IL NUOVO CIMENTO **44 C** (2021) 26
DOI 10.1393/ncc/i2021-21026-5

Communications: SIF Congress 2020

# Beppo Occhialini's Brazilian period

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received 5 January 2021

**Summary.** — The aim of this work is to deepen Occhialini's Brazilian period. In particular, we want to offer an analysis of the documents kept in Milan and São Paulo archives, on Occhialini's activity in Brazil between 1937 and 1942. Occhialini was called in Brazil by Gleb Wataghin in order to found a new physics group focused on the study of cosmic rays. The decision to deal with this topic is due to the geomagnetic location of Brazil that makes it suitable for measurement campaigns of cosmic rays. Moreover, this kind of study can be develop also in a country, like Brazil, that has few economic resource for research. We therefore analyze the research activities carried out by Occhialini in this context, and his contribution to the international conference on cosmic ray held in Rio de Janeiro in 1941. We will also show Occhialini's activity in helping scientists who lived in European regimes, in particular the role he played in the Houtermans affair.

## 1. – Introduction

Historiography has already dealt with the scientific biography of Giuseppe Paolo Stanislao Occhialini [1-3]. However, historiography is not very detailed as regards Occhialini's Brazilian period. Indeed it focuses on the Fascist Italian mission in Brazil but not on the contribution to scientific research. The aim of this work is to deepen this period analyzing the archival documents held in Milan (BIFC Library, University of Milan), and São Paulo (Department of Physics, University of São Paulo) concerning Occhialini's activity and relations during the second half of the 1930s [4-6]. Moreover, correspondence of the period was found among the documents in the Milan archive. Due to the relevance of the information contained therein, a full transcript was made([1]) [7].

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([1]) This research work was carried out, together with Leonardo Gariboldi, during the writing of my degree thesis at the University of Milan.

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## 2. – Occhialini's biography

Occhialini graduated at the Physics Institute of Florence in 1929, and worked as regular assistant at the Institute of Physics in Arcetri. Between 1927 and 1928, the research of the group led by Bruno Rossi began to focus on nuclear and cosmic rays physics. In order to learn the technique of the cloud chamber, Occhialini was admitted to the Cavendish Laboratory from 1931 to 1934. Here Occhialini worked with Patrick Maynard Stuart Blackett, one of the greatest experts in the use of cloud chambers. The collaboration between Occhialini and Blackett led to the invention of the controlled cloud chamber. This new instrument allowed to discover the electron-positron pair production. Occhialini went back to Florence in 1934, but researches regarding cosmic rays had already been interrupted. In fact, all members of the group led by Bruno Rossi had moved to other universities. During this period Occhialini did the militar service at the Militar School in Lucca. Later, he taught physics at the Royal Institute of Art and at the Faculty of Architecture in Florence between 1935 and 1937. Occhialini was hired as professor at the Scientific High School in Macerata in 1937, but he never took up the job since he left for Brazil.

In June 1937 Occhialini accepted an invitation by Gleb Wataghin, an Ukranian-born Italian physicist, who worked at the University of São Paulo. This university was created in 1934 in order to gain cultural hegemony for the city. Due to the limited availability of professors, the University of São Paulo called some professors from Europe. As a matter of fact, the Italian Fascist government encouraged the transfer of Italian scientists to the country. That transfer was considered a cultural and political mission in a country that had a high rate of Italian Immigration [8].

Occhialini joined Wataghin in order to found a cosmic rays research school. Furthermore, they contributed to the realization of the *Symposium sôbre Raios Còsmicos* at the Academia Brasileira de Ciências in August 1941. This congress was organized for the American scientific delegation, led by Arthur Holly Compton [9].

In March 1942, Brazil entered the war alongside the enemy nations of Italy, so Occhialini was called back to Italy. However the British government refused to allow the free transit to Occhialini. For this reason, Occhialini took refuge in the mountains of Itatiaya, where he worked as a mountain guide. After the armistice in September 1943, Occhialini was hosted in the Biophysics laboratory of the Medical School in Rio de Janeiro, waiting to be able to return to Europe.

Occhialini returned to England only in January 1945, and he settled down at the H. H. Wills Physics Laboratory in Bristol. Occhialini collaborated with the physicist Cecil Frank Powell in order to improve the technique of the nuclear emulsion. This technique was applied to the research of cosmic rays on the French Pyrenees in 1946. With this experiment, the group demonstrated the existence of the $\pi$ meson and its decay in the $\mu$ meson.

