# *physics in* SOUTH AMERICA

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**a brief account based on observations during a recent Latin American tour made by the author, who is professor of physics at New York University's College of Engineering**

SOUTH America is a continent in which there are ten independent countries with full national sovereignty, and three small colonies of European powers. The independent countries range in size from tiny Uruguay, smaller than the state of Minnesota, to its huge neighbor Brazil, which is larger than the United States. As one might expect, there is a wide variation in the number and quality of the educational institutions dispensing instruction and engaging in research in physics. As there are no universities teaching physics in the three Guianas, we shall omit these colonies from the account that follows.

The general pattern of instruction follows the European rather than our own, and the word "colegio" corresponds roughly to our high school or junior college, from which students go next to the University. The title "doctor" usually implies the equivalent of a Bachelor's degree, and is widely used by lawyers and others. Ordinarily a person holding an engineering license or an engineering degree is called Ingeniero, abbreviated "Ing", while "Lic" usually implies that he is licensed to practice law. Not many institutions offer the equivalent of our PhD training. However, certain rather unique research institutions do exist, and it is our purpose to mention several of them here.

Starting in the northwestern corner of the continent, the country to which the isthmus of Panama is attached is Colombia. The capital city, Bogotá, lies at an altitude of about 8500 feet, and despite being a mere 4 degrees north of the equator it is not hot. The University does not offer any advanced training in physics. However, Colombia does have some research in progress in the domain of geophysics. Father Emilio Ramirez, SJ, of the Colegio San Bartholomeo-La Merced, maintains a geophysical laboratory and astronomical observatory.

Passing down the West Coast, we next find physics research facilities in Peru. This country lies along the Pacific Coast, between about 2 and 15 degrees south geographic latitude, and includes some high plateau country in the central Andes. The best known university is the University of San Marcos in Lima, the oldest in this hemisphere. Physics instruction here does not include graduate work as we know it. On the other hand, the Huancayo observatory does offer unique and important facilities. This observatory is located about eleven miles west of the small town of Huancayo on an extensive plain, at an altitude of 11 000 feet. The observatory was built some forty years ago as one of the chain of Carnegie magnetic observatories, and was later transferred to the Peruvian Government. The present director is Alberto Geisecke, Jr., PhD, who is one of Peru's outstanding scientists. At present, the observatory has not only the usual magnetometers and similar equipment, but also a program in ionosphere recording, a spectroheliograph, seismometers, earth-current measurement devices, a Simpson neutron monitor, and a Compton total-intensity ionization chamber for continuous recording of cosmic-ray intensities. The observatory is located on the geomagnetic equator. Many US scientists have visited here, and some have spent quite a bit of time and brought experiments with them.

The next country south of Peru is Bolivia. The capital city is La Paz, which is located at an altitude of about 12 500 feet on the same "altiplano" as Huancayo, but some 560 miles to the south. Here the unique research facility is the high-altitude station at Chacaltaya. This station is accessible by jeep, the drive taking some two hours. The altitude of the station is about 17 500 feet, thus making it the world's highest. An electric power line runs to the station and complete living facilities exist. This station has been more fully described in an article [1] in this journal, so the present author will not discuss it further. The leading scientist of Bolivia is Professor Ismael Escobar, PhD, well known to many for his cosmic-ray researches.

The next country to the south, and the last one along the Pacific coast, is Chile. This country is very long and narrow, being over 2000 miles in length but only an average of perhaps 100 to 150 miles wide. Its border

[1] T. Bowen, *Physics Today*, **9**, 7, July 1956.

