One Hundred Years of Strong Gravity Meeting

History of General Relativity in Portugal

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Outline

1. *Einstein and General Relativity*
2. *Einstein in Lisbon*
3. *General Relativity in Portugal*
4. *Conclusions and acknowledgements*

1. Einstein and General Relativity

- **Einstein played a major role in several fields in physics: statistical physics, solid state physics, quantum mechanics, electrodynamics, special relativity, general relativity, unification theories, foundations of quantum mechanics, and philosophic principles of physics.**
- **The pinnacle is without a doubt the general theory of relativity.**
- **Born (1955) wrote: "The foundation of General Relativity appeared to me then, and it still does, the greatest feat of human thinking about Nature, the most amazing combination of philosophical penetration, physical intuition, and mathematical skill."**
- **Dirac (1968) stated: "General Relativity is probably the greatest scientific discovery that was ever made."**

1. Einstein and General Relativity

- **After an effort that started in 1907, Einstein presented to the Prussian Academy of Sciences, on November 4, 1915, the first of four seminars showing a new, relativistic, tensorial and covariant theory of gravitation, later called the General Theory of Relativity, or General Relativity, for short.**
- **Einstein equation (1915):**

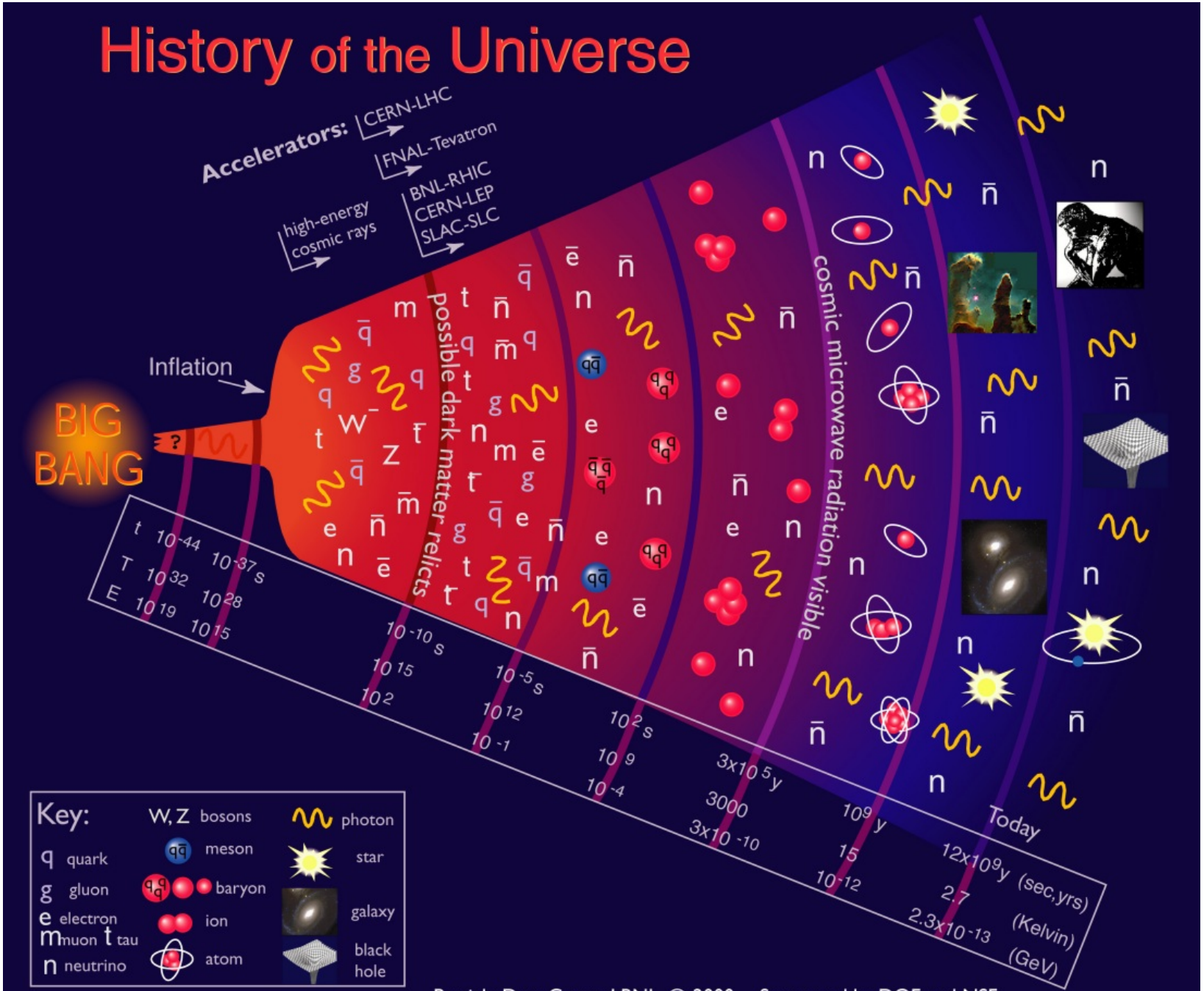
$$G_{ab} = \frac{8\pi G}{c^4} T_{ab} \,.$$