In 1948 Occhialini and his wife Costance Dilworth were called by Max Cosyns at the Université Libre de Bruxelles. During this period, the group enhanced the use of nuclear emulsion in order to study cosmic rays in the high atmosphere. From 1952 Occhialini was professor of Superior Physics (*i.e.*, contemporary physics) at the University of Milan. One of the main feature of the research team was the participation in international cooperation. One of these cooperations, called G-Stack Collaboration, allowed the study of the decay of the $K^+$ meson.

In 1960 Occhialini and his wife went at the Massachusetts Institute of Technology in order to learn the technique used in space research. The main goal was to find a

space physics group after their return to Milan, in order to apply the technique of space research to cosmic rays.

During the eighties, Occhialini spent more and more time in Marcialla, in Tuscany. He died in Paris on December 30th, 1993.

## 3. – Occhialini's researches in Brazil

The decision to develop the research on cosmic rays in Brazil was a winning choice for several reason. First of all, cosmic rays are free compared to the radioactive sources. Moreover, measuring instruments for cosmic rays are cheap and easy to make. For these reasons, this kind of study could be developed also in a country that had few economic resources for research. This type of research was also at the forefront of the time. Indeed other prominent scientists were dealing with these topics, like Compton and Millikan. Lastly, the geomagnetic location of Brazil makes it suitable for measurement campaigns of cosmic rays.

The main studies of the Brazilian group concerned: 1) the variation in the intensity of cosmic rays during a solar eclipse [10, 11]; 2) the ultra-soft component of cosmic radiation [12-15]; 3) the latitude variation of the ultra-soft component [16-18]. Moreover there are several studies concerning the improvement of cosmic rays instrumentation that we omit in this paper. We also found in in the Milan archive a draft of an unpublished article concerning the production of mesotrons in the upper atmosphere.

**3**˙1. *The variation in the intensity of cosmic rays during a solar eclipse*. – This topic was studied thanks to two different solar eclipses, the first one on October 1st, 1940 and the second one on March 27th, 1941. It was known that the solar phenomena can affect the geomagnetic field which in turn affects the intensity of the cosmic radiation. The aim of the group was to reveal any flux variation of cosmic rays during solar eclipse. The instruments used for this measurement were of two different types. The first one was a cosmic rays telescope and the second one was a disk counter, invented by Occhialini and Damy de Souza Santos [19]. The disk counter allowed to store the count of the number of cosmic rays detected by a Geiger-Müller counter over long periods.

Due to the large quantity of data, the analysis of the measurements of the eclipse on October 1st, 1940 was completed and published on the occasion of the Symposium in 1941. The result showed an 20% of increase in the intensity of cosmic rays during the eclipse.

For the second eclipse, the group used two different cosmic rays telescopes, in order to cover a larger solid angle. The results differed a lot from those obtained during the previous eclipse, indeed only an 1% of increase in the intensity of cosmic rays was observed. Therefore the group was unable to confirm the influence of the solar eclipse on the intensity of cosmic rays.

The correspondence kept in the Milan archive provides additional information regarding the measurement conditions during the first eclipse. These informations show that the description of the measuring apparatus was not clear in the paper, and that the conditions of the eclipse were not favorable for the observation of the effect.

Between the documents kept in the Milan archive there is also a laboratory notebook. It contains most of the data and graphs obtained by the group during the eclipse on March 27th, 1941. Thanks to this notebook we were able to carry out an analysis of the data contained in it. The data consist of the incremental counts of cosmic rays that the group read out by means of an electronic counter every few minutes. Considering the

readings in pairs and making the difference between them, the group derived the number of cosmic rays detected in the time interval between two measurements. Later, the group determined for each pair of data the ratio between the difference in the number of cosmic rays detected and the time interval. Last, they plotted the relative increase as a function of the time of the measurement.

In our analysis, we used as time of measurement the mean of the time of the pairs of measure, as there is no information regarding the criterion chosen by the group. The results we obtained in the calculation of the increases differ several times from those reported in the notebook, due to calculation errors of the group. However these errors do not influence the final results of the experience. From the comparison between the original graphs and the graph we obtained from our analysis, it can be seen that there are gaps to be attributed to data not reported in the notebook.

We did not find information about the criterion used for the calculation of the uncertainty on the experimental data. However, from the observation of the bars of uncertainty and the nature of the phenomenon, we can attribute an uncertainty on the count obtained from the Poisson distribution. We then calculated the uncertainty on the differential increment as the square root of the ratio between the number of counts and the time interval considered. In conclusion, the results we obtained are in agreement with those of the group, which did not find an increase greater than 1% during the solar eclipse.

