Cosmology in Brazil – 50 years

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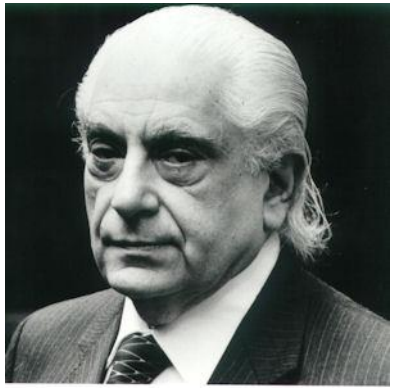
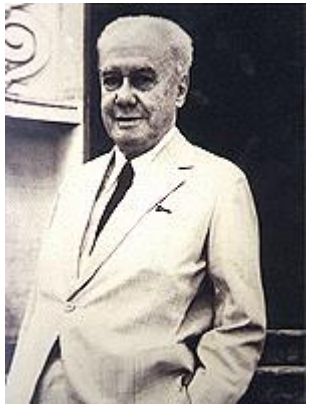
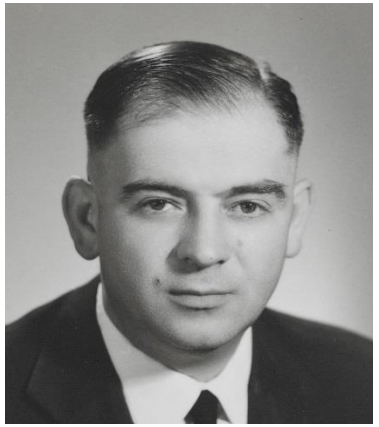
INPE – 2013 September

Astronomy in Brazil – a “turbulent” history

- Late implantation in comparison with Physics
- Institutional instabilities & personal disputes
- Absence of continuity in scientific programs
- Individual actions – Mario Schoenberg, Lélio Itapuambyra Gama, Abrahão de Moraes







The National Observatory
Example of a “turbulent” history

- Imperial Observatory – created in 1827 – D. Pedro I – Imperial Ministry
- Internal personal disputes – director nominated only in 1845 under D. Pedro II
- 1865 – Imperial Observatory ⟶ Central School ⟶ Military School – up to 1871
- 1871 – administrative reorganization (meteorology, astronomy, geophysics and legal time)
- Emmanuel Liais becomes director – only six months – a second period beginning in 1874
- Dispute Liais vs Urbain Le Verrier (director of Paris Observatory) – Dispute Liais vs Manuel Pereira Reis ⟶ return to France in 1881
- Luiz Cruls – new director – new reorganization in 1890 after the Proclamation of the Republic ⟶ Observatory of Rio de Janeiro ⟶ Ministry of War
- 1909 – National Observatory – Meteorology & Astronomy Services – Ministry of Agriculture
- 1930 – new reorganization ⟶ Ministry of Education & Culture
- 1976 – new reorganization ⟶ institute of CNPq
- 2000 – new reorganization – Ministry of Science and Technology

Abrahão de Moraes in the History of Sciences in Brazil

- ***Necessity of a National Astronomical Observatory installed in an adequate site***

  (The Jean Roche mission – LNA)

- ***Necessity of an increasing contact with advanced centers of research***

  (Arrival of French astronomers – J. Delhaye, Roger Cayrel among others)

- ***Necessity of sending students (physicists and mathematicians) to high level centers of research***

(G. Giacaglia (Yale); S. Ferraz Mello (Bureau des Longitudes); P. Benevides (Besançon); L. da Silva (Meudon) and J.A. de Freitas Pacheco (IAP)

The implantation of Astronomy in Brazil

- ***The International Geophysical Year (IGY) – 1957 beginning of the organization in astronomy & geophysics in Brazil***
- ***Existence of stable teams in academic institutions***
- ***Existence of well defined scientific projects***
- ***Beginning of graduate of programs in Astronomy (Master and/or PhD)***

The sixties transition

- ***Early sixties – creation of GRAM (after CRAAM) under the leadership of Pierre Kaufmann– with a defined projects (solar physics, ionosphere) – Operating an Observatory in Campos de Jordão (then Atibaia) – formation of students***

- ***Late sixties – IFUSP – Jun'ichi Osada, Mauro Cattani, Normando Fernandes, Luiz da Rocha-Barros –theoretical astrophysics – source of students (Hugo V. Capelato, José Roberto Bonilha)***

- ***1966 – the dean of ITA – Luiz Cantanhede and Abrahão de Moraes – creation of a group for research in Astronomy – first projects in photometry – first graduate school in astronomy under the leadership of Sylvio Ferraz Mello***

The ITA's group – Bagé 1965 – experiment on the Einstein effect

IL NUOVO CIMENTO Vol. XLI B, N. 2 11 Febbraio 1966

Static Cosmological Model and Red-Shift for Radio Galaxies.

