We carried out the following works.

1. We analysed an alternative prescription for computing tree-level superstring amplitudes in the Pure Spinor formalism, which avoids the usual ghost-number-three measure $\langle \lambda^3 \theta^5 \rangle = 1$ by using only ghost-number-zero integrated vertex operators. Testing this prescription on the massless three-point amplitude (one boson and two fermions), we computed the correlator using free superspace OPEs. The result failed to reproduce the known amplitude and, importantly, violated $SL(2, \mathbb{C})$ invariance. Since this inconsistency persists under cross-checks, we concluded that the ghost-free prescription—and therefore the B-RNS-GSS formalism in its current form—is incomplete and cannot replace the standard PS prescription. This work has been published, see [7].
2. We also developed a direct method to compute the same amplitude using the fully interacting OPE, including regular terms that are usually neglected. This provides an independent check and resolves subtleties of the free-OPE computation and at the same time is an important exercise in 2D CFT. A draft is being completed.
3. Separately, we have found a prescription for computing the closed-string two-point amplitude in the Pure Spinor formalism, filling a gap in the existing literature. A draft of this work is also in preparation.

Ricardo Martinez-García: (CASUS / HZDR, Germany & ICTP-SAIFR/IFT-UNESP, Brazil) – (01/02/2025 - 14/02/2025)
I visited SAIFR twice in 2025. In my first visit (January 2025), I collaborated with SAIFR fellows Rafael Menezes and Pablo de Castro on different projects that combine stochastic processes, nonlinear dynamics, and statistical physics to answer ecological questions. More specifically, we developed theoretical models and statistical tools linking empirically observed patterns of animal movement to emergent spatiotemporal population dynamics. I am a SAIFR associate and external member of the IFT Graduate program and I list SAIFR as my secondary affiliation in all my papers. I provide a selection below, prioritizing those that are under review in high-profile journals and/or involve IFT students. A full list of my 2025 publications is available here: https://scholar.google.com/citations?view_op=list_works&hl=en&hl=en&user=tak0qSUAAAAJ&sortby=pubdate. Please feel free to reach out if you need more information. During my second visit, I taught one of the

SAIFR-PERIMETER Journeys mini-courses and dedicated a very small part of my time to the collaborations mentioned above.

arXiv links:

1. https://arxiv.org/abs/2409.04268v2.
2. https://arxiv.org/abs/2507.17058.
3. https://arxiv.org/abs/2505.08671.
4. https://arxiv.org/abs/2409.11433.

Zlatko Papic: (University of Leeds, England) – (02/09/2025 - 20/09/2025)
My visit consisted of co-organizing a program on Quantum Many-Body Dynamics: Thermalization and its Violations. During the visit, I had several scientific discussions with the program participants and have also worked on finalizing one paper mentioned below, which is currently under review in Reports on Progress in Physics (the arXiv version does not acknowledge the ICTP-SAIFR grant, but I will fix that in the revised version).

arXiv links:

1. https://arxiv.org/abs/2510.12875.

Nils Siemonsen: (Princeton University, USA) – (10/05/2025 - 24/05/2025)
During my three-week visit to the ICTP, I had the opportunity to take part actively in its scientific life. I delivered a mini-course on black hole superradiance and gave a seminar on using gravitational waves to probe new physics, both of which led to stimulating discussions and valuable feedback. Throughout my stay, I engaged in many fruitful exchanges with faculty, postdocs, and students, exploring ongoing research projects and developing new ideas. I also enjoyed informal conversations and interactions that helped deepen connections within the community. Overall, the visit was scientifically enriching and provided an excellent environment for collaboration and the exchange of ideas.

Comment about the visit: I had a great time at ICTP! One piece of feedback may just be that it would be beneficial to send out these surveys shortly after the end of the visit. My stay is now several months ago, and I simply don't remember all details of it.

Ivan Khaymovich (Nordita, Sweden) – (07/09/2025 - 20/09/2025)
Being a part of the ICTP-SAIFR program on Quantum Many-Body Dynamics: Thermalization and its Violations, I had a privelege to discuss with the top researchers in the above field. Our intensive discussions were related (but not limited) to the topics of - the localization properties of the correlated disorder in finite-dimensional lattices and on hierarchical graphs, - stabilizer

Renyi entropy and its relation to the multifractal wave-function properties, - kinetically constrained non-Hermitian models, - dynamical probes of quantum chaos, and - universal dynamics of short-range models with correlated disorder.

Comment about the visit: The school/workshop, organized by ICTP-SAIFR was on the level of the world's top conferences in the field and gave me a lot of things to think about later.

Wei Chen (PUC-Rio, Brazil) – (21/06/2025 - 28/06/2025)
We argue that because the valence band quantum metric determines the optical transition matrix element, a wide variety of dielectric and optical properties of semiconductors are actually quantum geometric effects, including charge susceptibility, optical conductivity, dielectric function, refractive index, absorption coefficient, reflectance, and transmittance. As a consequence, the spread of valence-band Wannier function, equivalent to the momentum integration of quantum metric, can be experimentally detected from the dielectric function. Applying our theory to 2D materials indicates that the quantum metric can be measured from absorbance, as demonstrated particularly for transition metal dichalcogenides. Furthermore, for topological materials, we examine the differential geometrical properties resulting from the quantum metric. Their momentum space is found to be always a maximally symmetric space with a constant Ricci scalar, and the vacuum Einstein equation is satisfied in 3D with a finite cosmological constant, indicating the peculiar yet universal quantum geometrical properties of these models.

arXiv links:

1. https://arxiv.org/abs/2409.04893.
2. https://arxiv.org/abs/2405.06146.
3. https://arxiv.org/abs/2506.14501.
4. https://arxiv.org/abs/2406.15145.

Jörg Schmalian (KIT, USA) – (31/08/2025 - 07/09/2025)
Most of my time was spent participating in the workshop Frontiers in Quantum Materials, an exceptionally well-organized event of outstanding academic quality. I greatly enjoyed the talks, the stimulating discussions during the breaks, and the overall atmosphere. My sincere congratulations to the organizers for putting together such a strong and engaging program. The most notable research outcome from discussions during my visit is an ongoing collaboration with Rafael Fernandes (Univ. of Illinois) and Rui Aquino of ICTP-SAIFR on the Hall viscosity of altermagnets, a recently identified class of unconventional magnetic systems. During the visit, we initially conjectured - and eventually proved - that the Hall viscosity provides a clear diagnostic for identifying an altermagnet. We subsequently carried out a symmetry analysis of the effect and developed the theoretical framework for the acoustic Faraday effect as an experimental probe of this quantity. We are now complementing these results with a more microscopic

analysis and are optimistic that this work will soon be ready for publication. Thank you again for hosting me at ICTP-SAIFR.

Comment about the visit: I loved visiting ICTP-SAIFR and would love to come back in the future.

Rodrigo Soto-Garrido (Pontifical Catholic University, Chile) – (15/06/2025 - 24/06/2025)
I was one of the organizers of the Program on Anomalies, Topology, and Quantum Information in Field Theory and Condensed Matter Physics. I attended the lectures and talks given by the invited lecturers and speakers. We engaged in several discussions about the topics presented during the program and spoke with students during the coffee breaks and poster sessions.

Comment about the visit: I just want to thank the local organizers again. They did a wonderful job providing everything we needed for a successful program. The accommodations and the food were excellent, and everything ran smoothly. It's a wonderful place to visit and to engage in research.

Alessandro Podo (IHES, France) – (20/07/2025 - 01/08/2025)
As a first-time participant to a Bootstrap Collaboration conference I greatly benefited from interactions and discussions with the other conference participants. The research I performed during my visit was in collaboration with Slava Rychkov, on the theoretical study and proposal of a test of conformal invariance that can be effectively realized and carried out in the real world. The work in on progress but proceeding steadily and should be finalized in the coming months. I also greatly benefited from discussions and interactions with many other members of the collaboration, among which Antonio Antunes, Miguel Correia, Subham Dutta-Chowdhury, Manuel Loparco, and many others.

Comment about the visit: The workshop was a great success, both from the scientific and from the social point of view.

Ubirajara Van Kolck (French National Institute of Nuclear and Particle Physics, France) – (31/05/2025 - 07/06/2025)
Quantum systems can have sizes much larger than the range of the interaction and, as a consequence, display unique structures. One is a halo, first discovered in the form of halo nuclei, where a "valence" particle orbits at a large distance from a tight cluster of other particles. A related phenomenon is that of a shallow resonance, where the additional particle is almost bound. The simplest system of this type is the ground state of the 5He nucleus, a shallow resonance in neutron-alpha scattering. The fact that this nucleus is not bound has important implications for nucleosynthesis. A systematic treatment for this class of system is provided by the framework of effective field theory, which treats the tight cluster as an explicit degree of freedom and

exploits an expansion on the ratio of interaction range to system size. In particular, Halo EFT (HEFT) has been applied to the two-body halo 5He, but there are puzzles in the description of the three-body halo 6He, which trace back to the 5He. During my visit I worked on a new organization of the HEFT expansion for 5He.

Pedro Jorge Martinez (Universidad Nacional de La Plata, Argentina) – (11/07/2025 - 19/07/2025) My visit was only one week long. In this week I discussed with Professor Pedro Vieira on the possibility some of his work on huge conformal dimension operators n-point functions in the context of AdS/CFT to a mathematically similar problem we found in a previous work of mine related to Renyi entropies in AdS/CFT. I had an analytic candidate solution in mind but with the help of Prof Vieira we realized that my proposed ansatz was inconsistent. As a product of that interaction I am currently collaborating with Cesar Agon and are on the right track to write a paper on a new analytic sddle in the context of AdS3/CFT2 for Renyi entropies wich is neither connected nor disconnected and dominates at Renyi parameter n-¿0. Our recipe can be extended to higher dimensions.

Comment about the visit: I am very grateful to Profs Nathan and Pedro for this opportunity to visit SAIFR and collaborate and discuss. They were both very friendly and open for discussion. I was provided very comfortable visitors office, was also comfortable at the hotel and had no problem whatsoever with my visit.

4.3 Organization of Activities

Between December 2024 – November 2025, ICTP-SAIFR organized fourteen São Paulo International Schools for Theoretical Physics, six minicourses, seven workshops, three programs, six meetings/conferences, and weekly outreach events, seminars, colloquia, and journal clubs. The complete list of 2025 activities is on the website https://www.ictp-saifr.org/2025-activities/, the list of weekly seminars, colloquia, and journal clubs is on the website https://www.ictp-saifr.org/2025-research-seminars-and-activities/. Most of the activities were recorded, and the videos are available online on the associated websites.

4.3.1 São Paulo International Schools

The fourteen São Paulo International Schools covered the subjects of data science and machine learning (December 2 - 6, 2024, and November 16 – 21), synchronization (February 3-14), origins of life, behavior, and cognition (March 10-21), biological physics and biomolecular simulations (April 14-19), disordered systems (April 28 – May 9), infectious disease dynamics (May 12 – 18), multineutron clusters in nuclei and in stars (May 27 – 31), Holography and

related topics (June 30 – July 11), cosmology (July 28 – August 8), astroparticle physics (August 11 - 15), light and cold atoms (October 20 – 31), and emergent phenomena in many-body systems (November 3 – 14). The schools were mostly for 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 evaluate the schools anonymously, and the links to view their evaluations are:

- Third School on Data Science and Machine Learning
- School on Synchronization: from collective motion to brain dynamics
- School on the Origins of Life, Behavior and Cognition
- School on the Physics of Life
- School on Biological Physics and Biomolecular Simulations in the Machine Learning Era
- São Paulo School of Advanced Science on Disordered Systems
- II School on Modelling Infectious Disease Dynamics
- School on Multineutron Clusters in Nuclei and in Stars
- VI Siembra-HoLAGrav Young Frontiers Meeting at ICTP-SAIFR
- V Joint ICTP-Trieste/ICTP-SAIFR School on Cosmology
- CLAF/ICTP-SAIFR Latin-American Astroparticle Physics School
- IV School on Light and Cold Atoms
- School on Emergent Phenomena in Many-Body Systems
- Fourth School on Data Science and Machine Learning

All lectures from the schools were filmed, and the videos are available online on the schools' websites.

Third School on Data Science and Machine Learning (December 2-6, 2024)

The Third School on Data Science and Machine Learning (December 4-8, 2023) is described on the website `https://www.ictp-saifr.org/dsml2024/` and involved 5 lecturers and 40 participants. This school focused on training PhD students, postdocs, and outstanding master's students in neural networks, convolutional neural networks, computer vision, natural language processing, generative models, sequential and recursive learning, High Performance Computing (HPC), HPC for Machine Learning (GPU Accelerated Training), and profiling and Benchmarking machine learning models.

Lecturers and Topics:

- **Esther Colombini** (UNICAMP. Brazil): *Intro to Machine Learning Models and Neural Networks.*
- **Alexandre Xavier Falcão** (IC – Unicamp, Brazil): *Convolutional Neural Networks.*
- **Renato Vicente** (IME-USP, Brazil): *Generative Models.*

- **Marcelo Finger** (IME-USP, Brazil): *Natural Language Processing.*
- **Hermes Senger** (UFSCar, Brazil): *HPC and Machine Learning.*

School on Synchronization: from collective motion to brain dynamics (February 3 – 14)

School on Synchronization: from collective motion to brain dynamics (February 3 – 14) described on the webpage https://www.ictp-saifr.org/sscmbd2025/ and involved 8 lecturers and 55 participants. At the school, students were familiarized with complex dynamical systems, including synchronization in networks, metastability in neuroscience, epilepsy dynamics, collective motion in biological and robotic systems, and emergent order in active matter.

