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Astronomy in Brazil

S. O. Kepler[1]

[1]Departamento de Astronomia, Instituto de Física, UFRGS, Porto Alegre, RS, Brasil
email: kepler@if.ufrgs.br

Abstract. Astronomy in Brazil grew to around 500 astronomers in the last 30 years and is producing around 200 papers per year in refereed journals. Brazilian astronomers are participating in several international collaborations and the development of instrumentation is on the rise.

1. Introduction

Brazil is the fifth most populous nation in the world with nearly 200 million inhabitants. The history of Astronomy in Brazil starts around 1639, when the first observatory in Brazil was built under the Dutch government of Johann Moritz von Nassau-Siegen in occupied Recife, at the Northeast of Brazil. The observatory was located at the Fribourg palace in Antonio Vaz island. The astronomer in charge, Georg Markgraf (1616–1644), observed the solar eclipse of November 13th, 1640, published in his *Tractatus topographicus et meteorologicus Brasiliae cum eclipsi solaris*. The observatory was in fact the first observatory built in the Southern Hemisphere and in the Americas, except for the Maia's and Astek's monuments. When the Portuguese retook the region in 1654, the whole palace was razed to the ground.

A few later observations are know, like the observations of a comet in 1668 by the Jesuit priest Valentim Estanciel (1621–1705), explicitly mentioned by Isaac Newton in the Principia (1687), and the observations obtained at Morro do Castelo, in Rio de Janeiro, to measure the latitude and longitude of the city, from 1781 to 1788 by the Portuguese astronomer Bento Sanches Dorta (1739–1795), published in 1797. He observed the eclipses of Jupiter satellites with John Dollond (1706–1761) achromatic telescopes, one of 1 1/2 foot focal distance and another of 17 inches. With the 17 inch he also observed the lunar eclipse of November 10th, 1783.

2. Observatório Nacional

In 1827, emperor Don Pedro I (1798–1834) decreed the start of the Imperial Observatory which was finally installed by Don Pedro II (1831–1889) in 1845, at Morro do Castelo, where it stood till 1922, with a 92 mm telescope. Don Pedro II was as astronomy enthusiast and he observed the total solar of April 25th, 1865 from his palace at São Cristóvão, while Camilo Maria Ferreira Armond (1815–1882), Baron of Prados, observed it from the observatory. Antônio Luís von Hoonholtz (1837–1931), Baron of Teffé, observed the transit of Venus over the solar disk in December 6th, 1882 with a 16 cm equatorial telescope at San Thomas island, in the Antilles, leading one of the three groups sent by the observatory. In 1906, the observatory receives the name Observatório Nacional. By 1922 the observatory was moved to its present location, in São Cristóvão, Rio de Janeiro city. Henri Charles Morize (1860–1930), naturalized Brazilian as Henrique Morize, was the director from 1908 to 1930, and he organized the English