F. M. GOMIDE

Departamento de Fisica, Instituto Tecnológico de Aeronáutica, Comissão Nacional de Atividades Espaciais - São José dos Campos, São Paulo

(ricevuto il 14 Giugno 1965)

Summary. — Forty-four strong radio sources optically identified with peculiar galaxies were used in a plot of the radio magnitudes with the logarithm of the red-shifts. A (m_r, log $c\delta$) plot was established also for weak radio sources in 9 groups and clusters. These plots were compared with the photographic magnitude red-shift relation analysis of 15 groups and clusters with log $c\delta$ smaller than 3.74. The coefficients of the three straight lines obtained were not essentially different from the 2.5 value predicted for an Einstein-de Sitter static universe. These results are not inconsistent with that obtained by Hawkins in 1962 for the (m_p, log $c\delta$) relation of field galaxies brighter than 14 mag.

1. – Introduction.

It was shown by HAWKINS (1) that a least-square solution of the (m_p, log $c\delta$) points for field galaxies brighter than $m_p = +14$, leads to a straight line with a gradient of 2.26, provided that no systematic biases are assumed. Now, this result approximates to a quadratic red-shift law derived from a static de Sitter metric (2), which determines for the (m_p, log $c\delta$) relation a gradient of 2.5.

Inspecting Humason, Mayal and Sandage's least squares solution of the plot for 474 field galaxies up to $m_p = +20$ or log $c\delta = 4.80$, we can see that 3% of the samples are distributed from 14 to near 20 magnitudes, or, from log $c\delta = 3.7$ to log $c\delta = 4.8$. These points play a heavy rôle on the dete:mination of the angular coefficient of the straight line. These researchers have assumed the resonable judgement that red-shifts of the fainter galaxies would present

(1) G. S. HAWKINS: *Nuovo Cimento*, 23, 1021 (1962).
(2) R. TOLMAN: *Relativity Thermodynamics and Cosmolgoy* (Oxford, 1958).

The sixties – the pioneering work of F. M. Gomide

The beginning of Cosmology in Brazil

One of the first papers in Cosmology published in 1966 by Fernando de Mello Gomide, from ITA, in "Il Nuovo Cimento" vol 41

Symposium in Crimeia – 1969 – Among others, Zeldovich, Silk, Sunyaev, Field, Syrovatskii, Habing, Pottasch, Toomre, Gogh, Spiegel, Pikelner, Greenberg

The seventies – CBPF & IFT

M. Novello & P. Rotelli – "The cosmological dependence of weak interactions"
J.Phys. A5, 1488, 1972

Ruben Aldrovandi

Studies on the Omnès Cosmology

Creation of the group of Cosmology & Gravitation by Mario Novello in 1976 (I. Damião Soares, J. Salim)
Program of an Eternal Universe (GR&G 16,535,1984)

IFT – 1976
Formation of a group in Gravitation & Cosmology

The School of Gravitation & Cosmology – founded in 1978 - XV edition in 2012

Rogério Rosenfeld

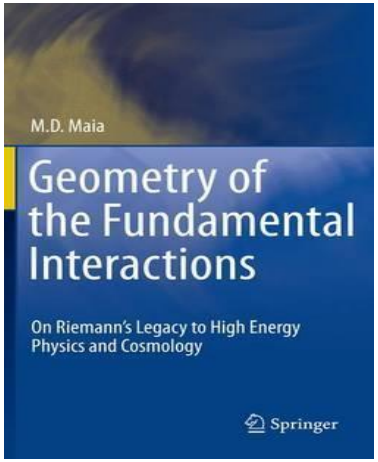
The School of Gravitation & Cosmology

* *The first Scholl was held in Rio de Janeiro (1978)*
  Lecturers – Mario Novello, Colbert G. Oliveira, M. D. Maia,
  J.A. de Freitas Pacheco and M. Gomide