Lecturers and Topics:

- **Ulrike Feudel** (University of Oldenburg, Germany): *Critical transitions in complex dynamical systems: theory and implication for neuroscience and Synchronization and Desynchronization of complex networks: The role of perturbations to single nodes and Metastability and transient dynamics in neuroscience.*
- **Jesus Gómez Gardeñes** (University of Zaragoza, Spain): *Synchronization phenomena and the Kuramoto model and Synchronization in Complex Networks I: Onset of Sync and Synchronization in Complex Networks II: Stability of Sync.*
- **Klaus Lehnertz** (University of Bonn, Germany): *Network theory of epilepsy and Statistical approaches to detection and prediction of critical transitions into epileptic seizures.*
- **Christian Meisel** (Charité–Universitätsmedizin Berlin, Germany): *An introduction into epilepsy and Long-range correlations in the brain and their implications for seizure forecasting.*
- **Maria Del Carmen Miguel Lopez** (Barcelona University, Spain): *Collective motion and decision making in the dynamics of social animals and robot swarms.*
- **Fernando Peruani** (Cergy Paris University, France): *Emergence of order in active matter: From synchronization of moving oscillators to collective motion.*
- **Luisa Ramirez** (Johannes Gutenberg University, Germany): *Efficient coding in circuits of sensory neurons: searching for evolutionary principles in visual systems.*
- **Hitten Zaveri** (Yale University, USA): *Monitoring the brain in epilepsy and Controlling seizures.*

School on the Origins of Life, Behavior and Cognition (March 10-21)

This two-week school organized from March 10 - 21 provided lectures on biology and physics of birdsong production, collective neuronal behavior and the critical brain hypothesis, the phys-

ical origins of brain cortical morphology, the topology and geometry of perception and knowledge, and Lévy walks and search optimization. The school involved 8 lecturers, 3 tutors and 47 participants. For a more detailed description see the website https://www.ictp-saifr.org/solbc2025/

Lecturers and Topics:

- **Ana Amador** (University of Buenos Aires, Argentina): *Biology and physics of birdsong production.*
- **Randall Beer** (Indiana University Bloomington, USA): *Constitution and From Physics to Cognition in the Game of Life: Interaction.*
- **Mauro Copelli** (UFPE, Brazil): *Collective Neuronal Behavior and the Critical Brain Hypothesis.*
- **Asif Ghazanfar** (Princeton University, USA): *The Central Role of the Individual in the History of Brains.*
- **Donald Katz** (Brandeis University, USA): *Standard neuroscience assumptions and the dynamical alternative.*
- **Bruno Mota** (Federal University of Rio de Janeiro, Brazil): *The physical origins of brain cortical morphology.*
- **Manuel Schottdorf** (University of Delaware, USA): *The topology and geometry of perception and knowledge.*
- **Gandhimohan M. Viswanathan** (Universidade Federal do Rio Grande do Norte – UFRN, Brazil): *Lévy walks and search optimization: Free will, randomness and determinism in animal locomotion.*

Tutors:

- **Thiago Varella** (Princeton University, USA): *Computational Approaches to Social Learning Across Timescales.*
- **Renata Biazzi** (Princeton University, USA): *From Species Traits to Evolutionary Patterns: A Practical Guide to Phylogenetic Comparative Methods.*
- **Albin Salazar** (University of Konstanz, Germany): *A role for formal languages to study natural and artificial collective systems.*

School on the Physics of Life (March 24 – 28)

This one-week school organized from March 24 – 28 provided lectures on molecular and cell biophysics, neurophysics, dynamical systems and collective motion, and machine learning tools for biological physics. The school involved 4 lecturers and 87 participants. For a more detailed description see the website https://www.ictp-saifr.org/swpl2025/

Lecturers and Topics:

- **Olga Dudko** (University of California at San Diego, USA): *How living systems accomplish things on time: beating the speed limit in genomic interactions, viral infection, and neuronal communication.*
- **Gabriel B. Mindlin** (Universidad de Buenos Aires, Argentina): *Artificial intelligence and dynamics applied to biophysics: the case of birdsong.*
- **Tomás S. Grigera** (Universidad Nacional de La Plata, Argentina): *Statistical physics of collective motion.*
- **Faruck Morcos** (University of Texas at Dallas, USA): *From biomolecular prediction to design, the impact of machine learning in biological physics.*

School on Biological Physics and Biomolecular Simulations in the Machine Learning Era (April 14-19)

The School on Biological Physics and Biomolecular Simulations in the Machine Learning Era (April 14-19) took place in the IFT-UNESP auditorium and provided an introduction biological neural networks, CD spectroscopy and fluorescence, machine learning approaches for biomolecular and biophysical research, constant-pH simulation methods for biomolecular systems and machine learning for functional protein design. The school involved 8 lecturers and 87 participants. For a more detailed description see the website https://www.ictp-saifr.org/sbpbs2025/

Lecturers and Topics:

- **Fernanda Selingardi Matias** (Universidade Federal de Alagoas, Brazil): *Biological neural networks.*
- **Atilio Tomazini** (IFUSP, Brazil): *CD and fluorescence and applications.*
- **Luiz Fernando de Camargo Rodrigues** (IFUSP, Brazil): *SAXS.*
- **Oliver Lieleg** (Technical University of Munich, Germany): *Machine learning approaches for biomolecular and biophysical research.*
- **Shaker Chuck Farah** (IQUSP, Brazil): *Proteins and nucleic acids: basic concepts and challenges?*
- **Fernando Barroso** (FCFRP/USP, Brazil): *Constant-pH simulation methods for biomolecular systems: the physics behind it.*
- **Ralf Eichhorn** (Nordita, Sweden): Introduction to Machine Learning
- **Helder Veras Ribeiro Filho** (CNPEM, Brazil): *Machine Learning for Functional Protein Design.*

São Paulo School of Advanced Science on Disordered Systems (April 28 – May 9)

This advanced school organized from April 28 – May 9 provided lectures neuroscience, complexity and mean-field theory, driven disordered systems, strongly correlated systems, elastic materials and machine learning applications to disordered systems. The school involved 7 lecturers, 5 invited speakers and 88 participants. For a more detailed description see the website https://www.ictp-saifr.org/spsasds2025/

Lecturers and Topics:

- **Jasna Brujic** (New York University, USA): *Bioinspired applications.*
- **Mauro Copelli** (Federal University of Pernambuco, Brazil): *Neuroscience.*
- **Letícia Cugliandolo** (Sorbonne Université, France): *Complexity / Mean-field theory.*
- **Ezequiel Ferrero** (CONICET-CNEA, Argentina): *Driven Disordered Systems.*
- **Eduardo Miranda** (State University of Campinas, Brazil): *Disordered strongly correlated systems.*
- **Anton Souslov** (University of Cambridge, UK): *Disordered elastic materials.*
- **Matthieu Wyart** (Johns Hopkins University, USA & EPFL, Switzerland): *Machine learning.*

Invited Speakers:

- **José Soares Andrade** (Federal University of Ceará, Brazil): *From Correlations to "Interactions": Application of a Maximum Entropy Model to Finance.*
- **Jeferson Arenzon** (Federal University of Rio Grande do Sul, Brazil): *Order from Disorder - percolation and coarsening.*
- **Vivian França** (São Paulo State University, Brazil): *Disorder, Interaction, and Entanglement: Tracking Quantum Phase Transitions in Fermionic Chains.*
- **Letícia Paiva** (Federal University of São João del Rei, Brazil): *Emergent dynamical phases in termites.*
- **Luis A. Pugnaloni** (Universidad Nacional de La Pampa, Argentina): *Statistical mechanics of static granular packing.*

II School on Modelling Infectious Disease Dynamics (May 12 – 18)

The II School on Modelling Infectious Disease Dynamics (May 12 – 18) is described on the webpage https://www.ictp-saifr.org/smidd2025/ and involved 3 lecturers and 34 participants. This school, dedicated to studying epidemic dynamics and data analysis.

Lecturers and Topics:

- **Renato Coutinho** (UFABC, Brazil): *Numerical Methods.*
- **Marcelo Ferreira da Costa Gomes** (Fiocruz/RJ, Brazil): *Epidemiological Data Analytics.*
- **Roberto Kraenkel** (IFT-UNESP, Brazil): *Deterministic Epidemic Dynamics.*

School on Multineutron Clusters in Nuclei and in Stars (May 27 – 31)

The School on Multineutron Clusters in Nuclei and in Stars (May 27 – 31) is described on the website https://www.ictp-saifr.org/smcns2025/ and involved 4 lecturers and 84 participants. The school was aimed at PhD students, postdocs and outstanding Master's students and lecture topics included ab-initio approaches to heavier nuclei and applications, halo nuclei, clustering and universality, and experimental probes of multineutron systems.

Lecturers and Topics:

- **Francesca Bonaiti** (Michigan State University, USA): *Extension of the ab-initio approach to heavier nuclei.*
- **Chen Ji** (Central China Normal University, China): *Halo nuclei, clustering and universality.*
- **Takashi Nakamura** (Tokyo Institute of Technology, Japan): *Experimental probes of multineutron systems.*
- **Ingo Tews** (Los Alamos National Laboratory, USA): *Ab-initio approach and applications.*

VI Siembra-HoLAGrav Young Frontiers Meeting at ICTP-SAIFR (June 30 – July 11)

The VI Siembra-HoLAGrav Young Frontiers Meeting at ICTP-SAIFR (June 30 – July 11) is described on the website https://www.ictp-saifr.org/yfm2025/ and involved 6 lecturers and 64 participants. Topics discussed in the lectures included holography, black holes and cosmology.

Lecturers and Topics:

- **Julio Parra-Martínez** (IHES, France): *Scattering Amplitudes and Gravitational Waves.*
- **Alejandra Castro** (Cambridge U., DAMTP, UK): *Topics in AdS_3/CFT_2: The Power of Symmetries in Holography.*
- **Chiara Toldo** (Harvard U., USA & Milan U., Italy): *Black Holes and Quantum Gravity.*

- **Guilherme Pimentel** (Scuola Normale Superiore, Italy): *Theory of the Initial Conditions of Our Universe.*
- **Tarek Anous** (Queen Mary University of London, UK): *Statistical Systems Out of Equilibrium.*
- **Dionysios Anninos** (King's College London, UK): *Quantum Aspects of a* $\Lambda > 0$ *Universe*.

V Joint ICTP-Trieste/ICTP-SAIFR School on Cosmology (July 28 – August 8)

This school organized from July 28 – August 8 provided lectures in modern cosmology and observational techniques. The school involved 6 lecturers (three per week) and 102 participants. For a more detailed description see the website https://www.ictp-saifr.org/ictptriestesc2025/.

Lecturers and Topics:

1st week

- **Roman Scoccimarro** (New York University, USA): *Large scale structure theory.*
- **Gonzalo Palma** (Universidad de Chile, Santiago, Chile): *Physics of Inflation.*
- **Jose M. Ezquiaga** (Niels Bohr Institute, Denmark): *A premiere on Gravitational Wave Cosmology.*

2nd week

- **Emmanuel Schaan** (SLAC National Accelerator Laboratory, USA): *Physics of the Cosmic Microwave Background.*
- **David Alonso** (University of Oxford, UK): *Large scale structure observables.*
- **Francisco Antonio Villaescusa Navarro** (Simons Foundation and Princeton University, USA): *Machine Learning Methods for Cosmology.*

CLAF/ICTP-SAIFR Latin-American Astroparticle Physics School (August 11 – 15)

The CLAF/ICTP-SAIFR Latin-American Astroparticle Physics School is described on the website https://www.ictp-saifr.org/claf-ictp-saifr-laaps/ and involved 5 lecturers, 3 seminars and 77 participants. The school included lectures multi-messenger and high-energy astrophysics through lectures and hands-on sessions on cosmic rays, gamma-ray astronomy, dark matter, and high-energy sources.

Lecturers and Topics:

- **Rafael Alves-Batista** (IAP, France):
  1. *Introduction to HECRs: phenomenology, observations, and open questions.*
  2. *Cosmic-ray acceleration and sources.*
  3. *Extragalactic propagation of cosmic-rays.*
  4. *Galactic propagation of cosmic rays.*
- **Gustavo Romero** (IAR, Argentina):
  1. *Very-High Energy Galactic Sources I.*
  2. *Very-High energy Galactic Sources II.*
  3. *Galactic PeVatrons.*
- **Michele Doro** (INFN and University of Padova, Italy):
  1. *Introduction to Cherenkov Telescopes.*
  2. *Fundamental Physics with Gamma-rays I: Dark Matter.*
  3. *Fundamental Physics with Gamma-rays II: Other Topics.*
- **Elisabetta Bissaldi** (INFN and University of Bari, Italy):
  1. *High-energy GRBs: Lessons learned from the Fermi mission and TeV observations.*
  2. *The Gamma-ray role in multi-messenger observations of gravitational waves: From Fermi to ground-based observations.*
- **Markus Boettcher** (NWU, South Africa):
  1. *Active Galactic Nuclei with Gamma-rays.*
  2. *Active Galactic Nuclei and Multi-messenger neutrinos.*

Seminars:

- **Felix Aharonian** (DIAS, Ireland): *Overview of Ground-based Gamma-ray Astronomy.*
- **Shoushan Zhang** (IHEP, China): *Introduction to Extensive Air-Shower Arrays and LHAASO.*
- **Ulisses Barres de Almeida** (CBPF, Brazil): *The Southern Wide-Field Gamma-ray Observatory, SWGO.*

IV School on Light and Cold Atoms (October 20 – 31)

This two-week school organized from October 20 – 31 provided lectures on quantum networks with cold atoms, two-dimensional Bose gases, quantum information processing with photons, optical lattices, and related topics. The school involved 8 lecturers and 60 participants. For a more detailed description see the website https://www.ictp-saifr.org/slca2025/

Lecturers and Topics:

- **Carla Hermann-Avigliano** (University of Chile, Chile): *Hands-on Scientific Communication: From Writing to Presenting Your Research.*
- **Daniel Felinto** (UFPE, Brazil): *Quantum networks with cold atoms.*
- **Hélène Perrin** (Université Sorbonne Paris Nord, France): *Two-dimensional Bose gases.*
- **Irina Novikova** (College of William and Mary, USA): *Atom-based quantum sensors: fundamentals and applications.*
  - *Atom-based quantum sensors: some like it hot (seminar).*
- **Johannes Schachenmayer** (Université de Strasbourg, France): *Hands-on advanced numerical methods for quantum many-body dynamics.*
- **Michel Brune** (ENS + Collège de France, France): *From cavity QED to quantum simulations with circular Rydberg atoms.*
- **Stephen Walborn** (Universidad de Concepción, Chile): *Quantum information processing with photons.*
  - *Multicore optical fiber devices for quantum optics and information (seminar)*
- **Thereza Paiva** (UFRJ, Brazil): *Optical lattices.*

II School on Emergent Phenomena in Non-Equilibrium Quantum Many-Body Systems (November 3 – 14)

The II School on Emergent Phenomena in Non-Equilibrium Quantum Many-Body Systems (November 3 – 14) is described on the website https://www.ictp-saifr.org/neq2025/ and involved 10 lecturers (5 per week) and 52 participants. Topics discussed in the lectures included many-body statistical mechanics and the equilibrium physics of systems with short- and long-range interactions, setting the stage for an in-depth exploration of non-equilibrium dynamics, thermalization, and ergodicity.