- **Confirms notion of spacetime initiated by Minkowski, and states physics is geometry, spacetime is curved, free particles follow geodesics. The metric is the gravitational potential, the connection is the gravitational force, and the curvature is the tidal force. The connection can be put to zero locally (principle of equivalence), but the curvature no, maintaining the universality of the gravitational field.**
- **General Relativity is the most intriguing among the fundamental interactions in the Universe. In its 100-year-long history, GR has passed many stringent tests, and is now accepted as the standard theory of gravity and one of mankind's greatest achievements.**

1. Einstein and General Relativity

- **Classical tests: Mercury perihelion precession, light deflection in the gravitational field of the Sun (gravitational lensing), gravitational Doppler effect, and delay in the radar echo from a planet.**
- **Technological applications: GPS. It would not function without general relativistic corrections.**
- **Gravitational waves: spacetime ripples predicted by Einstein in 1916. Detected by Hulse e Taylor (Nobel 1993). To be detected by LIGO 2016 and eLISA.**
- **Cosmology: dynamical study of the universe. Started by Einstein in 1917 with the static universe solution. Then expanding universe of Lemaitre and Hubble up to the amazing developments of today.**
- **Black holes: the geometrical object of General Relativity par excellence. Einstein never understood it. Nicknamed by Wheeler in 1968.**
- **Fundamental theories: Unification of gravitation and electromagnetism started by Weyl in 1918 and Eddington in 1921, and picked up by Einstein in 1922 onwards. Now are called theories of everything and try to unify all four fields in a quantum geometrical scheme, perhaps.**