Figure 1. Observatory at Fribourg palace, in Recife

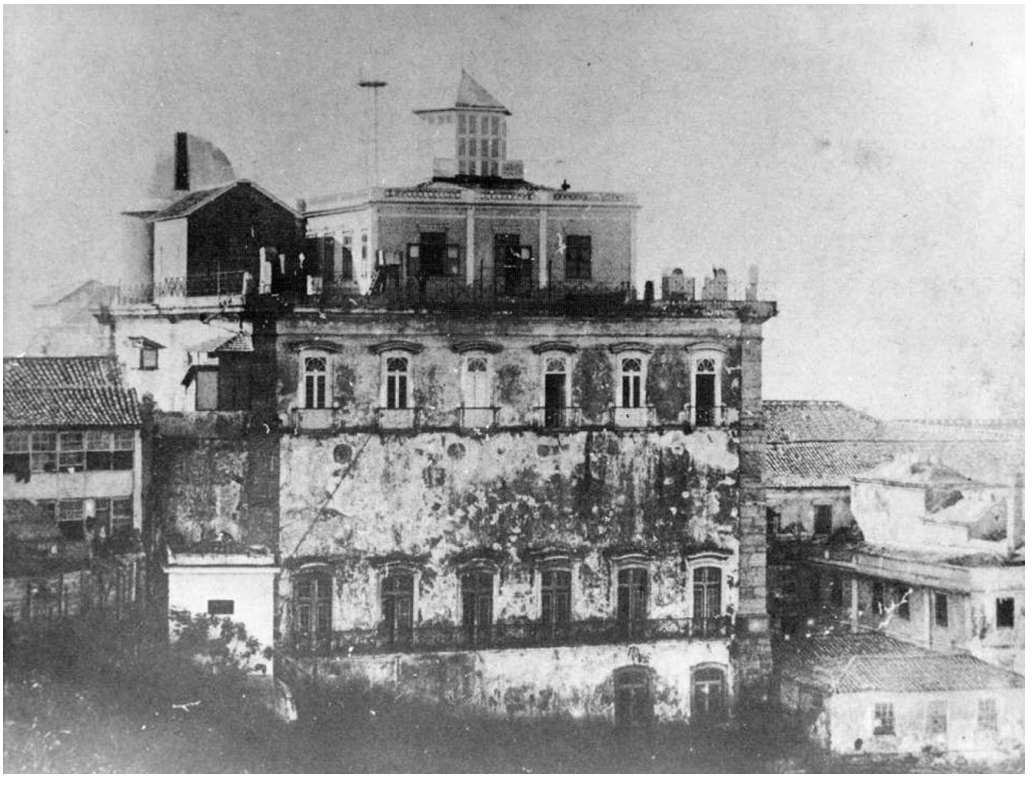

Figure 2. Observatory at Morro do Castelo, Rio de Janeiro.

expedition lead by Andrew Claude de la Cherois Crommelin (1865–1939) and Charles Rundle Davidson (1875–1970) to observe the total solar eclipse of May 29th, 1919, in Sobral, Ceará, to test the bending of light by mass predicted in Albert Einstein's general relativity. The eclipse occurred in the Hyades, with 13 bright stars in the field. The

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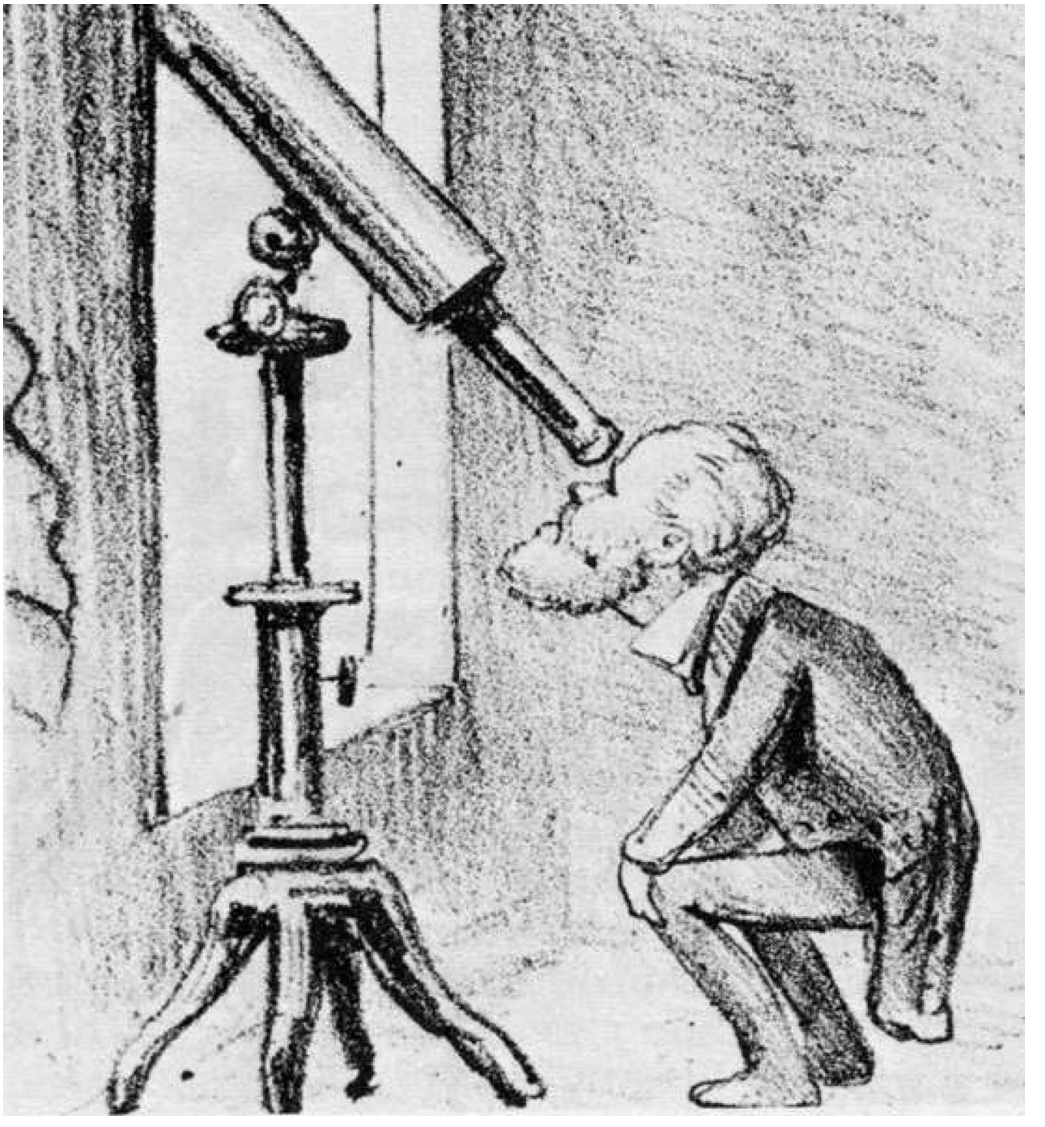