**3**˙2. *The ultra-soft component of cosmic radiation.* – The purpose of these researches was to explore the cosmic radiation of lesser energy. Usually, the focus was mainly on the hard component of the cosmic rays, so the soft component had not been thoroughly studied. Only after 1938 Gilberto Bernardini and Bruno Ferretti began the research on this region of energy.

Occhialini's group discovered that the ultra-soft component of cosmic radiation is isotropic. The group showed that it is part of the shower produced in the atmosphere and it correspond to 16% of the total radiation. Also in this case, the conclusive results were presented during the Symposium in 1941.

**3**˙3. *The latitude variation of the ultra-soft component.* – In order to understand the nature of ultra-soft component of cosmic rays, the Earth's magnetic field can be used. If the initial particles that generate the soft component are charged, an anisotropy of the distribution of this component on Earth must be observed. This is caused by the interaction of those particles with the Earth's magnetic field.

Occhialini made a campaign of measurement during a travel from Bahía to Trieste. In these measurements a difference in cosmic ray flux between the equatorial and temperate zones could not be noted. This seems to support the hypothesis that the ultra-soft component is generated by neutral particles, *e.g.* gamma rays. The results were published in three different articles, between 1939 and 1940.

Occhialini also organized a second measurement campaign on board the motor ship Neptunia. However, during this campaign a violent change in voltage damaged the high voltage filter, rendering it unusable.

## 4. – Occhialini's teaching in Brazil

When Occhialini arrived at the University of São Paulo, he was in charge of the course of General and Experimental Physics. Since 1937 Wataghin taught the course of Superior Physics. Starting in 1941 this course was taught by Occhialini and the part of

experimental atomic physics was added for third year students. The course programs drawn up by Occhialini and Wataghin are kept in the São Paulo archive and an analysis of them is found in [20]. The presence of Occhialini and Wataghin in São Paulo has allowed the development of a theoretical and experimental knowledge of a European type. The environment of scientific and academic activities that they built facilitated the contact of Brazilian scientists with other important members of the international scientific community.

In the Milan archive there are some papers by Occhialini's students, but they add nothing new to the scientist's teaching activity.

## 5. – Occhialini's stay in Manchester

In an interview that Occhialini released in 1971, he claimed to have been to Manchester to participate in the construction of a cloud chamber with Blackett [21]. In the correspondence of the Milan archive there is some information confirming his stays in Manchester, in at least two different moments between 1938 and 1939. In particular, the correspondence with Blackett shows that Occhialini first arrived in Manchester between March 12th and a few days before March 28th, 1938, but there is no information on his departure. Another letter from Blackett shows that Occhialini returned to Manchester after November 22nd, 1938. In a letter dated November 11th, 1938, Blackett wrote him that the casting of a cloud chamber was waiting for him. Other informations about a cloud chamber are in an agenda of 1941, where there are some details regarding its calibration. Probably this cloud chamber was built and brought to Brazil in the early 1939, since also in the interview he refers to having used it in Brazil.

## 6. – Occhialini in the European political context

In the correspondence kept in the Milan archive, we found the evidence of Occhialini's main role in helping scientists during the Brazil years, living in bad condition in European countries with a totalitarian regime.

The most interesting case is Friedrich Houtermans' one. His biography has been treated in historiography [22-27], but Occhialini's contribute is unprecedented.

Friedrich "Fritz" Georg Houtermans was a German-Jewish physics sympathetic to Communism, who graduated in Göttingen. In 1933 Houtermans decided to relocate from Berlin to Cambridge with his wife Charlotte Riefenstahl, due to the increase of the National Socialist party power. During this period the couple became friends with Occhialini. In 1934 Aleksand Il'ic Leipunskii from USSR convinced Houtermans to move to the Institute of Physics in Kharkov. Some of European physicist, such as Pauli, tried to dissuade Houtermans, without success. In a short time the situation in Kharkov deteriorated. Some of Houtermans' colleagues began to be arrested for political reasons as early as 1937. More and more alarmed by the situation, the Houtermans spouses began to plan their escape from the country. Officially for a vacation, Charlotte left for London in the early 1937 with the intention of asking for help from their European friends. However, nobody believed her. Meanwhile suspicion grew in Kharkov and she had to return. Charlotte and Fritz decided to move to Landau's house, in the hope that political pressure would be less in Moscow. On December 1st, 1937 Houtermans was arrested and imprisoned in Lubianka. Thanks to Bohr's help, Charlotte managed to reach Copenhagen, then London and the USA. In June 1938 Iréne Curie, Frédéric Joliot-Curie and Jean Perrin sent a telegram and a letter to Stalin, asking him the

liberation of Houtermans and other scientists. Following the Molotov-von Ribbentrop pact, German Communists who had emigrated to the USSR where handed over to the Gestapo. Houtermans was imprisoned in Berlin in 1940 and later released in July 1940.