Bolivia's Chacaltaya Laboratory, 17 100 feet in altitude

Astronomical Observatory at Rio de Janeiro, Brazil

Chilean High-Altitude Laboratory near Santiago, at 14 100 feet; high peak at right is Aconcagua, 22 900 feet

runs along the backbone of the Andes, including some of the highest peaks, right down to the Straits of Magellan, and includes about two-thirds of the island of Tierra del Fuego. Cape Horn is itself out on a still smaller island to the south of Tierra del Fuego. The northern part of the country is desert. There is a marked concentration of people in the region of its capital, Santiago. This city lies at an elevation of around 3000 feet, and its population is over two million. In Santiago there are two major universities, the University of Chile and the Catholic University. The Instituto Pedagogico and the College of Engineering both belong to the University of Chile, and both are centers of research. The Catholic University operates a good astronomical observatory. This observatory has a 36-inch reflector, and spectroscopic equipment which enables it to do radial velocity measurements on the southern hemisphere stars. A program of this work was set up years ago by the Lick Observatory expedition, and is continuing today. Owing to the increase in the lights from the city, the observatory is being moved to a site further from the center of town.

The Instituto Pedagogico has a program of cosmic-ray investigation under way, using photographic emulsions. A medium-size cloud chamber is being constructed. A high-altitude cosmic-ray laboratory is also being built. At present the walls are complete and the roof was being finished at the time this author visited it. The observatory is at 4300 meters (14 100 feet) in the Andes, just back of Santiago. It is at present accessible by a three-hour mule ride from the present end of the road, but plans for extending the road are well along. Likewise, a power line from a mine a few miles away is planned. The view from the laboratory is magnificent, as Aconcagua, the highest peak (22 900 ft) in South America, dominates the skyline to the northeast.

The College of Engineering (strictly the Facultad de Fisica y Mathematica de la Escuela de Ingeneria de la Universidad de Chile) operates a Nuclear Physics Laboratory, and adjoining it, a radiochemistry laboratory. The special studies at present are mostly devoted to $P^{32}$ as a tracer, and the physics unit is building an 800 kilovolt cascade generator. Most of the more complex tubes and other parts are imported from Europe. Counters, circuits, and the microscopes of the emulsion project are likewise mostly European. A number of the staff, including Professor Alvial, have spent some years abroad, again mostly in Europe, and distinguished Europeans often visit Santiago. Foreign exchange problems tend to favor Chilean cooperation with soft money countries, for example Italy, as hard currencies are especially difficult to obtain.

Argentina occupies almost exactly the same range of latitudes as does Chile, and spreads from the Andes out east to the Atlantic. This country is the most populous and probably the wealthiest in South America. The capital is Buenos Aires, which has grown until today it numbers some six million people. The latitude of Buenos Aires, usually called "BA", is almost exactly the same as that of Santiago, about 34° South. This makes it roughly equivalent to Wilmington, North Carolina, climatically and as an Atlantic port. Santiago, being on the Pacific as well as higher, is appreciably cooler.

In Argentina most of the research in physics is conducted by the Argentine Atomic Energy Commission (Commission Nacional de Energia Atomica) whose director is Captain Quillihalt of the Argentine Navy. The Commission has a large building, well out from the center of town, which houses a 36-Mev cyclotron, a small Van de Graaff, a Cockcroft-Walton generator and probably the best scientific library in South America. The laboratory equipment includes a high-resolution beta-ray spectrometer, gamma-ray spectrometers, and scintillation counters. They also have isotope separation equipment, are producing deuterium and boron-ten, and are planning to separate uranium isotopes in the near future. They have a plant for making counters, and technicians are building electronic circuits. A number of their staff have studied in the US or in Europe. They also have a radiochemistry laboratory with good equip-

ment and good people. Since the Phillips company has a plant which makes vacuum tubes in Buenos Aires, practically everything they need can be made in their own shop or obtained in their own country. The level of work by the top people is as high as anywhere in the world, and the theoretical physics group numbers several quite sophisticated theorists.

Uruguay, which is the smallest independent sovereign nation in South America, is also a country in which the population is very much concentrated. Over a million people live in the capital city of Montevideo. The College of Engineering there has just acquired a fine new building, and physics is taught on the undergraduate level. A new astronomical observatory has been proposed, and may be constructed soon.