Lecturers and Topics:

1st week

- **Nicolo Defenu** (ETH Zürich, Switzerland): *Universality and out-of-equilibrium dynamics with long-range couplings.*
- **Ana Maria Rey** (JILA – University of Colorado, USA): *Building with Crystals of Light and Quantum Matter: From clocks to quantum computers.*
- **Thereza Paiva** (UFRJ, Brazil): *Emergent Phenomena in Strongly Correlated Systems.*
- **Subir Sachdev** (Harvard, USA): *Planckian Dynamics.*

- **Mohammad Ali Rajabpour** (UFF Niterói, Brazil): *One Critical Story, Three Entropies: Unifying entanglement, Shannon–Rényi, and stabilizer diagnostics.*

2nd week

- **Hossein Hosseinabadi** (Johannes Gutenberg University Mainz, Germany): .
- **Daniel Stariolo** (UFF, Brazil): *Non-Equilibrium dynamics in disordered systems.*
- **Anatoli Polkovnikov** (Boston University, USA): *Adiabatic transformations: from quantum state preparation to chaos and thermodynamics in motion.*
- **Martino Stefanini** (JGU Mainz, Germany): *Is Lindblad for me?*
- **Jamir Marino** (JGU Mainz, Germany): *Light-matter quantum networks and spin glass dynamics.*

Fourth School on Data Science and Machine Learning (November 16 – 21)

The Fourth School on Data Science and Machine Learning (November 16 – 21) is described on the website `https://www.ictp-saifr.org/dsml2025/` and involved 10 lecturers and 38 participants. This school focused on training PhD students, postdocs, and outstanding master's students in Deep Learning, AI, Machine Learning, and related topics.

Lecturers and Topics:

- **Alexandre Simões** (Unesp, Brazil): *Deep Learning.*
- **Ana Carolina Lorena** (ITA, Brazil): *Explainable AI.*
- **Carolina Gonzalez** (Instituto Santos Dumont, Brazil): *AI in Life Sciences.*
- **Fabio Ortega** (USP, Brazil): *AI for the Climate Emergency.*
- **Rafael Zanatta** (USP e Data Privacy Brasil, Brazil): *Ethics in AI.*
- **Raphael Cobe** (NCC-UNESP/AI2, Brazil): *Introduction to Machine Learning.*
- **Renato Vicente** (USP, Brazil): *Introduction to Neural Networks.*
- **Sérgio Novaes** (NCC-UNESP/AI2, Brazil): *AI and the University.*
- **Felippe Alves** (CIAAM – USP): *AI Benchmarks.*
- **Davi Bastos Costa** (CIAAM – USP, Brazil): *Multi-agent LLM system.*

4.3.2 Workshops

ICTP-SAIFR organized workshops on the subjects of synchronization: from collective motion to brain dynamics, the physics of life, soft matter, gravitational waves, multineutron clusters in nuclei and stars, and the Bootstrap technique, and quantum materials. The purpose of these workshops was to discuss the status, recent progress, and perspectives in each of the mentioned fields.

Workshop on Synchronization: from collective motion to brain dynamics (February 8–9)

This two-day workshop, held at the IFT-UNESP auditorium , focused on synchronization phenomena across a wide range of systems, from active matter and collective motion to neural dynamics, epilepsy, and higher-order interactions in brain networks. The presentations covered theoretical modeling, neuroimaging, medical-device development, nonlinear dynamics, and synchronization in biological and physical systems. The website of the workshop is https://www.ictp-saifr.org/sscmbd2025/ and the speakers included:

Day-1 Talks (February 8):

- **Albert Diaz-Guilera** (Universitat de Barcelona, Spain): *Unexpected properties of synchronization in complex networks of Kuramoto oscillators*.
- **Hitten Zaveri** (Yale University, USA): *Development of medical devices to monitor and modulate the human brain*.
- **Clarissa Yasuda** (Unicamp, Brazil): *Neuroimaging and epilepsy: beyond lesion identification*.
- **Everton Medeiros** (UNESP, Brazil): *Local control for the collective dynamics of self-propelled particles*.
- **Elbert Macau** (UNIFESP, Brazil): *The effect of time delay for synchronization suppression in neuronal networks*.
- **Ignacio Pagonabarraga** (University of Cataluña, Spain): *Emergent phases and synchronization in active matter*.
- **Marie Sellier-Prono** (École Normale Supérieure / Université Paris Sciences et Lettres, France): *Models of coupled oscillators to study the parcellation of the brain pial arterial network*.
- **Klaus Lehnertz** (University of Bonn, Germany): *What have we learned about the mechanistic underpinnings of the pre-ictal state?*

Day-2 Talks (February 9):

- **Mario Chavez** (Sorbonne, France): *The latent geometry of brain networks as a biomarker in epilepsy*.
- **Christian Meisel** (Charité–Universitätsmedizin Berlin, Germany): *Critical dynamics as the set point of optimal brain function*.
- **Guilherme Costa** (ICTP-SAIFR / IFT-UNESP, Brazil): *Bifurcations in the Kuramoto model with external forcing and higher-order interactions*.
- **Diogo Leonai Souza** (Universidade Estadual de Ponta Grossa, Brazil): *Effects of Potassium and Calcium Currents on Bistable States*.

- **Ricardo Martinez-Garcia** (CASUS/HZDR, Germany & ICTP-SAIFR/IFT-UNESP, Brazil): *Imperfect coordination in collective behaviors across scales: from microbial aggregates to ungulate migration*.
- **João Lizarraga** (UNICAMP, Brazil): *Swarmalator models in one- and two-dimensional spaces*.
- **Pablo de Castro** (IFT–UNESP, Brazil): *Epidemic percolation among motility-induced clusters of active particles*.
- **David Ortiz del Campo** (IFISC, Universitat de les Illes Balears–CSIC, Spain): *Anticipated synchronization in systems with distributed delay*.
- **Leonardo Rodrigues da Costa** (Unicamp, Brazil): *Unveiling Epileptic Networks: Motif Synchronization for Interictal Spike and Foci Localization*.
- **Thierry Njougouo** (IMT School for Advanced Studies Lucca, Italy): *Collective Dynamics in Pairwise and Higher-Order Networks*.
- **Michael Luchtan** (Open University of Catalonia, Spain): *Fractal Associations, Synchronization Events, and Circulating Pacemakers: How musicians learn Bluegrass in Barcelona*.
- **Jesus Gómez Gardeñes** (University of Zaragoza, Spain): *Explosive Synchronization: some recent advances*.

Workshop on the Physics of Life (March 28–30)

This 3-day workshop brought together researchers from across Latin America to discuss recent advances in biological physics, covering topics ranging from collective behavior and neural dynamics to molecular and cellular processes. In addition to invited research talks, the meeting featured discussion sessions aimed at strengthening regional collaboration and building a long-term network of biological physicists. The website of the workshop is https://www.ictp-saifr.org/swpl2025/.

Invited Speakers:

- **Guillermo Abramson** (Centro Atómico Bariloche, Instituto Balseiro, Argentina): *Seed propagation waves from delayed deposition.* & *FiEstIn.*
- **Marcus Aguiar** (Unicamp and ICTP-SAIFR, Brazil): *Simulating the Origin of Species.*
- **Gabriel Aguilar** (UFRJ, Brazil): *Studying perception of quantum light*
- **Ana Amador** (UBA, Argentina): *Bringing together physics and biology at the Physics Dept. of the University of Buenos Aires.*
- **Sabrina Araújo** (UFPR, Brazil): *Island speciation under migration.* & *Modeling animal behavior, ecology, and evolution*

- **Oswaldo Baffa** (USP-RP, Brazil): *Navigating the Future of Devices for Neurostimulation and Biomagnetism.*
- **Paulo Bisch** (UFRJ, Brazil): *Física Biológica - Biofísica.*
- **Mauro Copelli** (UFPE, Brazil): *Systems and Computational Neuroscience lab.*
- **Silvina Ponce Dawson** (UBA, Argentina): *About some biological physics groups in Argentina.*
- **Diego Ferreiro** (UBA, Argentina): *How natural sequence variations modulate protein folding dynamics.*
- **Daniel Fraiman** (University of San Andrés, Argentina): *Stochastic methods for Modeling and Analyzing Complex Data.*
- **Vitor Barbanti Pereira Leite** (UNESP, Rio Preto, Brazil): *Molecular Biological Physics at IBILCE-UNESP.*
- **Karin A. Riske** (UNIFESP, Brazil): *Biophysical characterization of membrane models and bio-inspired peptides.* & *Biomimetic membranes as platforms for the study of antimicrobial peptides.*
- **Enzo Tagliazucchi** (UBA, Argentina): .

Discussion on Science Philanthropy: The workshop also featured a discussion session on science philanthropy, led by:

- **Hugo Aguilaniu** (Serrapilheira Institute, Brazil).
- **Sérgio T. Ferreira** (UFRJ & IDOR Pioneer Science, Brazil).

II Brazilian Workshop on Soft Matter (April 7-11)

The II Brazilian Workshop on Soft Matter (April 7-11) involved 16 speakers and 54 participants. In the workshop were discussed various topics related to glass crystallization, colloidal dynamics, mechanical properties of active materials, and topological defects in nematic liquid crystals. The website of the workshop is `https://www.ictp-saifr.org/bwsm2025/` and the speakers included:

Invited Speakers:

- **Edgar Zanotto** (UFSCAR, Brazil): *Fundamentals and applications of glass crystallization.*
- **Liesbeth Janssen** (Eindhoven University of Technology, Netherlands): *TBA.*
- **César Osvaldo Solano Cabrera** (División de Ciencias e Ingenierías, Universidad de Guanajuato): *Covariant description of colloidal dynamics.*
- **Karen Gonzales Flores** (Universidad de Guanajuato): *Mesoscopic Modeling of Enveloped Virus in Fluids.*

- **Jorge Mario Escobar Agudelo** (UNESP-IFT): *Correlated Disorder and Viscoelasticity of Soft Colloidal Gels.*
- **Daniel Canavello** (UFPE): *Polarization and dynamic phases of aligning active matter in periodic obstacle arrays.*
- **Leila Separdar** (UFSCAR): *Effect of molecular aspect ratio on structure and dynamics of thermotropic liquid crystals studied by molecular dynamics simulation.*
- **Ignacio Bordeu** (Universidad de Chile, Chile): *Dynamics of branching morphogenesis.*
- **Chantal Valeriani** (Universidad Complutense de Madrid, Spain): *Mechanical properties of active materials.*
- **Rodrigo Coelho** (Universidade de Lisboa, Portugal): *Pumping and mixing in active nematics.*
- **M. Leticia Puzzo** (Universidad Nacional de La Plata, Argentina): *Short-time dynamics in active systems: the Vicsek model.*
- **Dan Beller** (Johns Hopkins University, USA): *Topological defect lines in 3D nematic liquid crystals.*
- **Eduardo Jagla** (Instituto Balseiro, Argentina): *Soil creep, a statistical mechanics perspective.*
- **Frederic Nallet** (Université de Bordeaux, France): *Stabilizing water-in-water emulsion with swollen lamellar phases.*
- **Yan Levin** (UFRGS, Brazil): *Theory and Simulations of Charge Regulation of Colloidal Particles in Electrolyte Solutions.*
- **Wim Noorduin** (AMOLF, Netherlands): *Make with minerals!.*

Gravitational Wave Open Data Workshop 2025 (May 12 – 14)

The Open Data Workshop 2025 took place from May 12–14, 2025, offering participants the opportunity to work with real LIGO/Virgo/KAGRA gravitational-wave data and explore essential analysis tools used in the field. The workshop website is www.ictp-saifr.org/gwodw2025/.

Workshop on Multineutron Clusters in Nuclei and Stars (June 2–6)

This workshop, held at ICTP-SAIFR / Principia Institute in São Paulo, gathered theoreticians and experimentalists working on neutron-rich nuclei and astrophysical applications. The main goal was to advance the understanding of multineutron correlations, clustering phenomena near the neutron drip line, and their implications for nuclear structure and stellar matter — especially relevant for neutron stars and related astrophysical phenomena. The website of the workshop is https://www.ictp-saifr.org/smcns2025/ and the speakers include:

- **Takashi Nakamura** (Kyoto University, Japan): *Multi-neutron cluster studies at RIBF.*

- **Ubirajara Van Kolck** (French National Institute of Nuclear and Particle Physics, France): *Emergence of clustering from the two-nucleon unitarity limit.*
- **Daniel Phillips** (Ohio University, USA): *Testing universality in breakup reactions on halo nuclei.*
- **Kelly Cezaretto** (University of São Paulo, Brazil): *Reactions Induced by the ^{6}He Exotic Nucleus: Recent Results from RIBRAS.*
- **Nir Barnea** (The Hebrew University of Jerusalem, Israel): *The Relative Abundance of Correlated Spin-zero Nucleon Pairs.*
- **Saori Pastore** (Washington University in St. Louis, USA): *Electroweak structure of nuclei.*
- **Anna McCoy** (ANL, USA): *Evolution of shapes and symmetries along isotopic chains in neutron-rich nuclei.*
- **Gaute Hagen** (Oak Ridge National Laboratory, USA): *Coupled cluster computations of deformed nuclei.*
- **Francesca Bonaiti** (Michigan State University, USA): *Connecting electroweak properties of nuclei to astrophysics.*
- **Valdir Guimarães** (USP, Brazil): *Proton-rich nuclei structure using 3n-cluster (3He,6He) transfer reaction.*
- **Kenjiro Miki** (Tohoku University, Japan): *Experimental Study of the 3n System and an Upcoming Experiment on Multineutrons.*
- **Aurora Tumino** (University of Catania, Italy): *Sub-Coulomb Nuclear Reactions Studied with the Trojan Horse Method.*
- **Renato Higa** (USP, Brazil): *Update on capture reactions in Halo EFT.*
- **Felipe Canto** (UFRJ, Brazil): *Fusion reactions in collisions of weakly bound nuclei.*
- **Brett Vern Carlson** (ITA, Brazil): *Compound nuclear reaction mechanisms of light composite particles.*
- **Takaharu Otsuka** (University of Tokyo, Japan): *Emerging features of the shapes and their motions of atomic nuclei.*
- **Hans Werner Hammer** (TU Darmstadt, Germany): *Nuclear reactions and multi-neutron correlations.*
- **Live-Palm Kubushishi** (Ohio University, USA): *Core excitation in halo nuclei using Halo-EFT.*
- **Jesus Lubian Rios** (UFF, Brazil): *Effect of correlations in multinucleon transfer reactions.*
- **Roberto Linares** (UFF, Brazil): *Hints on the nucleon-nucleon correlations from two-nucleon transfer reactions induced by heavy ions.*
- **Rimantas Lazauskas** (IPHC, Université de Strasbourg, France): *Description of neutron-rich He isotopes.*