Figure 3. Charge of Don Pedro II observing the eclipse.

expedition obtained 7 good pictures (Davidson 1922). The expedition to Brazil resulted in a measured bending of $1,98 \pm 0,12$" (internal) $\pm$0,30" (systematic). The metal primary telescope used in Sobral lost its focus due to the large temperature change during eclipse and the best observations where obtained with the secondary telescope. The expedition lead by Arthur Stanley Eddington (1882–1944) (Eddington 1919) to the isle of Principe obtained only two plates, measuring a bending of $1,61 \pm 0,30$" (internal). As Einstein's prediction was 1.73", both measurements confirmed the theory (Dyson, Eddington & Davidson 1920; Crelinsten 2006). When Einstein visited Brazil in 1925, he declared to the local newspapers: "The idea that my mind conceived was proven in the sunny sky of Brazil."

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Figure 4. Observatório Nacional in Rio de Janeiro.

Figure 5. Telescopes used in Sobral on May 29th, 1919.

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Figure 6. Observatório da Universidade Federal do Rio Grande do Sul.

3. The Observatory in Porto Alegre

In 1908, the construction of the observatory of the Universidade Federal do Rio Grande do Sul was completed in Porto Alegre, where it still stands as the oldest observatory in Brazil in its original location, still open to the public for visits every week, with its 190 mm equatorial telescope from Paul Ferdinand Gautier (1842–1909), *Constructeur d'instruments de précision, Paris.*

4. São Paulo

The main observatory in São Paulo was built between 1932 and 1941, part of Instituto Astronômico e Geofísico da Universidade de São Paulo.

Two important Brazilian researchers in astronomy were Mário Schenberg (1914–1990), who proposed the Urca process of energy loss by neutrino emission in stellar interiors with George Antonovich Gamow (1904–1968) (Gamow & Schoenberg 1940), and the Schenberg-Chandrasekhar limit for the end of the hydrodynamical equilibrium at the end of the main sequence life of a star, with Subrahmanyan Chandrasekhar (1910–1995) (Schönberg & Chandrasekhar 1942), and Cesare Mansueto Giulio Lattes (1924–2005), a Brazilian experimental physicist, co-discoverer of the pion, pi meson, studying cosmic