Brazil, the largest country in South America, occupies most of the eastern part of the continent. The largest city in Brazil is São Paulo, which lies at an elevation of about 2500 feet just inland from the coast. Here the Brazilian Government has established a center at the University, supported by the Centro Brazileiro de Pesquisas Fisicas (CBPF) which corresponds roughly to a combination of our National Research Council and our National Science Foundation, plus an operating branch such as our National Bureau of Standards. At the University of São Paulo, Professor D. De Sousa Santos, who is well known to many in the US is not only building a 4-Mev Van de Graaff, but is operating a 30-Mev betatron which is being used to study various gamma-ray reactions. A five-megawatt Babcock and Wilcox swimming pool reactor is being planned. Theory is also well along, with Dr. G. Molière, the director of the Institute for Theoretical Physics, as the leading theoretician. He will be remembered for his important work in the calculation of giant showers and other cascade phenomena, and his chapter in Heisenberg's book.

Cosmic-ray work is mostly at Rio de Janeiro, the capital, some 250 miles east of São Paulo. Here Ugo Camerini who is now permanently in Brazil, is carrying on a program which includes cooperation with the Bolivian station at Chacaltaya. Cosmic-ray work was started under Wataghin, and is still also continuing at São Paulo. A small laboratory at about 2500 meters is located in the mountains between São Paulo and Rio. Although this is not as high as Chacaltaya, it is nearer and useful for some experiments. In Rio, and again assisted by the CBPF, a study is being made of radioactive isotopes produced by cosmic rays, resulting for example in the identification of $P^{32}$ formed as a spallation product of argon. To identify it, it was necessary to concentrate a few drops out of a ton of rainwater.

The Astronomical Observatory at Rio has complete equipment for taking part in the international time signal activity. It has a crystal clock, is obtaining others, and has star transits with complete electronic attachments, as well as a set of receivers and chronographs for receiving signals from France and from Washington for comparison. Dr. Lelio Gama is the director, and is also the chairman of Brazil's National Committee for the International Geophysical Year.

Coming next to Venezuela, a country located to the north of Brazil and fronting on the Caribbean sea, we find an unusual situation in physics research. This is the only country in South America in which the good equipment exceeds the personnel to operate it. Thanks to excellent petroleum production, the country has enough income so that it can afford to support physics research with good equipment. A number of excellent chemists have already been developed or imported from Europe, but as yet very few physicists. Still the equipment does exist, more is being bought, and it seems certain that physics will become an important factor here before too long.

There are at present two principal research institutions in the country. Both are just outside of Caracas, the capital city, whose population has grown in the last few years so that now it exceeds a million. The first of these is the astronomical and astrophysical Observatorio Cagigal, under the direction of Dr. Eduardo Röhl. This observatory has a set of new buildings, and a telescope, as well as fairly complete geophysical equipment, including a set of Askania magnetometers, seismographs, and a 20-ton Wiechert pendulum of which there are only three or four in the world. A crystal clock is being installed and accurate time will be available soon.

The second quite remarkable research institution is the Neurological Institute, which from its name one might assume to be devoted to a branch of medical research. It is directed by Dr. Humberto Fernandez-Moran, one of Venezuela's ablest scientists, and a man whose ability would make him outstanding in any country. This institute is to be the site of Venezuela's first nuclear reactor, at present being designed, a substantial swimming-pool type with a planned neutron flux of between $10^{12}$ and $10^{13}$. Already operating at the institute are complete x-ray and electron diffraction instruments, and an electron microscope which has attained a resolution of 6 angstroms, far better than the majority of such instruments. A mass spectrometer is functioning, as is a Collins cryostat producing liquid helium. A building for a 1.5-Mev cascade generator is under construction. Virus studies are already under way.

Obtaining good qualified personnel is a problem. Very few are available locally. It has been Dr. Fernandez-Moran's policy to select good people, usually from Europe, as his department heads, and then give to each the opportunity to build his department slowly and over a period of time. With substantial funds from the government available, both for buildings and for equipment, it appears that this foundation will presently emerge as one of the world's leading research institutions, operating in many branches of science.

In conclusion therefore, we see that South America does have quite a number of unusual research facilities in the field of physics. Physicists from the United States are welcomed, and in turn can help our neighbors materially by encouraging cooperation, exchange of scholars, placing research projects designed to use the unique facilities, and even merely visiting and giving occasional lectures.