1. Einstein and General Relativity



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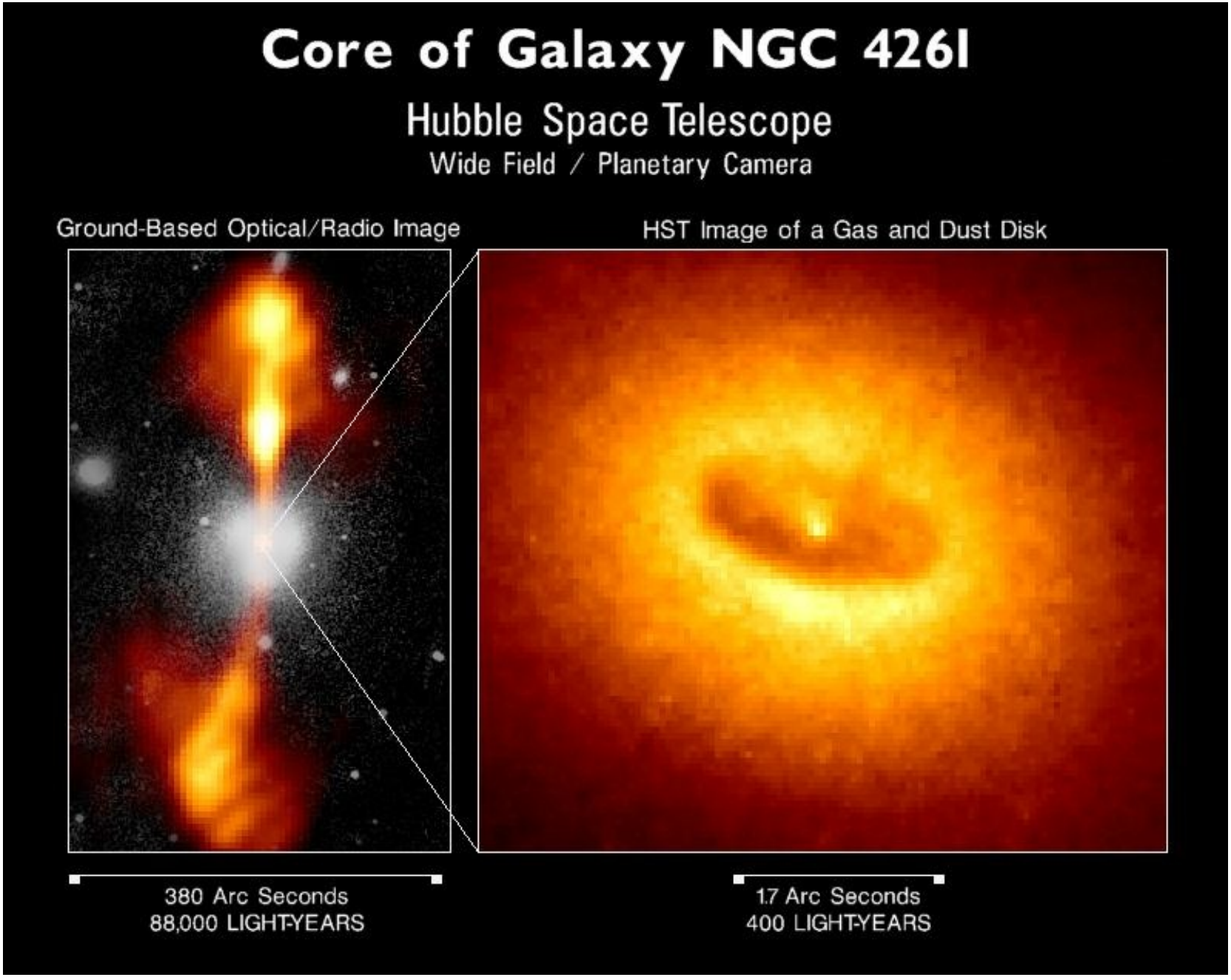

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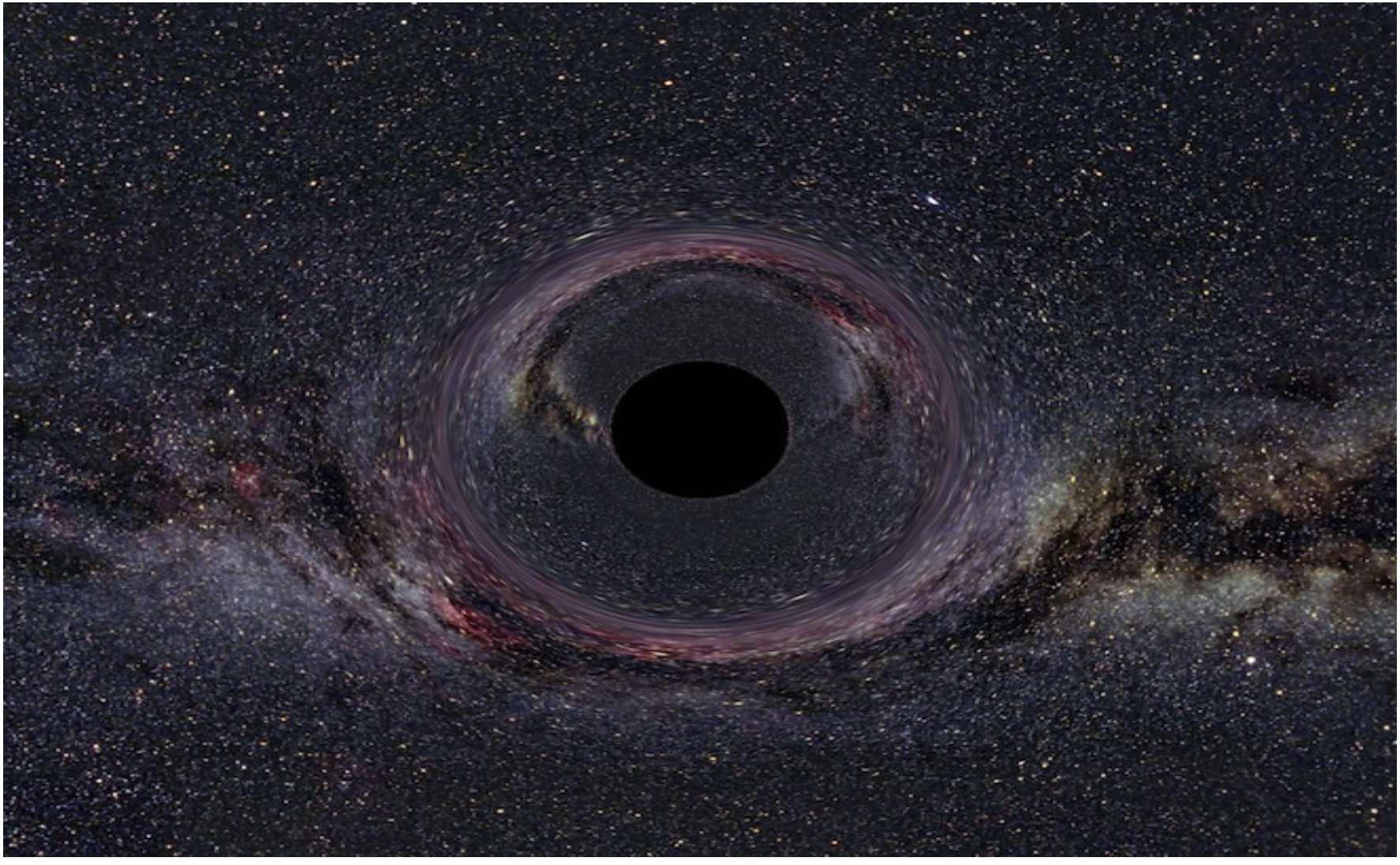