- **Leandro Gasques** (USP, Brazil): *Coupling Effects and Reaction Mechanisms in Weakly-Bound Nuclear Systems.*
- **Josef Pochodzalla** (University of Mainz, Germany): *Measurement of ^{6}H ground state energy at MAMI.*
- **Bahati Mukeru** (UNISA, South Africa): *Structure of three-body systems with hard-core nucleon-nucleon interactions.*
- **Lauro Tomio** (IFT-Unesp, Brazil): *Role of Coulomb breakup cross-sections at sub-barrier energies with ^{11}Be projectiles on heavy targets.*
- **Adamu Issifu** (UFPB, Brazil): *Effect of dark matter on neutron star evolution.*
- **Yutaka Watanabe** (KEK, Tsukuba, Japan): *KISS project: Spectroscopy of neutron-rich nuclei near $N = 126$ and actinides toward elucidating r-process nucleosynthesis.*

Simons Collaboration Bootstrap 2025 (July 21 – August 8)

This workshop was held from July 21 to August 8 at the Principia Institute. The workshop gathered more than 100 experts in Bootstrap techniques and strongly coupled quantum field theory to explore the application of consistency requirements to fundamental physics phenomena. The website of the workshop is https://exact.ictp-saifr.org/ and the speakers included:

1st Week:

- **John McGreevy**: *Entanglement Bootstrap (Mini-Course)*
- **Marco Meineri**: *The Numerical Bootstrap of Points and Lines*
- **João Penedones**: *Einstein gravity from a matrix integral*
- **Slava Rychkov**: *Tensor Networks and Renormalization Group*
- **Rajeev Erramilli**: *Bootstrapping the 3d Ising Stress Tensor: New Data, Spectra, and Numerology*
- **Philine van Vliet**: *Consequences of symmetry-breaking on conformal defect data*
- **Ellis, Francesco, Xinan**: *Panel Discussion on QG and CFT*
- **Adrien Martina**: *Massive deformations of supersymmetric Yang–Mills matrix models*
- **Harish Murali**: *Heavy Operators in Matrix Models*
- **Manuel Loparco**: *QFT as a set of coupled ODEs*
- **Johan Henriksson**: *EFT meets CFT*
- **Sebastian-Philip Harris**: *Sparsity in the numerical six-point bootstrap*
- **Gordon Rogelberg**: *Bootstrapping heavy CFT correlators*
- **Thibaud Raymond**: *A new boundary state in the $c = 2$ Narain CFT*
- **Yixin Xu**: *A genus-2 crossing equation in $d > 2$*

2nd Week:

- **Ian Moult**: *Energy operators in Particle Physics, QFT, and Gravity (Mini-Course)*
- **Thomas Hartman**: *Triangulating quantum gravity in AdS_3*
- **Balt Van Rees**: *Theorems for the lightcone and modular bootstrap*
- **Yuan Xin**: *Yang-Lee Criticality in Various Dimension*
- **Fabiana De Cesare**: *Disturbing news about the 2+ϵ expansion*
- **Nikolay Gromov**: *Recent Developments in Gauge/String Duality: A Report from IGST 2025*
- **Noe Suchel**: *Solving 1d crossing in QFT2/CFT1.*
- **Bruno Fernandes**: *AdS $\times$ S Mellin bootstrap and hidden symmetry of five-point functions in N=4 SYM*
- **Alessandro Piazza**: *Bootstrapping the simplest deconfined quantum critical point*
- **Antonio Antunes**: *Lifshitz Meets Zamolodchikov*
- **Nikolay Ebel**: *Some steps toward implementation of the RG blueprint*
- **William Pannell**: *Magnetized Bounds for CFTs*
- **Francesco Russo**: *Heavy-Heavy-Light Asymptotics from Thermal Correlators*
- **Jan Albert**: *Some imprints of asymptotic freedom on confining strings*

3rd Week:

- **Henry Lin**: *Bootstrapping matrix quantum mechanics (Mini-Course)*
- **Silviu Pufu**: *Supercurrents and (partial) supersymmetry in 2d adjoint QCD and its generalization*
- **Frank Coronado**: *Open-Closed-Open triality in N=4 sYM*
- **Andrea Guerrieri**: *Maximizing the interaction strength*
- **Junchen Rong**: *Irrational CFTs from coupled anyon chains?*
- **Fernando Alday**: *Scattering of open and closed strings on AdS*
- **Xi Yin**: *The Unreasonable Effectiveness of D-instantons*
- **Ilija Buric**: *Holographic thermal coefficients, Borel resummation and black holes*
- **Alex Radcliffe**: *Spinning Defects in the O(2N) Model*
- **Lorenzo Quintavalle**: *Virasoro OPE, Casimir, and blocks*
- **Rodrigo Pitombo**: *Mellin Amplitudes for AdS_3 and their simplicity*
- **João Vilas Boas**: *Five-Point Function of $N = 4$ SYM and Stringy Corrections*
- **Shai Chester**: *Bootstrapping string and M-theory*
- **Liam MacAllister**: *Computational compactifications and de Sitter*

Workshop on Frontiers in Quantum Materials (September 1 – 5)

The Workshop on Frontiers in Quantum Materials (September 1 – 5) took place at Principia Institute and involved 55 participant. The workshop discussed various topics related to topological and magnetic transitions, skyrmions and exotic spin textures, altermagnetism and strain-tunable electronic responses, unconventional superconductivity and nematicity, correlated transport in topological devices, localization in curved spaces, relativistic electron–phonon effects, Kagome-metal magnetism, quantum geometry, emergent order in low-dimensional systems, and novel instabilities in quantum Hall and Chern-band states. The website of the workshop is https://www.ictp-saifr.org/wfqm2025/ and the speakers included:

- **Santiago Grigera** (IFLYSIB-CONICET): *Topological transitions in a frustrated magnet.*
- **José Hoyos** (IFSC-USP): *A powerful method to evaluate the mass gaps of free-particle quantum critical systems.*
- **Flavia Albarracín** (IFLYSIB-CONICET): *Skyrmions and merons in magnetic spin systems.*
- **Willian Natori** (Unicamp): *The spin-orbital Kitaev model: a parent Hamiltonian for quantum spin liquids in Rydberg simulations.*
- **Marli dos Reis Cantarino** (ESRF): *Competing magnetic excitations and electronic structure in Cr-doped $BaFe_2As_2$: Insights from RIXS and ARPES.*
- **Turan Birol** (University of Minnesota): *Atomic and Unit Cell Multipoles in Altermagnets.*
- **Na Hyun Jo** (University of Michigan): *Strain-tunability of the Anomalous Hall Effect in Altermagnetic MnTe.*
- **Vanuildo Carvalho** (UFG): *Superconductivity in spin-orbit assisted altermagnets.*
- **Eduardo da Silva Neto** (Yale): *From Nematic Fluctuations Pairing to Kagome Symmetries: Superconducting Gaps in Fe-Based and CsV_3Sb_5 Systems.*
- **Joe Meese** (UIUC): *Compatible Instability: Gauge Constraints of Elasticity Inherited by Electronic Nematic Criticality.*
- **Gabriela Pasquini** (UBA): *Interplay between nematic order and superconductivity.*
- **Michal Papaj** (UH): *Pair density modulation in iron-based superconductors.*
- **Eduardo Novais** (UFABC): *Strongly Correlated Transport in Topological Y-Junction Devices.*
- **Tobias Micklitz** (CBPF): *Anderson Localization in Negatively Curved Space.*
- **Maria Gastiasoro** (DIPC): *Relativistic effects in the electron-phonon coupling to odd-parity modes in $KTaO_3$.*
- **Luis Gregório Dias** (IF-USP): *Effects of interlayer Coulomb interaction in the superconducting pairing symmetry of bilayer $La_3Ni_2O_7$ under pressure.*
- **Robert McQueeney** (Iowa State University & Ames Lab): *Magnetism of the RT_6Sn_6 kagome metals.*

- **Ian Fisher** (Stanford): *Strain-control of quantum materials: the case of multipolar order.*
- **Ilya Esterlis** (UW): *Electron crystals in two-dimensional materials.*
- **Vivian França** (UNESP): *What can one site tell us? Entanglement, Symmetry Breaking, and Emergent Order in 1D Systems.*
- **Inti Sodemann** (University of Leipzig): *A new instability of Laughlin fractional quantum Hall states in ideal Chern bands.*
- **Jörg Schmalian** (KIT): *Holography and Emergent Geometry in Superconductors without.*
- **Marcello Barbosa Neto** (UFRJ): *Quantum geometry and the electric magnetochiral anisotropy in tellurene field effect transistors.*
- **Mariana Malard** (UNB): *Electronic interactions in a vacancy-engineered honeycomb lattice: Transition from a nodal-line semimetal to a magnetic insulator.*
- **Rodrigo Pereira** (IIP/Natal): *Tunneling spectroscopy of the spinon-Kondo effect in Mott insulators.*
- **Paula Mellado** (Adolfo Ibáñez University): *Sliding phasons in moiré quasi one-dimensional heterostructures.*
- **Krissia Zawadzki** (IFSC-USP): *DFT-inspired approximations for quantum thermodynamics.*
- **Dario Rosa** (ICTP-SAIFR): *Adding structure to the SYK model: from single-particle to many-body physics.*
- **Jörg Schmalian** (KIT): *Superconductivity and Loop Currents: from Cuprates to Kagome Metals.*
- **Maria Carolina de Oliveira Aguiar** (UFMG): *Electronic Raman response of cuprate superconductors.*
- **Diego Rabelo** (UFC): *Topological phase transitions in strained Lieb-Kagome lattices.*
- **Eduardo Bittar** (CBPF): *Study of the charge density wave and superconductor states in the* $\mathrm{Cs_{1-x}Rb_xV_3Sb_5}$ *Kagome system.*
- **Victor Quito** (IFSC-USP): *Multidimensional spectroscopy of exactly solvable spin liquids.*
- **Rodrigo Arouca** (CBPF): *Topological edge and corner states in bismuth fractal nanostructures.*
- **Ricardo Urbano** (UNICAMP): *Beyond the Bulk: Discovering New Physics in 1D* $CeIn_3$ *Structures.*

4.3.3 Programs

ICTP-SAIFR organized three programs on 2025, the Program on Anomalies, Topology and Quantum Information in Field Theory and Condensed Matter Physics, the Program on Fundamental Aspects of String Theory, and the Program on Quantum Many-Body Dynamics: Ther-

malization and its Violations. The purpose of these programs was to discuss the status, recent progress and perspectives in each of the fields mentioned.

Program on Anomalies, Topology and Quantum Information in Field Theory and Condensed Matter Physics (June 16 – 27)

From June 16 – 27, this ICTP-SAIFR program, organized at Principia Institute, brought together 73 participants for an intensive two-week event. The program consisted of one week of advanced minicourses covering topology and phases of matter, symmetries and entropy in quantum field theory, non-invertible symmetries and dualities, the generalized Landau paradigm, and higher Berry phases in quantum many-body systems, followed by a one-week workshop featuring 19 seminars from leading researchers in the field. For more information, visit https://www.ictp-saifr.org/patqi2025/.

Lecturers and Topics:

- **Fiona Burnell** (University of Minnesota, USA): *Topology, hidden information and phases of matter.*
- **Horacio Casini** (Bariloche Atomic Centre, Argentina): *Symmetries, algebras and entropy in Quantum Field Theory.*
- **Paul Fendley** (University of Oxford, UK): *Non-invertible symmetries and dualities from the ground up.*
- **John McGreevy** (UC San Diego, USA): *The generalized Landau paradigm.*
- **Shinsei Ryu** (Princeton University, USA): *Higher Berry Phase in Quantum Many-Body Systems.*

Workshop Speakers:

- **Cesar Arias** (Pontificia Universidad Catolica de Chile, Chile)
- **Connor Beham** (ICTP-SAIFR, Brazil): *In search of generic CFTs in two dimensions.*
- **Valentín Benedetti** (ICTP, Italy): *Modular Invariance and Selection Rules for RG Flows.*
- **Wei Chen** (PUC-Rio, Brazil): *Quantum geometric effects in semiconductors and superconductors.*
- **Jose Carlos Egues** (USP, Brazil): *Topological phenomena in "ordinary" systems.*
- **Vivian França** (UNESP-Aranquera, Brazil): *Entanglement as a Topological Marker in a Confined Superfluid Chain.*
- **Jaume Gomis** (Perimeter Institute, Canada): *On the existence of non-invertible symmetries.*
- **José Abel Hoyos Neto** (USP São Carlos, Brazil): *A powerful method to evaluate the mass gaps of free-particle quantum critical systems.*

- **Vladimir Juricic** (Universidad Técnica Federico Santa María, Chile): *Non-Hermitian Dirac Matter: Emergent Yukawa-Lorentz Symmetry and Exceptional Magic Angles.*
- **Vladimir Korepin** (Stony Brook, USA): *Lessons of Many-Body Quantum Mechanics for Circuit Design.*
- **Caio Lewenkopf** (UFRJ, Brazil): *Beyond translational symmetry: Strongly disordered and amorphous topological insulators.*
- **Javier Magán** (Balseiro Institute, Argentina): *On the existence of non-invertible symmetries.*
- **Dmitry Melnikov** (UFRN, Brazil): *TQFT as error-correcting codes.*
- **Javier Molina Vilaplana** (Universidad Politécnica de Cartagena, Spain): *Entanglement Entropy in CFT with Non-Invertible Symmetries.*
- **Horatiu Nastase** (IFT-Unesp, Brazil): *Krylov complexity from circuit complexity and from instantons.*
- **Leo Radzihovsky** (University of Colorado, USA): *Rotated superfluids QFT.*
- **Germán Sierra** (Instituto de Fisica Teorica UAM-CSIC, Spain): *Bridging the Lattice and the Continuum: Dualities and Criticality.*
- **Ho Tat Lam**(MIT, USA): *Symmetry Enforced Entanglement from Projective Non-invertible Symmetry.*
- **Rodrigo Pereira** (IIP & UFRN, Brazil): *Fracton-like behavior in a classical spin-orbital model.*

Program on Fundamental Aspects of String Theory (August 4 – 15)

From August 4 – 15, the Program on Fundamental Aspects of String Theory took place at Instituto Principia. The two-week program featured presentations on key topics including the pure spinor formalism, string field theory, AdS/CFT correspondence, and algebraic geometry. Invited speakers included [list of speakers]. For more information, visit https://www.ictp-saifr.org/pfast2025/.