Thanks to the document kept in the Milan archive, we can describe Occhialini's contribution in the attempt to free Houtermans from the USSR prison. In a letter dated April 8th, 1938, Charlotte wrote to Occhialini that she was delighted that Joliot responded so quickly to his request. In a later letter, dated July 1st, 1938, Charlotte wrote that Joliot's letter had been sent off and that it would be presented by the French ambassador in Moscow. Moreover Charlotte described Houtermans' condition of imprisonment, underlining that he was not in isolation. In this letter, Charlotte thanked again Occhialini for having talked to Joliot. In a third letter, dated July 25th, 1938, Charlotte asked Occhialini if he could write to Joliot, in order to find out when Joliot would have an answer to his letter or what Joliot intended to do in case there would have been no answer. In these letters it is therefore possible to fully appreciate Occhialini's contribution in sending the telegram to Stalin.

Also interesting are the correspondences with three other scientists, who asked Occhialini for an opinion to leave Europe for Brazil or the United States.

Gerhard Herzog, a Swiss-Jewish physics, on April 29th, 1938 asked Occhialini for information on living condition in Brazil. As a matter of fact Herzog expressed his concern about the political situation caused by Hitler's annexation of Czechoslovakia. He emigrated to the United States in 1938 [28].

Leo Pincherle, a Jewish physicist at the University of Padua, wrote to Occhialini in a letter dated August 9th, 1938. He expressed his desire to go abroad, particularly to Brazil or other countries in South America. This letter was written shortly before the enactment of the racial laws, and this is probably the reason for his desire to emigrate. However he lost his teaching position at the University of Padua and was forced to emigrate to Switzerland and then to England. Here he became professor at Bedford College of the University of London [29].

Guido Pontecorvo, a biologist, wrote to Occhialini on July 12th, 1938 stating that he needed better accommodation, letting implied the reasons for this need.

Lastly, during the Brazilian years Kate Margaret Thornycroft often wrote to Occhialini. She helped several Spanish refugee children in England after the end of the Spanish War. She was also active in sending money and instructions to help people in Czechoslovakia, occupied by Germany, to escape to Poland [30].

## 7. – Conclusion

With this work we can claim to have enriched the knowledge of the scientific activity of the São Paulo group. From the analysis of the scientific documents in the Milan archive, we have found some new information, like the unpublished article "Sobre a Existencia de Duplas de Mesotron na Alta Atmosfera". We also found and analyzed the data collected during the solar eclipse on March 27th, 1941, whose results were in agreement with those of the group. Moreover, it was possible to highlight Occhialini's contribution to these researches and how these works have made Brazil relevant in the international context. As a matter of fact we have shown that most of the results of the cosmic rays researches were collected and exhibited during the Symposium in Rio de Janeiro, chaired by Compton in 1941.

In the Milan archive we also found some unpublished informations regarding the scientist's stays in Manchester. These informations also allow us to believe that Occhialini

brought a cloud chamber, built with Blackett, to Brazil in the early 1939.

Finally, from the analysis of the correspondence kept in the Milan archive, we obtained interesting information concerning the relationships that Occhialini maintained with relevant European personalities. In fact, we showed his unprecedented contribution in the Houtermans' affair. We were also able to document the fact that Occhialini had remained in contact with European scientists. In some cases, such as Pincherle, Herzog and Pontecorvo, they asked him some information on living conditions in Brazil, with the purpose of relocating. We also found information about Occhialini's friendship with Thornycroft, active in helping people in difficulty due to Spanish bombardments or Hitler's expansionist policy.

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This work could not have been carried out without the active cooperation and advice of Leonardo Gariboldi. We want to thank all the staff of the BIFC Library of the University of Milan, who helped us get the information we needed. A special thank to Laura Stefanizzi, for her help in the consultation of the Milan archive.

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