2. Einstein in Lisbon

- In March 11th, 1925, in transit to Buenos Aires, Montevideu, and Rio, the cruise ship Nord Cap of the shipliner Hamburg-Rio, in which Einstein travelled, docked in Lisbon for two days. He visited the Castle and the Monastery of Jerónimos.
- He is not recognized, nobody notices his passage, in spite of being already very famous (Nobel in 1921).
- In his log he writes that he liked the Varinas (fisher women in downtown Lisbon).
- He annotates: "A fisher woman selling fish, photographed with a fish basket, proud gesture, naughty".
- Then later in Rio in the Copacabana Palace he said to Gago Coutinho (famous Portuguese Admiral for being the first to traverse by plane the South Atlantic, making the trip Lisbon-Rio in 1922): "Sellers of fish of great elegance; I stopped several times to admire them. In the group where I was we photographed them often and put the portraits in our dining table on board."

2. Einstein in Lisbon

Varina in a beach.

2. Einstein in Lisbon

Lisbon varinas.

2. Einstein in Lisbon

Lisbon varinas.

2. Einstein in Lisbon

- **In March 17h, 1932, under the presidency of Egas Moniz (Nobel of Medicine in 1945) and following a suggestion of the great Portuguese mathematician Mira Fernandes, Einstein and Levi-Civita, are nominated foreigner correspondents of the Lisbon Academy of Sciences. It certainly was a welcome event for the country.**

- **Interesting to note that in the following day, amid hundreds of many other news, the newspaper Pittsburgh Press announces this ceremony (Pittsburgh Press, Friday, March 18, 1932, p. 35):**

Lisbon Honors Einstein

Lisbon, March 18 - Prof. Albert Einstein has been named an associate at the Academy of Sciences in Lisbon.

3. General Relativity in Portugal

- **A major event worldwide was the 1919 eclipse and the confirmation of General Relativity through the light deflection prediction.**

- **The May 29, 1919, eclipse was special because the Hyades were on the background.**

- **Frank Dyson, astronomer royal, presided a committee of the Royal Society of London and the Royal Astronomical Society. It approved two expeditions to minimize the risk of failure by bad weather.**

- **Eddington went to Príncipe, a Portuguese island at the time, belonging to the archipelago of São Tomé and Príncipe.**

- **Crommelin went to Sobral in Ceará state, North of Brazil. Arrived six weeks before.**

3. General Relativity in Portugal

São Tomé e Príncipe

3. General Relativity in Portugal

São Tomé e Príncipe

3. General Relativity in Portugal

Come and visit São Tomé e Príncipe.

