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Physics in Latin America

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The southern skies and tall mountains of Latin America have cultivated a long history of astronomy on the continent. Today, the continent hosts over 80 observatories that are collaborative research centres for the region and the world. But what about other areas of physics? These have benefited from a culture of collaboration, but there are still challenges in fully developing the potential of research on the continent, such as insufficient researchers or resources. In this Viewpoint, seven physicists discuss the varying research landscapes of different areas of physics across the continent.

A heritage of astronomy

Gonzalo Tancredi: Astronomy in our region has deep roots that extend to native cultures. We identify three periods in our history of scientific Astronomy. First, the cosmogonic conception of several pre-Hispanic cultures and their understanding of astronomical cycles, as seen in the Maya calendar and the recognition of Incas of 'dark' constellations. Second, the establishment of numerous astronomical observatories in major cities during the early days of independence in the nineteenth century. These observatories made significant contributions to cataloguing the equatorial and southern skies (such as the Observatorio de Córdoba in Argentina). Finally, starting in the 1960s, there has been a proliferation of large-scale astronomical facilities in our region, especially in the clear skies of the Andes and the Pacific coasts in countries such as Chile, Argentina, Mexico and Venezuela. The collaboration between local scientific communities and international partners has fostered the growth of astronomy in our region. Argentina, Brazil, Chile and Mexico have well-established research groups in astronomy, whereas other countries have also developed groups that, in total, they cover a wide range of astronomical fields.

Joel Saavedra Alvear: At the beginning of the 1970s, a few bright scientific spots appeared in Chile, focused on gravitational physics. The strength of these initial seeds was so powerful that they triggered the Big Bang of gravitational physics in Chile. Soon it transformed into a 20-year long dark age, during which our talents worked from abroad. Nevertheless, in recent years, the seeds have started germinating, and the interest in gravitation and cosmology grew after the darkness. One key point was the gradual return of some Chilean physicists working on theoretical physics. Then, the international conferences and visits of world-class physicists create the fertile soil. The most significant fact in this story is the foundation of CECS in 1984 by Claudio Bunster. After that, PhD programmes from Chilean Universities started to graduate students with strength international collaborations working in supergravity, quantum gravity and Hamiltonian formalism, among other areas. More young spots have begun to accrete around the original generation, and research about black holes, cosmology and other mysteries of the Universe has become an active field of study by more Chilean physicists.

Gonzalo Palma: As a cosmologist, I feel fortunate to work in Chile, a country that hosts some of the most important astronomical observatories of the world. Standout examples are ALMA, Paranal, Gemini, E-ELT, CTAO, CLASS, the Simons Observatory and the Vera Rubin Observatory, to name a few. The presence of these modern scientific cathedrals has catalysed physics and astronomy owing to a law stipulating that these internationally funded observatories, in exchange for tax exemption, must allocate 10% of their time to local researchers. But their influence goes beyond. Observatories in Chile have fostered a profound sense of distinction, positioning us as a global gateway to the universe and consequently establishing a robust culture of scientific outreach. As a result, the general public has cultivated a tight bond with science and, today, more than ever, we see a myriad of gifted young students, especially women, entering scientific careers.

An uneven landscape

Karen Hallberg: Basic research in condensed matter is one of the most developed, mature and competitive research areas in physics in Latin America. However, there are large disparities among different countries and regions. For example, Argentina, Brazil, Chile and México lead in topics such as experimental, theoretical and computational material science, quantum science and technology, soft condensed matter, crystal growth, low temperature physics, electronic structure, semiconductors, superconductivity, magnetism and nanomaterials. Brazil hosts the only synchrotron in Latin America (the Sirius), whereas Argentina is building a neutron beam facility (the LAHN), two large experimental facilities for collaborative research in condensed matter in Latin America.

Carolina Brito: In Latin America, research in hard condensed matter has a longstanding tradition, whereas groups studying soft matter are more recent, less prevalent and often emerge from the statistical physics community, biophysics and dynamic systems. Brazil has a large statistical physics community but biophysics and dynamic systems are not well represented in the region. Although we have seen a rise in the number of lectures on soft matter during our physics congress in Latin America in recent years, I still believe that there is a shortage of research groups focusing on soft matter, particularly in the experimental aspects. Most of the groups involved in soft matter research primarily concentrate on theory and simulations. This perception is reinforced when considering the papers recently published in the 'Special Issue on Soft Matter Research in Latin America' or examining a map of groups and topics compiled by the Soft Matter community in Argentina, where the scarcity of experimental groups becomes evident.

