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FOREWORD

Sergio Mascarenhas a Polymath in Physics

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Sergio Mascarenhas was born in Rio de Janeiro on May 2, 1928, and sadly passed away on May 31, 2021, at the age of 93, after a prolific life dedicated to developing science and technology in Brazil. Sergio Mascarenhas is one of the founding fathers of condensed matter physics in Brazil. He was a student of the Joaquim da Costa Ribeiro at Universidade do Brasil in Rio de Janeiro. He published his first papers working on the thermodieletric effect, discovered by Costa Ribeiro. Mascarenhas was the one who called the new phenomenon the Costa Ribeiro effect. He took the first steps in his academic career in 1955 by moving from Rio de Janeiro, at the time, the country's capital and principal city, to a small city in the inland of the state of Sao Paulo, São Carlos, when the University of Sao Paulo was expanding its activities beyond the city of Sao Paulo. At that time, Sao Carlos was the host of a promising engineering school. Sergio was hired at the Physics Department and from the very beginning was doing research in condensed matter. This was off-stream at that moment, when the most prestigious areas of physics research were nuclear, high energy, and theoretical physics, and solid-state physics was considered as a second-class research area. He followed the steps of Joaquim da Costa Ribeiro, his mentor in Rio de Janeiro, working in the same class of problems. Of course, this was what was possible to do with the limited experimental resources available. Nevertheless, Mascarenhas published, as a sole author, an important paper in 1970 (*S. Mascarenhas* (1970) *Charge and polarization storage in solids, Radiation Effects: Incorporating Plasma Science and Plasma Technology*, 4:2, 263–270, https://doi.org/10.1080/00337577008242012), which summarizes the research he had done. In the paper, he reported on the study of the Costa Ribeiro effect (charge storage during phase changes), photo and thermo electrets (charge and polarization storage due to dipoles, space charge, or electronic effects associated with trapping), and ferroelectricity (in this case only related to ice). Thus, one can appreciate the breadth of studies he pursued and the vast network of collaborators he developed in his career. This is an important point to underline. Sergio always thought of research as a collaborative enterprise and loved sharing ideas and working with research teams. He also studied color centers in ionic crystals using optical techniques. By the mid 1970s, the entire Physics Department of the recently created Institute of Physics and Chemistry of Sao Carlos (IFQSC) was researching solid-state physics. The institute was a spin-off of the engineering school, and Sergio was one of the leaders who led to its creation. In the mid 1970s, Sergio was interested in using the physical techniques he managed to establish at the physics institute to study biological materials, and molecular biophysics was a natural area to approach. He started to investigate the role of water in biological matter. Was the water in an amorphous structure, or would it be organized? He did not like the idea that we humans, having 60% of our body composed of fluids, would be like a water bag! He used the very same techniques employed to study electrets, like thermally stimulated current (TSC), to show that depolarization peaks would occur as a function of humidity, showing in a very elegant and straightforward way that water molecules were not randomly oriented in biological molecules. This was the starting point

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of molecular biophysics research at IFQSC, which ultimately led to the creation of several research groups, such as protein crystallography, magnetic resonance, and computing physics applied to biological systems.

In the early 1970s, Mascarenhas was involved in the inception of the Federal University of Sao Carlos and the Department of Material Sciences. The undergraduate program in Material Science Engineering was also his idea. Those initiatives were the apples of his eyes. This department was a pioneer, and it is now a world-class research center in material sciences.

In the 1980s, Mascarenhas decided to study radiation dosimetry due to its importance to radiotherapy. At that moment, Brazil decided to start a nuclear program and construct three nuclear power plants, and there was the need to prepare human resources. Sergio proposed using electrets for dosimetry and started a broad research program in this area involving all the aspects, from basic science to technology. Electret dosimeter would work as a self-polarized ionization chamber, and one can see the links to Joaquim da Costa Ribeiro again appearing in this research. He produced and delivered several dosimetric systems based on this technology to the National Nuclear Energy Commission (CNEN). From this period, he started to work with other physical techniques for radiation dosimetry, and Electron Spin Resonance (ESR) was one of them. ESR not only works in radiation dosimetry, as seen in the recently published paper on dosimetry of the victims of the atomic bomb in Hiroshima (https://doi.org/10.1371/journal.pone.0192444), but also on archeological dating in samples from several interesting sites from Brazil.