Invited Speakers:

- **Luis Fernando Alday** (Oxford Univ., UK): *Discussion of superstring amplitudes on AdS.*
- **Nathan Berkovits** (ICTP-SAIFR/IFT-UNESP, Brazil): *Topological A-model dual to free $N = 4$ super-Yang-Mills.*
- **Kasia Budzik** (Harvard U., Canada): *Finite N indices and supergroup invariants.*
- **Shai Chester** (Imperial College, UK): *Bootstrapping string and M-theory.*
- **Veronika Hubeny** (UC Davis, USA): *Repackaging holographic entanglement.*
- **Henry Lin** (Stanford U., USA): *Bootstrapping matrix quantum mechanics 3.*
- **Liam McAllister** (Cornell U., USA): *Computational compactifications and de Sitter.*

- **Andre Mikhailov** (IFT-UNESP, Brazil): *Ext groups and deformations of AdS.*
- **Horatiu Nastase** (IFT-UNESP, Brazil): *AdS-CFT for cosmology and holographic cosmology.*
- **Silviu Pufu** (Princeton U., USA): *Supercurrents and (partial) supersymmetry in $2d$ adjoint QCD and its generalizations.*
- **Mukund Rangamani** (UC Davis, USA): *The super Virasoro minimal string.*
- **Jorge Russo** (U. Barcelona, Spain): *The D^8R^4 term in ten-dimensional superstring theory.*
- **Pedro Vieira** (Perimeter I., Canada & ICTP-SAIFR/IFT-UNESP, Brazil): *Some integrability predictions for very quantum strings in $AdS_5 \times S_5$.*
- **Xi Yin** (Harvard U., USA): *Comments on matrix string theory.*

Program on Quantum Many-Body Dynamics: Thermalization and its Violations (September 8 – 19)

The Program on Quantum Many-Body Dynamics: Thermalization and its Violations (September 8 – 19) is described on the webpage https://www.ictp-saifr.org/pqmbd2025/ and involve 33 speaker of thirteen different countries. Topics discussed in the program included the eigenstate thermalization hypothesis, quantum scarring, Anderson and many-body localization, Hilbert space fragmentation, and quantum chaos. Invited speakers included:

Invited Speakers:

- **Nikita Asterkhantsev** (Google): *Pauli path interference in a beyond-classical local observable*.
- **Lev Vidmar** (Jozef Stefan Institute and University of Ljubljana): *Introduction to Eigenstate Thermalization Hypothesis - Class 1*.
- **Ceren Dag** (Harvard University, USA): *Quantum scarring in many-body quantum systems*.
- **Tobias Micklitz** (CBPF, Brazil): *Path integral approach to quantum thermalization*.
- **Lev Vidmar** (Jozef Stefan Institute and University of Ljubljana): *Introduction to Eigenstate Thermalization Hypothesis - Class 2*.
- **Ivan Khaymovich** (Nordita): *Effects of correlations in disorder on localization and ergodicity breaking in long-range systems*.
- **Thomas Iadecola** (Iowa State University): *Concomitant Entanglement and Control Criticality Driven by Collective Measurements*.
- **Nikita Asterkhantsev** (Google): *Recent advances in the Google Quantum AI roadmap*.
- **David Logan** (Oxford): *Multifractality in high-dimensional graphs with radial disorder correlations*.

- **Anatoli Polkovnikov** (Boston University): *Three Different Scenarios of Chaos and Thermalization at Weak Integrability Breaking*.
- **Antonello Scardicchio** (ICTP): *Disorder in quantum systems: Anderson Localization and Many-Body Localization*.
- **Dries Sels** (New York University): *Mixing of quantum-enhanced Markov chains*.
- **Piotr Sierant** (Barcelona Supercomputing Center): *Fermionic Magic Resources of Quantum Many-Body Systems*.
- **Soumya Bera** (Indian Institute of Technology Bombay): *Fock space fragmentation in quenches of disordered interacting fermions*.
- **Yevgeny Bar Lev** (Ben Gurion University of the Negev): *Absence of localization in interacting spin chains with a discrete symmetry*.
- **Lea Santos** (University of Connecticut): *Dynamical manifestations of many-body quantum chaos and timescales for thermalization*.
- **Thomas Iadecola** (Iowa State University): *Hilbert space fragmentation and many-body scars*.
- **Eduardo Jonathan Torres Herrera** (Instituto de Fisica, BUAP): *Dynamics of disordered quantum interacting systems: Distribution functions and autocorrelated disorder*.
- **Jean-Yves Desaules** (Institute of Science and Technology Austria, Austria): *Slow thermalisation but fast transport: the U(1) lattice gauge theory as a unique paradigm of ergodicity breaking*.
- **Antonello Scardicchio** (ICTP, Italy): *Disorder in quantum systems: Anderson Localization and Many-Body Localization*.
- **Natalia Chepiga** (Delft University of Technology, Netherlands): *Probing quantum criticalities in Rydberg arrays with Kibble-Zurek mechanism*.
- **David Weiss** (Penn State University, USA): *Hydrodynamization and Local Prethermalization*.
- **Thomas Iadecola** (Iowa State University): *Hilbert space fragmentation and many-body scars - 2*.
- **Ulrich Schneider** (Cambridge, England): *Ultracold atoms in optical quasicrystals*.
- **Marcos Rigol** (Penn State University, USA): *Onset of Quantum Chaos and Ergoditicy in Spin Systems with Highly Degenerate Hilbert Spaces*.
- **Pieter Claeys** (Max Planck Institute for the Physics of Complex Systems, Germany): *Free Probability in Quantum Circuits*.

4.3.4 Minicourses

The ICTP-SAIFR organized six minicourses in 2025, on effective field theory in large scale structure, groundbreaking papers in theoretical physics, partial differential equations, black hole

superradiance, cosmological principle, and fundamentals of biological physics. The topics, lecturers and websites for these minicourses are:

1) January 6-7 – **Minicourse on Effective Field Theory in Large Scale Structure** – Henrique Rubira (LMU/Cambridge):
   This minicourse provided a powerful theoretical framework for understanding the distribution of matter and galaxies in the universe on cosmological scales. The website of the minicourse is https://www.ictp-saifr.org/meftlss2025/.

2) April 1-May 5 – **Groundbreaking Papers in Theoretical Physics** – Pedro Vieira (Perimeter/ICTP-SAIFR/IFT-UNESP):
   This seminar series provided a comprehensive theoretical foundation for engaging with landmark developments in modern physics, offering students deeper insight into topics ranging from quantum field theory and statistical mechanics to general relativity and holography. The website of the minicourse is https://www.ictp-saifr.org/gptp2025/.

3) May 5 – June 30 – **Minicourse on Partial Differential Equations: Analytical and Numerical Tools** – Oscar Reula (National University of Córdoba, Argentina), Joaquín Pelle (AEI-Max-Planck Institute at Golm, Germany), and Pablo Montes (National University of Córdoba, Argentina):
   The lectures covered theoretical and computational topics related to the analytic and numerical solution of ordinary and partial differential equations. The minicourse involved 60 participants. The website is https://www.ictp-saifr.org/mpde2025/.

4) May 15 – 22 – **Minicourse on Black Hole Superradiance** – Nils Siemonsen (Princeton University, USA) and Maxence Corman (Max Planck Institute, Germany):
   This minicourse discussed the fundamentals of the superradiance mechanism, from the underlying thermodynamics to the dynamics of unstable field configurations. The website is https://www.ictp-saifr.org/mobhs2025/.

5) June 16 – 17 – **Minicourse on Testing the Cosmological Principle** – Leonardo Giani (Queensland U.):
   This minicourse addressed the cosmological principle and its impact on cosmological inferences. The website is https://www.ictp-saifr.org/testingcosmologicalprinciple/.

6) November 10 – 14 – **Minicourse on Fundamentals of Biological Physics** – Silvina Ponce Dawson (UBA), Pablo de Castro (ICTP-SAIFR), and Rafael Menezes (ICTP-SAIFR):
   This minicourse discussed specific problems of diffusion and stochastic processes, phase separation in biological media, cellular signaling, active matter, and ecological interactions. The website is https://www.ictp-saifr.org/mfbp2025/.

4.3.5 Meetings and Conferences

APS-SAIFR Satellite Global Physics Summit (March 17)

As part of the APS Global Physics Summit held in Anaheim, California from March 16–21, 2025, ICTP-SAIFR organized a Satellite Session on Quantum Technologies on Monday, March 17. The hybrid session included 3 speakers in Anaheim and 3 speakers in São Paulo and was broadcast live to all participants of the APS Meeting. In addition, ICTP-SAIFR organized a session on Quantum Systems featuring student and postdoc presentations, as well as a seminar by Purpose-Led Publishing on "Avoiding Predatory Journals". The website of the meeting is https://www.ictp-saifr.org/apssgps2025/.

Invited Speakers:

- 15:30 – **Fernando Brandão** (Caltech, USA): *Scale-efficient quantum error correction using concatenated bosonic qubits.*
- 15:50 – **Simon Groeblacher** (Delft Univ. of Tech, Netherlands): *Controlling a superconducting qubit with light.*
- 16:10 – **Yiwen Chu** (ETH Zurich, Switzerland): *A mechanical qubit.*
- 16:40 – **Rafael Barros** (USP São Paulo, Brazil): *Hybrid quantum frequency conversion.*
- 16:50 – **Patricia Castilho** (USP São Carlos, Brazil): *A 2D Bose gas to study quantum hydrodynamic instabilities.*
- 17:10 – **Guilherme Temporão** (PUC Rio, Brazil): *Tackling engineering challenges in metropolitan quantum networks.*

Short Talks:

- 11:00 – 11:20 **Patricia de Assis Almeida** (UF Uberlandia): *Kondo effect in strained Kagome ribbons.*
- 11:20 – 11:40 **Gustavo Moreto** (Unicamp): *Fabrication and Characterization of a Superconducting Qubit*.
- 11:40 – 12:30 *Lauren Flintoft (IOP Publishing): Avoiding predatory journals*.
- 13:30 – 13:50 **Eduardo Gonçalves** (Unicamp): *Tunable Degenerate Optical Parametric Oscillation with Coupled Microresonators*.
- 13:50 – 14:10 **Lucas Cesar Gomes Alvarinho Squillante** (Unesp Rio Claro): *Grüneisen parameter as an entanglement compass and the breakdown of the Hellmann-Feynman theorem*.
- 14:10 – 14:30 **Pedro Ventura Paraguassú** (PUC Rio de Janeiro): *Effects of a quantum system upon a classical mesoscopic nanoparticle system*.
- 14:30 – 14:50 **Lauro Barreto Braz** (IFUSP): *Competing magnetic states on the surface of multilayer ABC-stacked graphene*.

Joint ICTP-Lincei Conference on Quantum Science and Technology (May 26)

This one-day meeting was part of the week-long "ICTP Global Event for the International Year of Quantum Science and Technology," organized together with the Accademia dei Lincei (Rome), ICTP, and SISSA (Trieste). Held on May 26, the program featured three roundtable discussions in the IFT-UNESP auditorium which explored the topics of recent scientific research, funding opportunities, and the development of a Latin American network in quantum science and technology. The website of the meeting is https://www.ictp-saifr.org/cqst2025/ and speakers included:

- **Carla Hermann Avigliano** (Univ. de Chile, Chile)
- **Christian Schmiegelow** (Univ. de Buenos Aires, Argentina)
- **Gustavo Wiederhecker** (Unicamp, Brazil)
- **Juan Pablo Paz** (Univ. de Buenos Aires, Argentina)
- **Karina Garay-Palmett** (CICESE, Mexico)
- **Liliana Sanz de la Torre** (Univ. Fed. de Uberlândia, Brazil)
- **Luiz Davidovich** (Univ. Fed. de Rio de Janeiro, Brazil)
- **Marcelo Abreu** (Venturus, Brazil)
- **Olival Freire Junior** (CNPq, Brazil)
- **Paulo Nussenzveig** (USP, Brazil)
- **Rodrigo Benevides** (IFUSP, Brazil)
- **Thiago Alegre** (Unicamp, Brazil)

9th Conference on Chirality, Vorticity and Magnetic Fields in Quantum Matter (July 7–11)

This one-week international conference from July 7–11 at the Principia Institute was organized by ICTP-SAIFR and brought together 51 theoretical and experimental physicists to discuss chiral and vortical phenomena in quantum matter, heavy-ion collisions, superconductors, magnetohydrodynamic systems and astrophysical objects. The conference's website is https://www.ictp-saifr.org/ccvmfqm2025/ and speakers include:

- **Ricardo Farias** (UFSM, Brazil): Chiral vortical catalysis: Insights from LQCD
- **Andrea Palermo** (Stony Brook University): *Spin alignment of the ϕ meson in the hadronic phase of the Quark Gluon Plasma*
- **Caio Vaz Brito** (Universidade Federal Fluminense): *Causal and stable magnetohydrodynamics for an ultrarelativistic two-component gas*