Some Reputed Lecturers

* *(1979) - I. M. Khalatnikov , E. M. Lifshitz*
* *(1982) – Bryce DeWitt*
* *(1984) – Yvonne Choquet-Bruhat, Edward W. Kolb*
* *(1987) – Jaynat V. Narlikar*
* *(1989) – Nathalie Deruelle*
* *(1993) – A. D. Dolgov, R. Triay*
* *(1995) – G. F. Ellis , V.N. Melnikov , R.H. Brandenberger, W.G. Unruh*
* *(1998) - G. F. Smoot, J. D. Bekenstein, Werner Israel, A. A. Starobinsky*

UnB and UFRGS



Arrival of Argentinians astronomers in 1976 at UFRGS (PA)

**** Miriani G. Pastorisa***
**** Horacio A. Dottori***
**** Zulema Abraham***
**** Federico Strauss***

Activities in Gravitation Theories & Cosmology at the UnB begun around 1976 with

- ***Colbert G. Oliveira***
- ***Marcos D. Maia***
- ***Patricio A. Letelier***

Research in extragalactic astronomy – AGNs & QSOs

**** E. Bica***
**** Thaisa S. Bergmann***

The beginning of observational cosmology in Brazil – early eighties

THE ASTRONOMICAL JOURNAL VOLUME 89, NUMBER 9 SEPTEMBER 1984

REDSHIFTS FOR 228 SOUTHERN GALAXIES

L. N. DA COSTA, P. S. PELLEGRINI, M. A. NUNES, AND C. WILLMER
Department of Astronomy, CNPq/Observatório Nacional, Rua General Bruce, 586, Rio de Janeiro, R. J., 20921, Brazil

D. W. LATHAM
Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, Massachusetts 02138
Received 29 March 1984; revised 29 May 1984

ABSTRACT

In this paper, we present new redshifts for 228 galaxies located south of declination $-30°$. The observations were made with a photon-counting Reticon detector on the Observatório Nacional (ON) 60-in. telescope. The detector is identical to the one used at Mount Hopkins for the CfA Redshift Survey, and the redshifts were derived using the same data-analysis system. A preliminary comparison with published 21-cm redshifts indicates that our velocities have a zero-point offset of about -4 km s^{-1}, with a typical uncertainty of 40 km s^{-1}. The observations reported here are the initial results of the ON-CfA Redshift Survey currently being undertaken in the southern hemisphere.

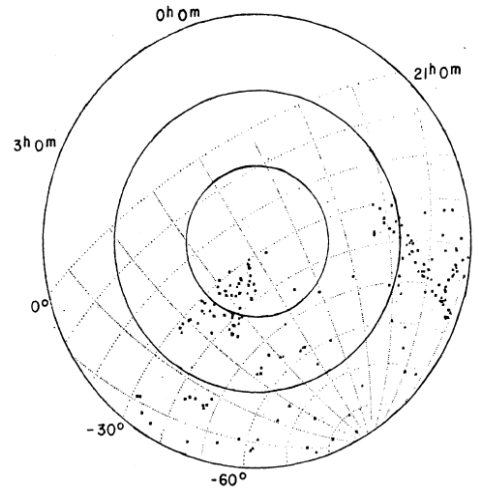
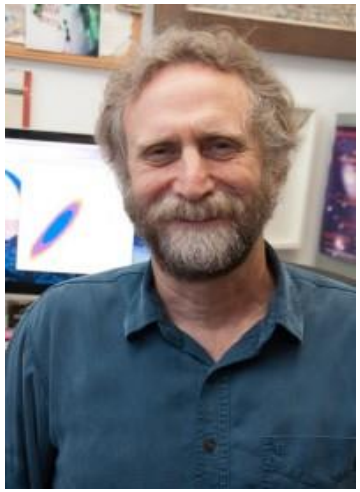


Fig. 3c Distribution of galaxies in the velocity range $4000 < v < 6000$ km s^{-1}

Return of Luiz Nicolacci da Costa to the National Observatory
Formation of students and a group – agreement CfA – Harvard – ON