3. General Relativity in Portugal

Príncipe and the village Santo António.

3. General Relativity in Portugal

Santo António bay. Eddington stayed here.

3. General Relativity in Portugal

Brazil

3. General Relativity in Portugal

State of Ceará and Sobral region.

3. General Relativity in Portugal

City of Sobral today.

3. General Relativity in Portugal

Fig. 22 – Vista panorâmica do observatório em Sobral

Panoramic view of the Observatory camp in Sobral in 1919, with the church.

3. General Relativity in Portugal

Museum of the eclipse in Sobral, panoramic view with the church.

3. General Relativity in Portugal

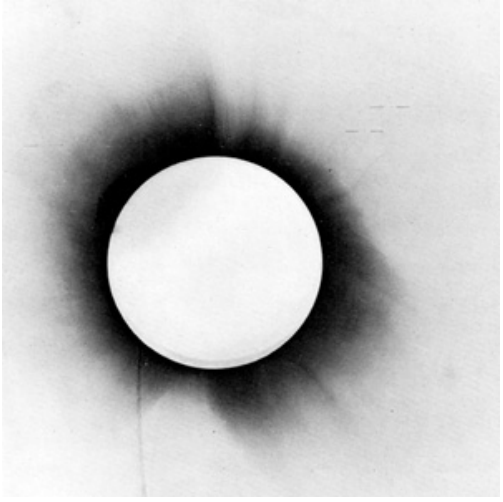
Museum of the eclipse in Sobral, a close.

3. General Relativity in Portugal

- **In Príncipe the weather was unfavorable, but it cleared up when totality began. In Sobral the weather was fine.**

- **The data pointed to 1.6”±0.3 in Príncipe and 1.98”±0.12 in Sobral, compatible with the 1.75” deflection predicted by General Relativity.**

- **Einstein is acclaimed.**



3. General Relativity in Portugal

- The Royal Society established contacts with the Astronomical Observatory of Lisbon.
- Correspondence between Eddington and the director and vice-director Campos Rodrigues and Frederico Oom to finalize the logistics. The trip had a stop in Funchal, Madeira Island.
- The newspaper O Século (Lisbon), informs in November 15, of the Royal Society and the Royal Astronomical Society meeting, in 6 November, when the results were publicized. The Times (London) announced it in November 7, the New York Times in November 10, and O Jornal (Rio de Janeiro) in November 12.
- The astronomer Manuel Peres Júnior of Observatório of Mozambique wanted to be present, but bureaucratic problems prevented him to join. In Rio de Janeiro Henrique Morize and Brazilian astronomers were present in Sobral.
- Peres Júnior wrote about General Relativity in the 1920s. The astronomers Ramos da Costa and Melo Simas also took interest.

3. General Relativity in Portugal

- **The Portuguese mathematical community also took part in the interest and development of General Relativity in Portugal.**

- **The 1st Mathematical Portuguese-Spanish Congress for the Advancement of Science, in Porto in 1921, gave a boost to General Relativity.**

- **Plans y Freire gave a lecture that strongly inspired Portuguese Mathematicians.**

- **Santos Lucas of Faculdade de Ciências, spurred by it delivered a course during the year 1922-1923 in General Relativity, the first regular course in General Relativity in the world.**

- **Others: Manuel dos Reis (Coimbra), Ruy Luis Gomes (Porto), António Geão (Lisbon). The personality that stands above all is Mira Fernandes (IST).**

3. General Relativity in Portugal

- **Mira Fernandes was a mathematician, Professor at IST from 1911 (inaugural year of IST) to 1954 (retirement).**
- **He got his Doctorate in Coimbra under Sidónio Pais (later President of Republic).**
- **From the very beginning he showed interest in Differential Geometry and General Relativity. In 1930 he published several interesting papers in Rendiconti della Accademia dei Lincei in unification theories of gravitation and electromagnetism.**
- **He corresponded with Levi-Civita and E. Cartan. Here in Portugal he standed alone.**