Wilfredo Tavera: In the area of nanoscience, a substantial number of publications come from a small number of countries, such as Argentina, Brazil, Chile and México, mainly those with consolidated science and technology programmes and institutions. This trend, which occurs in almost all scientific areas, reflects the

differences in the scientific and technological development of countries within the region. Nevertheless, there is a committed scientific community that contributes basic and fundamental research for the development of spintronics. Within this collaborative environment, I believe that there could be more joint research efforts among Latin American countries.

Increasing researchers and resources

GP: Currently, Chilean spending in science (under 0.4% of our gross domestic product) is well below that of developed nations and the number of researchers per inhabitant is just one-tenth of what one might encounter in the UK, France or Germany. Nonetheless, the scientific community is being reinforced by the return of many young researchers, whose graduate studies have been financed by the Chilean state and completed at the world's most prestigious institutions. Furthermore, our current scientific output (measured by published articles per inhabitant) is the third highest in the Americas, surpassed only by Canada and the USA. All in all, Chile offers a fertile soil for science. With a modest increase in funding, we might have a brilliant future ahead.

CB: Although it is the case in many parts of the world, Latin America faces slower progress in transitioning to different topics and acquiring laboratory equipment owing to limited funding for science. A critical factor in advancing this field is the need for sustained investment in science. This limitation is not exclusive to soft matter research but significantly hampers scientific progress in most South American countries.

KH: Funding for science, in general, should be a larger percentage of the gross domestic product (currently around 1.2 in Brazil and a low mean of 0.3 for the other countries), with a larger involvement from the private sector (currently very low or non-existent). A valued scientific system should also pay worthy wages and scholarships, which will avoid emigration of young researchers, will stimulate the repatriation of scientists and will attract foreign researchers and postdocs. In addition to an increase in funding, qualitative changes to how research is done in the region are needed. For example, a biennial evaluation of research (as done in the Max Planck Institutes in Germany) would improve efficiency. Academics spent a great deal of time on bureaucracy, such as for ordering equipment and materials, which distracts from research. Evaluating and reorganizing institutes to manage such research-adjacent tasks more efficiently would greatly benefit the research output. In addition, more efforts should be devoted to attracting more women and young students from marginalized sectors of our society.

Strengthening collaborations

David Vanegas Forero: High-energy physics experiments mostly take the form of experimental collaborations funded by various international agencies. Given the significant cost of building and operating a HEP experiment, and the lower investments in science by Latin American governments (with a few exceptions), most experimental physicists join collaborations led by recognized laboratories such as CERN and/or FERMILAB. Traditional scientific events such as SILAFAE have gathered the HEP community strengthening collaborations since 1996. It is also worth mentioning the support of International Center for Theoretical Physics, which has an institute in South America, the ICTP-SAIFR. However, theorists also have their own collaborative networks built from doctoral and post-doctoral positions. In addition to all the challenges and few resources, scientists in Latin America passionately and collaboratively do research with local and international peers in different topics such as (among others) high performance computing, statistical data analysis, theoretical modelling and taking part in the design, test and calibration of particle detectors parts.

WT: At the turn of the twenty-first century, Latin American countries undertook important initiatives for the development of nanoscience and nanotechnology in the region, such as the establishment of a National Nanotechnology System in Brazil or the creation of specialized research centres including the Nanoscience and Nanotechnology Center (CEDENNA) in Chile and the Brazilian–Argentinian Center of Nanotechnology (CBAN). These initiatives have encouraged training policies and incentives for research owing to their potential applications in strategic sectors. In this context, the development of spintronics has also attracted the attention

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of scientists in what is now a very active and yet under-explored field of research. At present, research on spintronics in South America covers various topics, including theoretical developments, numerical simulations and experimental work, the latter mainly in the development of spintronic new materials.

KH: Given the good level of education and training offered by universities, the existence of well-established laboratories, several decades of experience and, very importantly, our common culture and heritage, the continent could emerge as a leader in this important research area. This can be achieved by fostering regional international collaboration and cooperation including the exchange of students, postdocs and researchers and coordinating the efficient use of facilities, equipment and computational resources, which could be facilitated by the Latin American Center for Physics founded by UNESCO in 1962.

GT: Although a large number of internationally funded astronomical facilities exist on the continent, there is a need for a world-class astronomical facility owned and managed by a collaboration among large and small Latin American countries. Such a facility would greatly enhance regional collaboration, particularly with smaller countries. Additionally, the implementation of regional projects in space research, either with scientific or technological objectives, is needed. The European Southern Observatory and the European Space Agency, which were established not long ago, serve as examples to consider. We expect that the current efforts of Latin American political leaders to revitalize regional agreements will be complemented by joint science and technology projects, similar to those in the aforementioned topics. The upcoming Latin American Astronomical Regional Meeting (LARIM) in Montevideo, Uruguay, in November 2023 (https://rrla-larim-2023.uy/), will provide an opportunity to promote such collaboration.

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