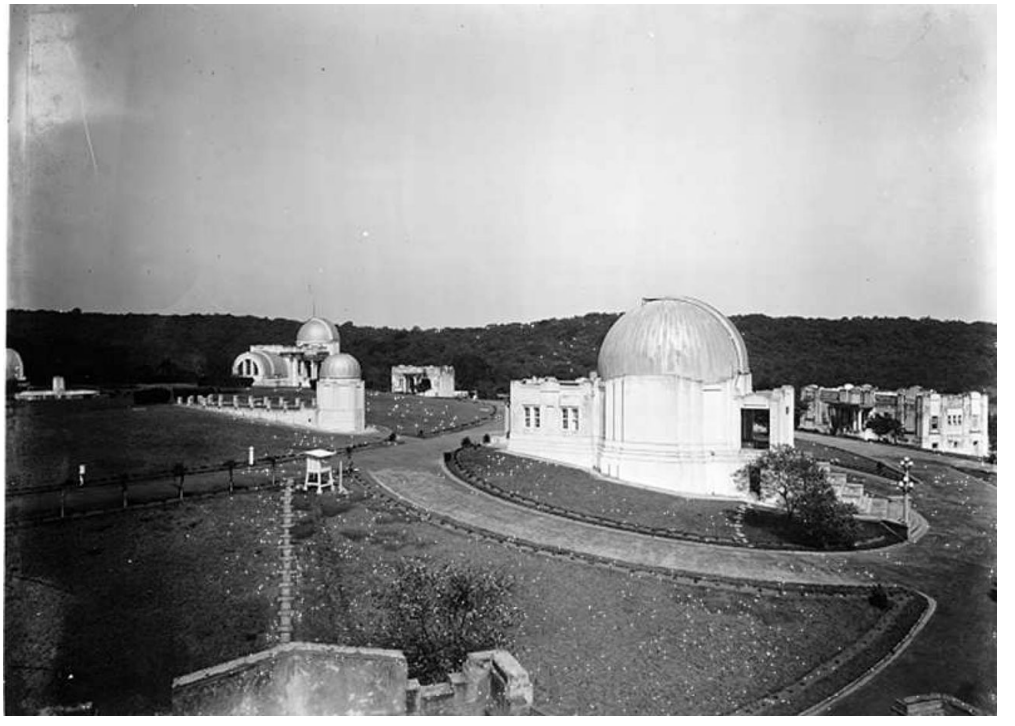

Figure 7. Observatório do Instituto Astronômico e Geofísico da Universidade de São Paulo.

rays (Lattes, Occhialini & Powell 1947). Both researchers spent most of their lives in Brazil.

5. Astrophysics

By the end of the 1960s, the first astronomy doctoral degree programs in Brazil started at São José dos Campos, São Paulo and Porto Alegre, and research in astrophysics really starts in Brazil. By 1971 a group of radio-astronomy from Universidade Presbiteriana Mackenzie builds a 13,7 m millimiter dish comprising the Rádio Observatório de Itapetinga. During the 1970's, a group lead by Observatório Nacional starts to build the Observatório do Pico dos Dias, with a 1.6 m optical telescope, later to become the Laboratório Nacional de Astrofísica. Other astronomy groups developed at Belo Horizonte, Natal and Instituto Nacional de Pesquisas Espaciais, in São José dos Campos. By 1981 Brazil had 41 astronomers with doctor degrees. Nowadays there are 284 doctors in astronomy hired by 41 institutions, plus 208 graduate students and around 60 post-docs. The groups in São Paulo and Rio de Janeiro are still the largest in Brazil, but there 11 institutions with graduate degree granting programs.

The Brazilian Astronomical Society, founded in 1974, currently has over 500 members.

Brazilian astronomers participate in a number of important international collaborations, including the construction and operation of the Gemini and SOAR optical and infrared telescopes in Chile, the Pierre Auger cosmic ray observatory and the Solar Submillimetric Telescope, in Argentina, the CoRoT space mission, and the Brazilian Decimetric Array. Brazil's participation as a 34% partner in the SOAR consortium has enabled the development of a Brazilian instrumentation program for this telescope with three world-class instruments currently under construction: a 1300 channel IFU fiber-fed

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Figure 8. Rádio Observatório de Itapetinga.

Figure 9. Observatório do Pico dos Dias.

dual-beam spectrograph, a tunable filter imager (both to be operated with ground layer adaptive optics) and an echelle spectrograph. Although Brazil is one of the smallest Gemini partners, with only a 2.5% share, Brazilians author about 10% of the total number of papers in the Gemini partnership. The group at INPE has participated over the years in several international collaborations for the construction and operation of ballom and satellite observations, including the construction of a small gravitational wave detector. A Brazilian group is also associated with the Dark Energy Survey.

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Figure 10. Photo at the annual meeting of the Brazilian Astronomical Society in 2008.

Table 1. Number of papers in refereed journals in Astronomy

1965	0
1970	8
1975	15
1980	25
1985	47
1990	74
1995	111
2000	205
2005	214
2008	219

Table 2. Areas of research of the 208 papers published in 2008

Optical and infrared stellar astronomy	63	28.8%
Theoretical cosmology	38	17.4%
Optical and infrared extragalactic astronomy	26	11.9%
Asteroid physics	12	5.8%
Theoretical stellar astrophysics	9	4.3%
Chemical evolution of stellar systems	9	4.3%
Dynamical astronomy	9	4.3%
Solar radio astronomy	7	3.2%
Instrumentation	7	3.2%
Exoplanets	6	2.7%
Others	29	13.2%

In terms of astronomy education and outreach, the most successful is the Brazilian Astronomical Olympiad, running since 1998, with 860 000 students participating in 2009 in more than 10 000 schools across the country.

Acknowledgements

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