- **Pracheta Singha** (TBA): *Finite spin density effects on the chiral phase transition in the linear sigma model*
- **Danielle Roselli** (Goethe University Frankfurt am Main): *Dissipative corrections to the particle momentum spectrum of a decoupling fluid*
- **Annamaria Chiarini** (Goethe University Frankfurt am Main): *Semi-Classical Spin Hydrodynamics: Current Status and the Road Ahead*
- **Alejandro Ayala** (UNAM, Mexico): *Asymmetric muon-antimuon emission from Z0 decays: a clear magnetometer in relativistic heavy-ion collisions*
- **Eduardo Fraga** (UFRJ, Brazil): *Hot and dense perturbative QCD in a very strong magnetic background*
- **Gastão Krein** (UNESP, Brazil): *Nonequilibrium Dynamics of the Chiral Quark Condensate: Magnetic Field Effects and Inhomogeneous Phases*
- **Cristian Villavicencio** (UBB, Chile): *Qark anomalous magnetic moment in the presence of an extreme magnetic field*
- **Alfredo Raya** (UMSNH, Mexico): *Aspects of Topology from the Dirac Equation and Supersymmetry*
- **Fabio Braghin** (Universidade Federal de Goiás): *Unusual quark effective interactions from vacuum polarization under relatively weak magnetic field*
- **Dima Cheskis** (Ariel University): *Magneto-Optical and Transport Measurements of $Co_3Sn_2S_2$, a Ferromagnetic Weyl Semimetal*
- **Huan Zhong Huang** (UCLA, USA, and Fudan, China): *Intriguing Features from CME and Critical Point Searches from RHIC BES Program*
- **Dimitri Kharzeev** (Stony Brook Uni. and BNL, USA): *Chiral magnetic effect in heavy ion collisions: The present and future*
- **Gergely Endrodi** (Eotvos Univ.): *Anomalous transport phenomena on the lattice*
- **Eduardo Garnacho** (Eotvos University): *Out-of-equilibrium CME conductivity from Lattice QCD*
- **Jose Javier Hernandez** (University of Bielefeld): *The axion-photon coupling from Lattice QCD*
- **Aritra Bandyopadhyay** (TBA): *Signatures of local acceleration of quark-gluon plasma in the dilepton production*
- **Marcelo Loewe** (Universidad San Sebastian, Chile): *π-π scattering lengths in the frame of the linear sigma model: Electric field effects (and something else)*
- **Enrique Muñoz** (PUC, Chile): *Exploring magnetic fluctuation effects in QED fields: Theory and phenomenological implications*
- **Maxim Chernodub** (TBA): *Chiral and deconfinement thermal transitions at finite quark spin polarization in lattice QCD simulations*

- **Jinfeng Liao** (Indiana Uni., USA): *Spin and Chirality Transport in Heavy Ion Collisions at BES Energies*
- **Francesco Becattini** (Florence, Italy): *Pseudogauge-invariant local equilibrium distribution*
- **Kenji Fukushima** (Tokyo, Japan): *Spin potential in and out of equilibrium*
- **Cicero Muncinelli / Jun Takahashi** (Unicamp): *TBA*
- **Norberto Scoccola** (UNSAM, Argentina): *Anomalous neutral pion decay in a strong magnetic field*
- **William Tavares** (Universidade Estadual do Rio de Janeiro): *Chirally imbalanced medium in a four-fermion interaction model beyond the large-N_c approximation*
- **Jorge David Castaño-Yepes** (Departamento de Física, Universidad del Valle, Colombia): *Twisting the Quark-Gluon Plasma: Insights into Electromagnetic and Dilepton Emission from a Rotating Medium*
- **Leticia Palhares** (UERJ): *Testing Infrared Confining Models Beyond Fundamental Correlation Functions*
- **Aihong Tang** (BNL, USA): *Probing Spin Dynamics and Magnetic Fields in Heavy-Ion Collisions*
- **Sergei Voloshin** (Wayne State, USA): *Recent results on polarization in high energy nuclear collisions at LHC and RHIC energies*
- **Fuqiang Wang** (Purdue University): *Measurements of azimuthal correlations with spectator and participant planes to search for the chiral magnetic effect in STAR*
- **Mike Lisa** (Ohio State University): *Vortex rings from high energy central p+A collisions*
- **Raul Wolters** (Utrecht University): *Spin-hydrodynamics and hyperon polarization in Trajectum*
- **Mauricio Hippert** (Centro Brasileiro de Pesquisas Físicas): *Effective action for relativistic hydrodynamics from Crooks fluctuation theorem*
- **Shu Lin** (Sun Yat-sen University): *Spin polarization in off-equilibrium medium at weak and strong coupling*
- **Igor Shovkovy** (Arizona State Univ., USA): *Neutrino emission from quark cores of magnetars*
- **Dyana Duarte** (UFSM): *Medium Separation Scheme and the Cold-Magnetized Superconducting Quark Matter*
- **Osvaldo Ferreira Neto** (Universidade Federal do Rio de Janeiro): *Pion condensation and chiral symmetry breaking in the early universe*
- **Cong Yi** (Central China Normal University): *Spin polarization of Λ hyperons along beam direction in p+Pb collisions at $\sqrt{s_{NN}} = 8.16$ TeV using hydrodynamic approaches*
- **Georgii Prokhorov** (Joint Institute for Nuclear Research): *Viscosity, entanglement and acceleration*

- **Khwahish Kushwah** (Universidde Federal Fluminense (UFF), Niteroi): *Relativistic Magnetohydrodynamics of Two-Component Plasmas in Accretion Disks and Heavy-Ion Collisions*
- **Nick Abboud** (TBA): *Dynamic magneto-chiral instability in a semiconductor*
- **Jesús Javier Rendón** (Instituto de Ciencias Nucleares (ICN), UNAM): *Neutral pion screening masses in the linear sigma model with quarks*
- **José Jorge Medina Serna** (Institute of Nuclear Science UNAM): *Relaxation time for Λ and $\bar{\Lambda}$ hyperons coming from rotating Corona regions in heavy ion collisions*
- **Luis Hernandez** (UAM, Mexico): *A Journey Beyond Mean Field: Toward Inverse Magnetic Catalysis and the Critical Point in the LSMq*
- **Saul Fernando Hernandez Ortiz** (Institute of Physics and Mathematics): *The speed of sound on the effective QCD phase diagram of Temperature–Magnetic Field plane*
- **João Paulo Sampaio Santos** (Universidade do Estado do Rio de Janeiro (UERJ)): *Superconductivity in confining models*
- **José Carlos Jiménez Apaza** (Centro Brasileiro de Pesquisas Físicas): *f-mode oscillations of strange stars obtained from the vector MIT bag model*
- **Pablo Sebastián Pais** (Universidad Austral de Chile): *Fractional vorticity, Bogomol'nyi–Prasad–Son systems for the Gross-Pitaevskii equations*

São Paulo Research Group meetings in Astro & Cosmo

ICTP-SAIFR organizes monthly one-day meetings at Principia Institute of the São Paulo community working in astrophysics, astroparticles, gravity, and cosmology. The website of the meeting is https://www.ictp-saifr.org/astrocosmomeeting/. The meetings organized in 2025 were:

November 28, 2025:

- 10:00 – **Rainer Menote** (UFES, Brazil): *CosmoDC2BCO: A Gateway to Multi-Messenger Cosmology.*
- 11:15 – **Tabata Aira** (INPE, Brazil): *Exploring the Origins of Glitches in the LIGO Detectors Using Machine Learning Techniques*.
- 14:00 – **Germán Lugones** (UFABC, Brazil): *New Stable Branches of Compact Stars Beyond the Maximum-Mass Turning Point*

October 3, 2025:

- 11:15 – **Pedro Henrique Rossetto** (USP, Brazil): *Continuous Gravitational Waves from Neutron Stars Magnetic Mountains.*
- 14:00 – **Joaquin Armijo** (USP, Brazil): *Cosmological constraints from the first year data of the Hyper Suprime-Cam*.

August 29, 2025:

- 11:00 – **Alexandre Le Tiec** (IFT-UNESP — CNRS): *What's in a Name: the Anthropocene.*
- 14:00 – **Fernanda Lima** (IF-USP, Brazil): *Ultra-light dark matter and power spectra emulators.*
- 15:15 – **João Ferri** (IF-USP, Brazil): *What can we gain from small scales in shear analysis? A comparison between Fourier and Real spaces.*

June 13, 2025:

- 10:00 – **Walter Riquelme** (IFT-UNESP, Brazil): *Imprints of Large-Scale Structures in the Anisotropies of the Cosmological Gravitational Wave Background*.
- 11:15 – **Ricardo Medina** (UFEI, Brazil): *Determining self-force corrections to the equation of the separatrix of a Schwarzschild black hole*.
- 14:00 – **Gustavo Figueiredo Severiano Alves** (IF-USP, Brazil): *Chasing Serendipity: Tackling Transient Sources with Neutrino Telescopes.*

May 9, 2025:

- 10:00 – **Pedro Bittar** (USP, Brazil): *Baryogenesis just around the corner: Generating the matter asymmetry at or below the weak scale*.
- 11:15 – **Rodrigo Voivodic** (Donostia Int. Physics Cent. San Sebastian, Spain & IFT-UNESP, Brazil): *Likelihoods*.
- 14:00 – **Gustavo Henrique dos Santos** (UFABC, Brazil): *ACT Constraints on Low Scale Inflation and a Mechanism for Vector Dark Matter Production*.

April 4, 2025:

- 10:00 – **Parth Bambhaniya** (USP, Brazil): *Are We Sure It's a Supermassive Black Hole at the Heart of Our Galaxy?*.
- 11:15 – **Natalia Villa Rodrigues** (USP, Brazil) : *Modeling halo bias with neural networks.*
- 14:00 – **Vitor Sampaio** (UNICID): *Disks and Spheroids across cosmic time: Morphological and Star Formation Evolution of Galaxies from* $z = 2.4$ *to* $z = 0.2$.

March 14, 2025:

- 10:00 – **Jorge Luiz Meléndez Moreno** (IAG-USP, Brazil): *Solar Twins and their implications for Planets, Stars and the Galaxy.*
- 11:15 – **Sylvain Fichet** (UFABC, Brazil): *Holographic Dark Matter.*
- 14:00 – **Camila Novaes** (INPE, Brazil): *Leveraging machine learning for cosmological inference.*

Research Group Meetings on Quantum Technologies

ICTP-SAIFR organized one-day meetings every two months for the São Paulo community working in quantum technologies, quantum information, and quantum computing. With a light schedule and ample time for discussion, these meetings aimed to promote interaction between experimental and theoretical groups and stimulate collaboration on emerging quantum technologies. The website of the meeting is https://www.ictp-saifr.org/quantum_technologies/. The invited speakers of the meetings organized in 2025 were:

November 28, 2025:

- **Rodrigo Capaz** (UFRJ, Brazil): *Microfab.*
- **Felix Hernandez** (USP, Brazil): *Cryogenics.*
- **Newton Frateschi** (Unicamp): *Device testbed.*
- **Eduardo Mobilon** (CPQD): *TBA*.
- **Paulo Nussenzveig** (USP, Brazil): *Quantum networks – Role of Institutions.*
- **Marcelo Nalim** (Unesp – Instituto de Química): *FAPESP EMU Program*.

April 23, 2025:

- **Rafael Chaves Souto Araújo** (IIF/UFRN): *Beyond Thought Experiments: Turning Quantum Foundations into Quantum Technology*.
- **Valeria Loureiro da Silva** (Senai/Cimatec/BA): *QuIIN – Estimulando a Inovação em Tecnologias Quânticas /QuIIN – Fostering Innovation in Quantum Technologies*
- **Antônio Zelaquett Khoury** (IF/UFF): *Rio Quantum Network: a metropolitan quantum communication network in Rio de Janeiro*.
- **Filippo Ghiglieno** (UFSCAR): *Recentes avanços na implementação da rede de comunicação quântica em São Carlos*.
- **Daniel Felinto Pires Barbosa** (DF/UFPE): *Perspectivas para implantação de uma internet quântica em Recife*
- **Rafael Ferreira Pinto do Rego Barros** (IFUSP): *QneSP – distributing entanglement across the state of São Paulo.*

February 20, 2025:

- **Daniel Varela Magalhães** (USP): *Quantum sensing with atoms.*
- **Carmem Maia Gilardoni** (CBPF): *Quantum sensing with defects in solids.*
- **José Inácio da Costa Filho** (Harvard Medical School): *Quantum-inspired super-resolution microscopy*.
- **João Paulo Sinnecker** (CBPF): *Superconducting devices.*

- **Luís Gustavo Marcassa** (USP): *Quantum sensors with Rydberg atoms.*
- **Philippe Courteille** (USP): *Matter-wave gravimetry*
- **Thiago Alegre** (Unicamp): *Optomechanical devices*.
- **Hans M. Florez** (UFABC): *Atomic vapor-cell magnetometers*.

December 3, 2024:

- **Diogo O. Soares-Pinto** (IFSC – USP): *Advantages and Drawbacks of Variational Quantum Algorithms*.
- **Felipe Fanchini** (Unesp): *Quantum Computing Today: Errors and Mitigation Strategies in the NISQ Era*.
- **Pierre-Louis de Assis** (Unicamp): *Working towards NISQ photonic devices.*

Physics of Life South American Network - PoLSAN

Created at the ICTP-SAIFR March workshop on the Physics of Life, this initiative brought together researchers, students, and institutions across South America working on biological physics and living systems. The network was chaired by Silvina Ponce Dawson (U. Buenos Aires & ICTP-SAIFR) and vice-chaired by Pablo de Castro (ICTP-SAIFR/IFT-Unesp), and aimed to strengthen regional collaboration in the rapidly growing field of the physics of life. The website of the meting is https://sites.google.com/view/phys-life-south-america/seminars/past-seminars?authuser=0, and seminars organized in 2025 were:

Seminars:

- June 12 – **William Bialek** (Princeton University, USA): *Scale invariance in the physics of life.*
- June 30 – **Fernanda Selingardi Matias** (UFAL, Brazil): *Brain dynamics: data analysis and numerical simulation of neuronal circuits.*
- August 8 – **Sergio Pantano** (Institut Pasteur de Montevideo, Uruguay): *Challenges in simulating whole virus particles and some initiatives to address in the South.*
- September 5 – **Pablo A. Marquet** (Pontificia Universidad Catolica de Chile, Chile & The Santa Fe Institute, USA): *The emergence, maintenance, and dynamics of biodiversity.*
- October 3 – **Mauricio Girardi-Schappo** (Federal University of Santa Catarina (UFSC), Brazil): *Neural adaptation and spatial learning: from navigation to the dentate gyrus*.
- November 7 – **Rita M.C. de Almeida** (Federal University of Rio Grande do Sul (UFRGS), Brazil): *Active matter, active solids, and cell migration: Epithelium-Mesenchymal transitions embrace them all!*

4.3.6 Outreach Events

The ICTP-SAIFR organized 17 different types of online outreach activities in 2025 aiming at high-school teachers, high-school students and the general public. The format, topics and websites for these events are:

Modern Physics for High-School Teachers - Portuguese

In this in-person course, pedagogical material developed by Perimeter Institute and translated by ICTP-SAIFR was presented to high-school teachers. On August 23 the topic was *Gravitational Waves* with Riccardo Sturani (IFT-UNESP & ICTP-SAIFR), and from November 8-9 was presented the course *The History of the Universe and the Formation of Chemical Elements* by Ana Luiza Sério (Escola Vera Cruz, São Paulo & ICTP-SAIFR), Bruna Camila Santos da Silva (MPEA/IAG-USP), and Gabriela Camargo Campos (MPEA/IAG-USP & CLP-Unesp). The webpage of the program is https://outreach.ictp-saifr.org/ensino-medio/professores/.