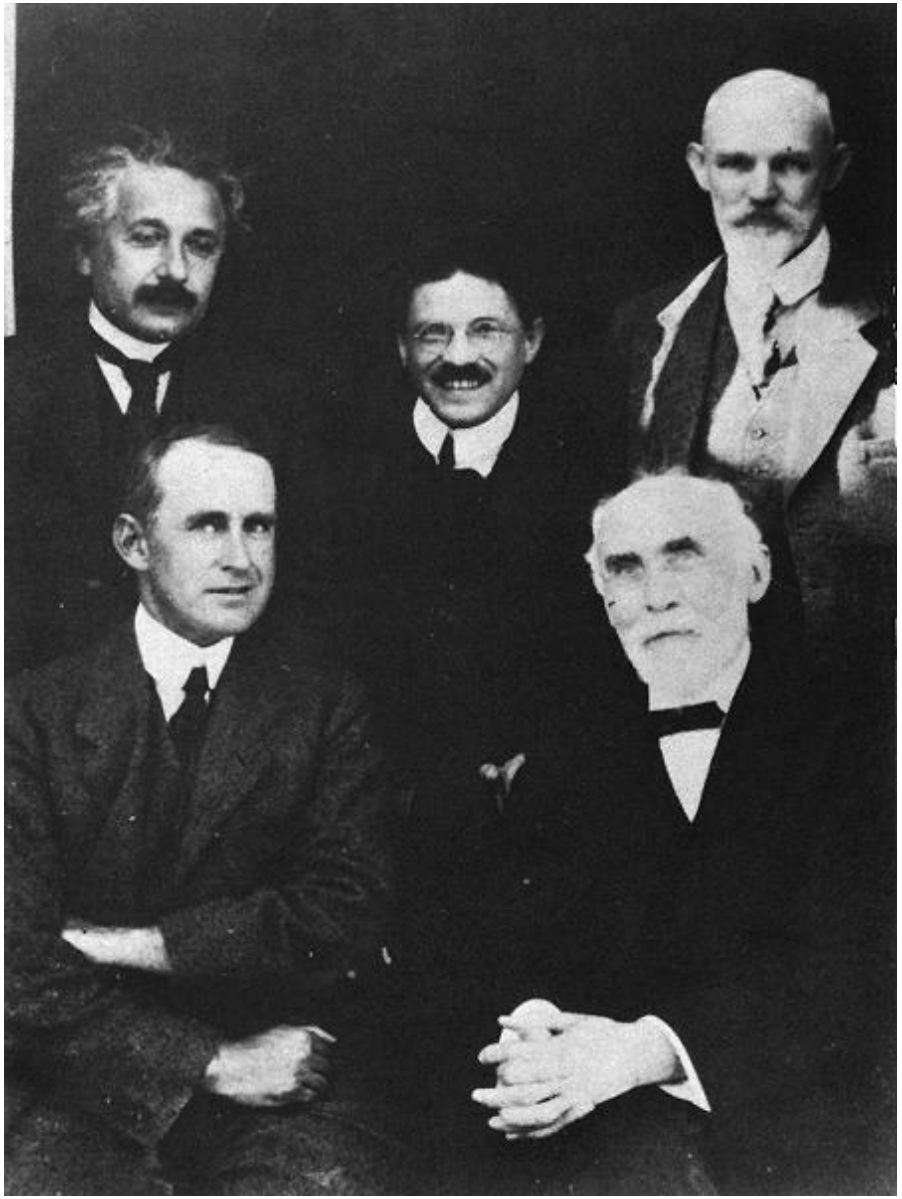
4. General Relativity in Portugal

- **From the 1950s until today great developments in the Portuguese Universities.**

- **Almost every Physics Department has a theoretical group working in Gravitation, General Relativity and related areas.**

- **To celebrate these 100 wonderful years of General Relativity we are organizing a meeting:**
  GR 100 years in Lisbon, 18-19 December 2015
  http://centra.tecnico.pt/network/gr100/

4. Conclusions and acknowledgements



Einstein, Ehrenfest, de Sitter, Lorentz, and Eddington. Leiden, 1920.

4. Conclusions and acknowledgements

Einstein in Haberlandstrasse. Berlin, 1930.