Still in the 1980s, Sergio also dedicated his efforts to develop physical applications in agriculture. He was a pioneer in using X-ray computed tomography to study water in soils and other applications. His efforts led to creating a Brazilian Agricultural Research Corporation branch, known as Embrapa, in Sao Carlos in 1984. This unity is the only one in the Embrapa network dedicated to physics, instrumentation, and nanotechnology applied to agricultural problems.

It is also from the 1980s, the involvement of Sergio Mascarenhas with important initiatives at the International Center for Theoretical Physics (ICTP) in Trieste. By invitation of Adbus Salam, whom Sergio knew for sharing office space in Princeton, when both were post doctoral fellows, he founded the College on Biophysics that had its first edition in 1982, followed by the inception of Soil Physics (1983), Colleges in Medical Physics (1986), and a conference on Archeometry (1994). All these activities in interdisciplinary areas were strongly supported by professor Salam and were very important to allow students from all parts of the world to get together in these intensive work schools for about 4 weeks, speaking the language of science, breaking social, political and cultural barriers, and forging relationships that would be long life lasting. Sergio used to recall, with strong happiness and joy, the moment when after all the preparation for the first College on Biophysics, he could see the students arriving from all parts of the world with the same hope and enthusiasm of him. During these activities, Prof. Salam will interview groups of students from the same region to greet them and learn about their difficulties, plans, and perspectives. Being received by a Nobel Laureate was also a strong and indelible experience.

One of us (JNO) during those years had the opportunity to be part of Mascarenhas' efforts towards bringing the field of theoretical biological physics to Brazil. Although Sergio Mascarenhas was not a theoretician himself, he established strong collaborations with groups in England and the USA that lead to the first simulations of the effect of water with biomolecules in Brazil. Since the importance of water in biophysics was already one of the main areas of research in Sao Carlos, this theoretical and computational work really complemented the experimental research. Radiating from this effort that started in Sao Carlos, the field of theoretical biological physics that started with these simulations of biomolecules is now a vibrant area of reserch in Brazil.

This synergy between theory and experiments became the focus of the College on Biophysics in the late 1980s and early 1990s when JNO joined Mascarenhas in directing those colleges. It is important to highlight those were the years that the importance of completementary theoretical and experimental research was starting to become central in biological physics research and the Trieste College in Biophysics was a pioneer in this field.

The most recent research endeavor of Sergio Mascarenhas was the proposal of a non-invasive method to monitor intracranial pressure (ICP). Again, he revolutionized the area by changeling the Monro–Kellie Doctrine that established that the human skull would be non-deformable. He knew all materials could be deformed as a physicist, and a stress–strain relation could be obtained. Thus, if one knows one variable, the other can be inferred. His efforts in moving forward with this technique as a translational research project with clinical trials led to the foundation of a startup company.

Sergio Mascarenhas was a leader in the education of many students. He was the organizer of the first national symposium on solid-state physics and materials science in 1969. He organized several schools and conferences to promote science and was a key person for the nucleation of research groups in condensed matter physics in other universities, such as the one at the Federal University of Pernambuco, in Recife, which gave rise to an outstanding physics department in Brazil.

In summary, Sergio Mascarenhas made several contributions to many areas of physics and applied physics along his long carrier. Until his last days, he was very active and full

of energy and ideas to continue contributing to science. He was an exponential social individual who loved to talk and discuss all current subjects. When not reading and searching for new information, he would be talking to someone over the phone, internet, or in person. Everyone who had the privilege to interact with him would feel reinvigorated and motivated to go ahead with new projects and ideas. All of us, editors of this special issue, had our scientific careers and successes shaped by Sergio Mascarenhas. Sergio cared much more about bringing new research to Brazil and forming a new generation of scientists than about his personal achievements. We all were extremelly lucky to have had him as a mentor. His creativitly, mentorship, and generosity has transformed Brazilian science!

As a tribute to Sergio Mascarenhas, the Brazilian Journal of Physics invited some of Sergio's collaborators to contribute to a volume dedicated to his memory. This volume is a collection of independent works contributed by the invited scientists. All articles have been peer-reviewed and judged by the progress they bring to the different areas of physics that Sergio was active.