Modern Physics for High-School Teachers - Spanish

In this online course taught in Spanish, pedagogical material developed by the Perimeter Institute and translated by ICTP-SAIFR was presented to high-school teachers from across Latin America using a Zoom platform with breakout rooms. The webpage of the program is https://outreach.ictp-saifr.org/ensino-medio/professores/fisica-de-fronteira-para-a-sala-de-aula-online/espanol/ and presentations were given from March - November on topics in quantum mechanics and gravitational waves.

V ICTP-SAIFR Summer Course for High School Physics Teachers

From January 20-24, 2025, ICTP-SAIFR organized a one-week online summer course in Portuguese and Spanish on Quantum Mechanics. The activities include seminars based on Perimeter material translated into Portuguese and Spanish by ICTP-SAIFR and discussion sessions with various researchers. Participants also attended lectures by Marcelo Terra Cunha (INICAMP, Brazil) in Portuguese and by Eduardo Fradkin (University of Illinois, USA) in Spanish. The website of the summer course is https://outreach.ictp-saifr.org/cursoveraoprofessores/.

Lecturers:

- **Cintia Cirillo** (E.E. PEI Álvaro de Souza Vieira, Ribeirão Pires – SP & ICTP-SAIFR – SP, Brazil): *Heisenberg's indeterminacy principle.*
- **Marcelo Terra Cunha** (INICAMP, Brazil): *Quantum Mechanics.* – Portuguese

- **Felipe Novaes** (E.E. PEI Dr. Antônio Ablas , Santos – SP & ICTP-SAIFR – SP, Brazil): *What is an electron?* – Portuguese & *Why do greenhouse gases absorb infrared radiation?*
- **Fátima Machado** (Brazil): *The Photoelectric effect.*
- **Ivan Morales** (Peru): *How can atoms exist?*
- **Juber Meneses** (Colombia): *What is an electron?* – Spanish
- **Martín Monteiro** (Universidad ORT Uruguay y Sociedad Uruguaya de Física, Uruguay): *The Planck's Constant.*
- **Zui Oporto** (Planetario Max Schreier – Universidad Mayor de San Andrés – La Paz, Bolivia): *Hydrogen atom.*
- **Eduardo Fradkin** (University of Illinois, USA): *Quantum Mechanics* – Spanish

Physics Games for High-School Teachers

In this activity, organized by ICTP-SAIFR outreach coordinator Ana Luiza Sério, designed as a board-based escape room, teachers will tackle various challenges or physics missions aimed at teaching students scientific knowledge about different topics of General Physics. On March 29 the *Particle Physics Mission* included topics such as moment conservation, vectors, Lorentz law, uniform circular motion, special relativity, among others. The website of this activity is https://outreach.ictp-saifr.org/ensino-medio/professores/jogos/.

Modern Physics for the Classroom – Brasilia

From August 24-25, ICTP-SAIFR organized a minicourse for high school teachers based on classroom material developed by Perimeter and translated and adapted by ICTP-SAIFR. The minicourse was held in Brasilia and covered topics such as dark matter, SM, scientific models of gravity, exoplanets, and climate change. The website is https://outreach.ictp-saifr.org/ensino-medio/professores/brasilia24/.

Minicourses for High-School Students

This program involves several minicourses on modern physics for high-school students every Saturday morning. The website for the minicourses is http://outreach.ictp-saifr.org/ensino-medio/minicurso/ and topics covered include:

- Ana Mizher (IFT-Unesp & UNICID): *Elementary Particle Physics: From the Origin of the Universe to Particle Accelerators* (March 22 - April 5).
- Riccardo Sturani (ICTP-SAIFR/IFT-Unesp): *Gravitational Wave Astronomy* (May 10 - 17).

- Dario Rosa (ICTP-SAIFR/IFT-Unesp): *Introduction to Quantum Mechanics* (June 1 - 14).
- Pedro Vieira (ICTP-SAIFR & Perimeter Institute): *Beautiful Ideas in Physics* (June 26 - August 9).
- André Landulfo (UFABC): *The Geometry of Spacetime: A Geometric Introduction to Relativity and Black Holes* (August 16 - 30).
- Marco Aurélio de Menezes Franco (IAG-USP) and Pedro Henrique Teixeira Tavares (Ph.D. student IFUSP): *Physics of Atmospheric Aerosols* (August 10-24).

5th Summer School for Young Physicists

U. Porto and ICTP-SAIFR jointly organized the 5th Summer School for Young Physicists from January 16-23, 2025. During this school, 33 talented high school students were selected to develop research projects created and supervised by 8 graduate students. Participants also attended three seminars and one minicourse:

Projects:

1) *The Origin of Thermodynamic Time* – Henrique Ay Casa Grande (USP).
2) *A First Approximation to Nuclear Binding Energy and Nucleon Stability* – Arthur Almeida Frazon (UFABC).
3) *Physical and Mathematical Modeling of Epidemics* – Guilherme Henrique da Silva Costa (ICTP-SAIFR & IFT-Unesp).
4) *Introduction to Black Hole Physics* – Níckolas de Aguiar Alves (UFABC).
5) *Transition Between the Classical and Quantum Regimes in the Harmonic Oscillator* – Viviane Brandão Silva Leite (IFT-Unesp).
6) *Introduction to Group Theory and Symmetries* – Marcelo Rezende (IFT-Unesp).
7) *Relativistic Corrections to the Law of Reflection in Plane Mirrors* – Felipe Freitas (IFT-Unesp).
8) *From Atoms to Materials: How Does the Discrete Structure Affect Macroscopic Behavior?* – Washington dos Santos (IFT-Unesp).

Seminars:

- Lia Doubrawa (IAG-USP): *Extragalactic Astronomy and Cosmology*.
- Guilherme Henrique da Silva Costa (ICTP-SAIFR & IFT-Unesp): *On Bridges, Social Networks, and Butterflies: The Physics of Complex Systems*.
- Ana Mizher (IFT-Unesp): *Little Bangs: The Origin of the Universe in the Laboratory*.
- Denis Oliveira Damazio (BNL/CERN/ATLAS): *Virtual Visit to ATLAS (CERN)*.

The school's minicourse was titled "Introduction to Quantum Mechanics" and taught Gastão Krein (IFT-Unesp). The website of this activity is https://outreach.ictp-saifr.org/edv25/. The sixth edition is planned for 2026 (see the website https://outreach.ictp-saifr.org/escolaverao/).

Classroom Modules for High School Students

This program involves several classroom modules on physics for high-school students held at the Auditorium of IFT-UNESP every Saturday afternoon. The website for the classroom is https://outreach.ictp-saifr.org/modulos-de-aulas-ift-unesp/ and topics covered include:

Modules:

- From May 24 to June 14: *Physics and Its Conservation Laws (Part 1)* – Lucas David Feitosa C. (Etec Albert Einstein, Colégio Santa Marcelina & ICTP-SAIFR).
- On August 2: *Physics and Its Conservation Laws (Part 2)* – Lucas David Feitosa C. (Etec Albert Einstein, Colégio Santa Marcelina & ICTP-SAIFR).
- From August 16 to October 11: *Module for University Entrance Exams (1st Phase)* – Felipe de Novaes (EE Dr. Antônio Ablas Filho & ICTP-SAIFR), Lucas David Feitosa C. (Colégio Santa Marcelina, Etec Dra. Maria Augusta Saraiva & ICTP-SAIFR), and Marcelo Cremer (Colégio Stockler).
- From November 28 to December 13: *Module for University Entrance Exams (2st Phase)* – Arthur Domont (graduando IFUSP), Felipe de Novaes (EE Dr. Antônio Ablas Filho & ICTP-SAIFR), Felipe Freitas (doutorando IFT-Unesp), Lucas David Feitosa C. (Colégio Santa Marcelina, Etec Dra. Maria Augusta Saraiva & ICTP-SAIFR), and Marcelo Cremer (Colégio Stockler)

ICTP-SAIFR Preparation for Participation in Physics Olympiads

Clewton Fonseca, who is also a high-school teacher with FAPESP fellowship, teaches classes for high-school and middle-term students to prepare for the physics olympiad exams in Campinas. The website of the project is https://outreach.ictp-saifr.org/programa-olimpiadas-cps/.

Physics Beyond the Classroom

The "Physics Beyond the Classroom" program, organized by William Carreras Oropesa (ICTP-SAIFR), was designed to introduce high-school students to key concepts and methods used in university-level physics. This year, the students studied topics related to logic, set theory, discrete mathematics, and algorithm analysis, as well as an introduction to the C programming

language. The website of the program is https://outreach.ictp-saifr.org/fisica-alem-da-sala-de-aula/.

ICTP-SAIFR Program for Young Scientists

ICTP-SAIFR offered highly motivated high-school students an opportunity to explore scientific research through themed introductory projects supervised by PhD students. Running from June to October 2025, the program provided participants with their first hands-on experience of how research in physics is conducted. More details about the 2025 projects were available in https://outreach.ictp-saifr.org/programajc/.

ICTP-SAIFR Winter Course for Young Physicists

From July 7–11, ICTP-SAIFR organized a one-week winter school for high school students. The program included two minicourses — *Quantum Mechanics* by Prof. Alexandre Reily (IFT-UNESP & ICTP-SAIFR) and *Introduction to Python* by IFT-UNESP physics PhD student Washington F. dos Santos — as well as a visit to the Sirius and Ilum facilities in Campinas. More information is available on the winter school website: https://outreach.ictp-saifr.org/cursodeinverno/.

ICTP-SAIFR Competition for Young Physicists

On Saturday, July 19, ICTP-SAIFR held the 19th version of its annual exam for top undergraduate students at the IFT-UNESP auditorium. The top five scorers of the exam receive cash prizes and were Renzo Mattos Cahui (PUC, Perú), Tomas Dominguez (Inst. Balseiro), Louis Bergamo Radial (USP São Paulo), Santiago Ferreyra (Inst. Balseiro) and Lucía Nebai Helou (Inst. Balseiro). More information is available on the winter school website: https://www.ictp-saifr.org/youngphysicistprize2025/.

ICTP-SAIFR Distinguished Public Lecture

In 2025, ICTP-SAIFR organized four Distinguished Public Lectures aimed at a broad audience, primarily Portuguese-speaking but not exclusively. These events featured leading international researchers discussing frontier topics in physics, from neutrinos and dark matter to cosmology and complex systems. The lectures attracted students, educators, and science enthusiasts from across Brazil. More information is available on the winter school website: https://outreach.ictp-saifr.org/public-lectures/.

Lectures:

- February 21 – **Andre Luiz De Gouvea** (Northwestern University): *Neutrinos, Dark Matter, and Other Mysteries.*

- May 19 – **Ze'ev Rosenkranz** (Caltech) & **Rogério Rosenfeld** (IFT–UNESP/ICTP-SAIFR): *Physics Day.*
- September 13 – **Marcelo Terra Cunha** (UNICAMP) & **Gustavo Wiederhecker** (UNICAMP): *Celebrating 100 Years of Quantum Mechanics.*
- October 31 – **Subir Sachdev** (Harvard University): *100 years of many-particle quantum mechanics: from Bose and Fermi to quantum materials and black holes.*

Book Club – Sci-SAIFR

In this outreach program, a physicist uses a science fiction book to discuss with the audience the physics concepts behind it. The webpage for the program is `https://outreach.ictp-saifr.org/clube-do-livro/`, and the books discussed from December 2024 to November 2025 meetings included:

- Pedro Cunha de Holanda (IFGW Unicamp, Brazil): *Solar Neutrinos and the Scientific Method* (October 16).
- Ana Cecilia Soja (IFF, Brazil): *Giants of Physics* (August 21).
- Leonardo Crochik (UFSC, Brazil): *The Life of Galileo* (June 26)
- Ze'ev Rosenkranz and Rogerio Rosenfeld ICTP-SAIFR & IFT-UNESP).: *Albert Einstein's Travel Diaries in South America* (April, 16)
- Bruno Leonardo do Nascimento Dias (USP): *Astrobiology in Six Lessons* (February 6)
- Henrique Silva (UFSC): *Awakening* (December 11, 2024)

Science in Cinema

ICTP-SAIFR and the Reag Belas Artes Cinema promoted special sessions to discuss films related to physics with a public audience. In these sessions, researchers invited by the ICTP-SAIFR answered questions from the audience after the films. The website of this activity is `https://outreach.ictp-saifr.org/ciencia-no-cinema/` and the films discussed and the invited researchers from December 2024 to November 2025 included:

- *Tenet* (October 21) with **Eric Andrade** (IFUSP)
- *The Matrix* (September 23) with **Fernando Navarra** (IFUSP)
- *Interstellar* (August 28) with **Riccardo Sturani** (ICTP-SAIFR & IFT-UNESP)
- *Mars One* (July 28) with **Alan Alves Brito** (UFGRS)
- *Everything Everywhere All at Once* (June 25) with **Gastão Krein** (IFT-UNESP)
- *Apollo 13* (May 27) with **Fabio Mota** (UFABC)
- *Mickey 17* (April 15) with **Ernesto Goulart** (IB-USP)
- *The Time Machine* (March 18) with **Ana Mizher** and **Ana Rüsche**
- *The Imitation Game* (February 18) with **Marcelo Finger** (IME/USP)

- *Interstellar* (January 28) with **Riccardo Sturani** (ICTP-SAIFR & IFT-UNESP)
- *Particle Fever* (December 17, 2024) with **Marcelo Munhoz** (IFUSP)

Additionally, there were two special film sessions for children, where the following movies were shown:

- *Elio* (July 28) with **Rogério Rosenfeld** (ICTP-SAIFR & IFT-UNESP)
- *Flow* (February 22) with **Tito Lotufo**

Papos de Física

"Papos de Física" is an activity organized by ICTP-SAIFR where one or more researchers lead discussions on science with a general audience. These events are hosted at Cervejaria Nacional (Av. Pedroso de Morais, 604 – Pinheiros) in São Paulo. The official event website is https://outreach.ictp-saifr.org/papos-de-fisica/. The sessions held between December 2024 and November 2025 were:

- *Gravitational Wave Astronomy* (March 28) with Riccardo Sturani (ICTP-SAIFR & IFT-UNESP).
- *The Evolution of the Laser and the Nobel Prize* (April 24) with Nathalia Tomázio (IFUSP).
- Pint of Science 2025:
  - *This So-Called Quantum Physics/What Would a Scientist and a Journalist Be Doing in a Bar?* (May 20) with **Marina Nielsen** and **Graciele Oliveira**.
  - *A Hundred Years of Quantum Revolutions* (May 21) with **Paulo Nussenzveig** (USP).
- *Elementary Particles and Their Secrets* (June 27) with **Riccardo Sturani** (ICTP-SAIFR & IFT-UNESP).
- *Little Bangs: The Beginning of the Universe in the Laboratory* (August 29) with **Ana Mizher**.
- *Riding the Electron Wave: From Basic Physics to Applied Physics* (September 25) with **Germano Penello** (IFUSP).
- *Brave Nano World: Physics and Technology at the Atomic Scale* (November 27) with **Alexandre Reily Rocha** (IFT-UNESP).

4.3.7 Weekly Seminars, Colloquia and Journal Clubs

In 2025, weekly seminars were regularly organized. There were 158 seminars and the complete list is on the website https://www.ictp-saifr.org/2025-research-seminars-and-activities/. There were also weekly journal club meetings in string theory, soft and biological matter, cosmology and quantum systems.

4.3.8 Annual Meeting of Steering Committee and Scientific Council:

On February 17-18, 2025, the ICTP-SAIFR scientific council met to discuss the activities planned for 2025. The council members are listed on the website http://www.ictp-saifr.org/steering-committee/ and http://www.ictp-saifr.org/scientific-council/. The 2026 meeting of the steering committee and scientific council will be on February 9 - 10.

4.4 Request of Additional Postdoctoral Fellowhips

In the previous scientific report of this thematic grant which was submitted on December 27, 2024, a modification of the budget was requested to increase the number of postdoctoral fellowships. This increase would have allowed extensions of the existing 2-year fellowships for an additional year (as was decided by FAPESP for new fellowships starting in June 2024), and would have allowed the expansion of ICTP-SAIFR into new research areas. Unfortunately, no response was received to this request despite the information on SAGe "histórico" that FAPESP received a referee "parecer" about this request on January 27, 2025. Because of the lack of response from FAPESP, several ICTP-SAIFR postdoctoral positions at FAPESP had to be discontinued after only two years despite the excellent performance of the postdocs.

One of the main accomplishments of ICTP-SAIFR has been to help reverse the brain drain by attracting hundreds of applications every year from around the world for its postdoctoral positions. The initial grant included 12 two-year postdoctoral positions, and these positions have already all been filled by carefully selecting candidates in the 12 different areas of the initial grant. In order to continue to attract talented postdoctoral candidates, it is necessary to be able to offer three-year postdoctoral positions as was recognized by FAPESP since June 2024 when they changed the duration of the fellowship. For this reason, ICTP-SAIFR repeats its request of an additional 12 one-year fellowships to be able to renew the 12 original two-year fellowships for an additional year. In addition, ICTP-SAIFR continues to request two 2 1/2-year postdoctoral fellowships in the new ICTP-SAIFR research areas of statistical mechanics with applications to search optimizations, and quantum chaos with applications to quantum technologies. With the new Simons-FAPESP faculty Jaron Kent-Dobias and Dario Rosa working in these rapidly growing research areas, these additional postdoctoral positions will allow ICTP-SAIFR to attract talented researchers from around the world to come to São Paulo and work in these strategic areas.

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.

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.

Activity Plan for 2026

In 2026, the ICTP-SAIFR will continue to expand its research, outreach and training activities in all areas related to theoretical physics. Confirmed scientific activities in 2026 which will be organized by ICTP-SAIFR are listed below and include international schools and workshops and programs on several topics which will take place both at IFT-UNESP and at the new installations of Instituto Principia. The list of 2026 activities planned up to now include the activities:

São Paulo International School on Theoretical Physics

- School on Biological Physics Across Scales: Phase Transitions (January 12 - 23).
- School on the Next Era of Network Science: Nonlinear Dynamics, Multiscale Interactions and Beyond (March 2 - 6).
- EGSnrc Monte Carlo school for Medical Physics (March 30 – April 3).
- IV School on Glasses and Glass-ceramics (April 27-28).
- School on Astroparticle and Multi-Messenger Astrophysics (June 15 - 26).
- IX Perimeter-SAIFR-IFT Journeys into Theoretical Physics School (July 6 - 12).
- IV Joint ICTP-SAIFR/ICTP-Trieste Summer School on Particle Physics (July 13 - 24)
- School on Collider Physics: Preparing for the HL-LHC Era (July 13 - 24).
- School on Open Quantum Systems: theory and experiment (July 27 – August 7).
- V Patricio Letelier School on Mathematical Physics (August 17 - 28).
- School on Analytical and Numerical Methods for Disordered Quantum Systems (September 14 - 25).
- School on Recent Advances in Strongly Correlated Quantum Materials (October 5 - 9).
- School on Quantum Simulation in the NISQ Era (November 9 - 13).
- 3rd Quantum Computing School (November 16 - 27).

Minicourses and Meetings

- Research Group Meetings on Quantum Technologies (January – December)
- Research Group Meetings in Astro & Cosmo (January – December)
- Physics of Life South American Network Meetings (January – December).
- ICTP-SAIFR Steering Committee and Scientific Council Meeting (February 9 - 10).
- Effective Field Theories at work: a practical minicourse (July).

Programs and Workshops

- High-Pressure Mineral Physics and Geophysics Applications (February 2 - 6).
- Workshop on Non-Equilibrium Statistical Physics (February 23 - 27).
- Workshop on Foundations and Applications of Spreading Phenomena on Complex Networks (March 9 - 12).
- APS-SAIFR Satellite Global Physics Summit (March 16).

- Challenges of Low-Dimensional Quantum Gases: Brazilian-German Wilhelm and Else Heraeus Seminar (March 23 - 27).
- Theory Meets Practice: Energy Correlators and Detector Operators (May 4 - 8).
- Horizons Beyond the Standard Model: from Colliders to Dark Matter and Axions (June 1 - 12).
- Third Generation Gravitational Wave Detectors: the view from Latin America (June 29 – July 3).
- Thermality in Quantum Field Theory in Curved Spacetimes (August 3-7).
- PHENOEXP 2026 (August 10 - 12).
- Novel Developments in Correlated Quantum Materials (October 12 - 16).
- 4th Symposium on Current Topics in Molecular Biophysics – CTMB4 (October 17 - 19).
- 3rd LSST@LATAM Meeting (November 2 - 6).

Outreach

- VI Escola de Verão ICTP-SAIFR para Jovens Físicos (January).
- VI Curso de Verão ICTP-SAIFR para Professores de Física de Ensino Médio (January).
- Ciência no Cinema (January – December).
- Clube do Livro Sci-SAIFR (February – December).
- Distinguished Public Lectures (February – December).
- Física Moderna para a Sala de Aula (March – November).
- Minicursos para Estudantes de Ensino Médio (March – December).
- Papos de Física (March – December).
- ICTP-SAIFR Competition for Young Physicists (July 11).

Data Management

The main data produced by ICTP-SAIFR activities are research articles, recorded videos and pdf files of lectures and seminars, and online material for the general public. The research articles are available online on public sites such as http://xxx.arxiv.org for preprints and on the journal sites for Open Access publications. The recorded videos and pdf files of lectures and seminars are all posted online on the ICTP-SAIFR websites of the activities and at https://www.ictp-saifr.org/2025-research-seminars-and-activities/ and https://www.ictp-saifr.org/other-years-research-seminars-and-activities/. The online material for the general public is available on the various websites of the ICTP-SAIFR website http://outreach.ictp-saifr.org/.

In addition, a new archive of recorded videos is now available through the SciVideos platform (https://scivideos.org/source-repository/ictp-saifr), a prototype project led by the Perimeter Institute with support from the Simons Foundation. This meta-repository brings together scientific talks from partner institutions worldwide, making ICTP-SAIFR lectures more easily discoverable within a broader international network.

Use of Reserva Tecnica Funds

Between December 2024 - November 2025, the part of the reserva tecnica funds related to "Custos de Infraestrutura Direta do Projeto" was used for the following purposes:

a) Design, fabrications and mailings of posters to international institutions for announcements of School/Workshops activities: R$ 11.229,74
b) Use of Comunique-se (Knewin) plataform for media-monitoring services: R$ 2.615,28
c) Use of Mailglum platform for ICTP-SAIFR email communications: R$ 90,84
d) Use of Cloudflare services for ICTP-SAIFR online infrastructure: R$ 57,48
e) Advertisement of activities using online mailing system (mailjet): R$ 1.543,18
f) Use of Zoom platform for all ICTP-SAIFR online activities: R$ 8.734,03
g) Purchase of a printer model Epson L3250 to support the activities of ICTP-SAIFR: R$ 1.403,84
h) Purchase of a pointer model Logitech Spotlight USB to support the activities of ICTP-SAIFR: R$ 579,90
i) Purchase of a projector model Epson Powerlife E20+, for Computational-Lab on the third floor to improve the recording activities: R$ 4.299,00
j) Purchase of Banner for dissemination of activities: R$ 780,00
k) Purchase of printer toner and memory card for photographic camera: R$ 4.146,25
l) Purchase of badges, badge clips and pens for participants at events: R$ 2.08,67
m) Purchase of notepads for event participants: R$ 18.000,00
n) Service payment to Felipe Saldanha for graphic design and communication activities, including the artistic creation of banners for the promotion of activities and general dissemination of ICTP-SAIFR events: R$ 9,000.00

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

a) Airfare for ICTP-SAIFR director Nathan Berkovits for a research visit to the United States from January 15–30, 2025, during which he visited Harvard University and the Institute for Advanced Study in Princeton to collaborate with Professors Xi Yin and Cumrun Vafa (Harvard) and Professor Juan Maldacena (IAS). He delivered blackboard seminars titled "Equivalence of Pure Spinor and Ramond–Neveu–Schwarz Superstring Amplitudes" on January 28 at Harvard University and on January 29 at the Institute for Advanced Study. R$ 8.670,72.
b) Airfare for ICTP-SAIFR director Nathan Berkovits to Djursholm to participate as invited speaker at the workshop Cohomological Aspects of Quantum Field Theory from March 31 - April 4, 2025 where he presented a 60 minute blackboard seminar on April 3 with the title "Equivalence Proof of Pure Spinor and Ramond-Neveu-Schwarz Superstring Amplitudes ". A webpage with description of the meeting is https://www.mittag-leffler.se/seminar/workshop-nathan-berkovits-equivalence-proof-of-pure-spinor-and-ramond-neveu-schwarz-superstring-amplitudes/: R$ 9.698,85

c) Airfare for ICTP-SAIFR director Nathan Berkovits to participate as an invited speaker at the Advanced Summer School on High Energy Theoretical Physics in Quy Nhon, Vietnam from June 15–22, 2025, and at the String Math conference in Beijing, China from June 23–29, 2025. In Quy Nhon, he presented a three-lecture minicourse using the blackboard entitled "Introduction to Supersymmetry". In Beijing, he presented the talk "Topological A-model for $AdS_5 \times S^5$ Superstring and the Maldacena Conjecture". Webpages with descriptions of the events are https://indico.in2p3.fr/event/35256/ and https://bimsa.net/conference/string-math/, with slides available at https://bimsa.net/doc/notes/42743.pdf?id=1: R$ 16.739,88

d) Perdiem, registration fee, and airfare reimbursement for ICTP-SAIFR principal investigator Alexandre Reily Rocha to participate in the XXIII B-MRS Meeting in Salvador, Brazil, where he presented the talk "Hexagonal Ice Density Dependence on Interatomic Distance Changes Due to Nuclear Quantum Effects" on September 30. A webpage with a description of the event is https://www.sbpmat.org.br/23encontro/: R$ 5.554,51

e) Perdiem, registration fee, and airfare reimbursement for ICTP-SAIFR principal investigator Alexandre Reily Rocha to participate in the APS March–April Joint Meeting 2025 in Los Angeles, USA, where he presented the talk "Current vortices in graphene-based quantum dots" on March 18. A webpage with a description of the event is https://www.aps.org/events/2025/joint-meeting: R$ 20.480,03

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Annexed Files

10.1 First Page of Publications

See the three annexed files, "**Papers**_$0i$" with $i = 1, 2, 3$, for publications of professors, direct doctoral students, and postdocs on the ICTP-SAIFR research team.

10.2 Scientific Reports of Postdocs and Direct Doctoral Students

See the three annexed files, "**RepotsDiredDoctoral_01**" and "**RepotsPostDoc**_$0i$" with $i = 1, 2$, for scientific reports of:

- Cassiano Antonio Daniel.
- Conor Behan.
- Debarghya Chakraborty.
- Duive Maria van Egmond.
- Guilherme Henrique da Silva Costa.
- Hao-Lan Xu.
- João Pedro de Rezende Gomide.
- Leonardo Pipolo de Gioia.
- Martino Stefanini.
- Noudéhouénou Gilles Koudafoke.
- Pablo Souza de Castro Melo.
- Rafael Menezes dos Santos.
- Rui Aquino dos Santos da Silva.
- Ulisses Marques Portugal.
- Walter Esteban Riquelme Chamblas.
- William Gabriel Carreras Oropesa.

10.3 Scientific Reports of EP, JC and TT

See the annexed file "**Reports_EP_JC_TT_01**" for reports of:

- Lucas Campos.
- Larissa Takeda.
- Clewton Luís Ferreira da Fonseca.
- Felipe Gustavo Guimarães Saldanha.
- Alexandre Vinicius Aleixo Lourenco Conceição.
- Cintia Aparecida Cirillo.

- Bruna Camila Santos da Silva
- Ana Clara de Paula Moreira.
- Rebeca Kenna Doi.
- Victoria Pimenta Barel.
- Igor Zolnerkevic.
- William Gabriel Carreras Oropesa.
- Marcelo Kenji Sime.

10.4 Slides Presented in Workshops, Conferences and Meetings

See annexed presentations, "**Slides_01**" of ICTP-SAIFR researchers who used Reserva Técnica funds.