- ***Paulo S. Pellegrini***
- ***Christopher Willmer***
- ***Reinaldo Ramos de Carvalho (⟶ INPE)***

New Groups appear in the eighties



Beginning of activities in Cosmology at UFRJ (~ 1986)

**** Ioav Waga***
**** Mauricio O. Calvão***
**** Marcelo Rebouças (previously at CBPF)***
**** Miguel Quartin (more recently)***

Formation of a Cosmology group at UFES (early 80's) by
**** José Plinio Baptista***
**** Antonio Brasil Baptista***
**** Julio César Fabris (present leader)***
**** Winfried Zindhal (more recently)***
**** Oliver Piatella (more recently)***

Cosmology at IAG-USP (early eighties)

** Return of H.V. Capelato from France*
** Ronaldo E. de Souza*
** L. Arakaki*
** Laerte Sodré*
** Armando Friaça*
** Sandra dos Anjos*

Important formation of graduate students

Research in Clusters of Galaxies
Dynamics of Galaxies
Large Structure of the Universe

IFUSP and UFRGN

Physicists in Quantum Field Theories ⟶ Cosmology

around 1982 ⟶ Gil C. Marques, O. Eboli and Ivan Ventura
(phase transitions –vacuum decay – structure formation)
Orfeu Bertolami Neto ⟶ moved to Lisbon in 1989
Victor Rivelles ⟶ Supergravity and quantum gravity
Elcio Abdalla ⟶ late 80's ⟶ dark energy theories
L.R. Abramo – more recently incorporated

Group in Natal
theoretical cosmology – dark energy models

Joel Câmara de Carvalho – late 70's (PE)
Nilza Pires
José Ademir Sales Lima ⟶ moved to IAGUSP 2005
Jailson Alcaniz ⟶ moved to National Observtory

Schoenberg – 70 years – USP 1984

Intervalo do 1º dia do Simpósio.

Da esquerda para a direita: S.R.A. Salinas, M. Schenberg, J.A.F. Pacheco, Guido Beck e S.R. de Groot.

Physica 127A (1984) 627–633
North-Holland, Amsterdam

THE VOLUME VISCOSITY OF A DEGENERATE MASSIVE NEUTRINO SYSTEM

S.R. DE GROOT and Ch.J. CALKOEN

Institute of Theoretical Physics, University of Amsterdam, Valckenierstraat 65, 1018 XE Amsterdam, the Netherlands

Received 16 May 1984

From the weak interaction and the relativistic generalization of the quantum transport equation the volume viscosity of a degenerate massive neutrino gas is derived as a function of the density and the neutrino mass.

Z. Physik B 32, 431–433 (1979)

für Physik B

Discussion on the possible acceleration of the expansion of the universe 14 yrs before …its discovery!

The Primordial Neutrino Gas

S.R. de Groot, W.A. van Leeuwen and Ch.G. van Weert
Institute of Theoretical Physics, University of Amsterdam, Amsterdam, the Netherlands

Received October 30, 1978

At an early stage the development of the universe was to a great extent determined by neutrino collisions. During this period the frequency of occurrence of these collisions was high enough so as to allow for a description by means of statistical methods.
Accordingly, in this note, the local time behaviour of this neutrino system has been supposed to be governed by a Boltzmann-type kinetic theory, which has been adapted in such a way that the extreme physical situation reigning shortly after the initial big bang has been accounted for. This means, particularly, that quantal and relativistic effects have to be incorporated.
On the basis of this newly developed theory and the neutral current part of the Hamiltonian describing the weak interactions, expressions for the heat conductivity and the viscosity – crucial parameters in cosmology – could be obtained as functions of the temperature and the weak coupling constant.

Studies of the CMB at INPE – early nineties

Proceedings of the Brazilian Decimetric Array Workshop
São José dos Campos, Brazil - July 28 – August 1, 2008

25 YEARS OF COSMIC MICROWAVE BACKGROUND RESEARCH AT INPE

Carlos Alexandre Wuensche and Thyrso Villela

Divisão de Astrofisica - Instituto de Pesquisas Espaciais - INPE
Av. dos Astronautas,1758 – 12201-970, São José dos Campos-SP, Brasil

ABSTRACT

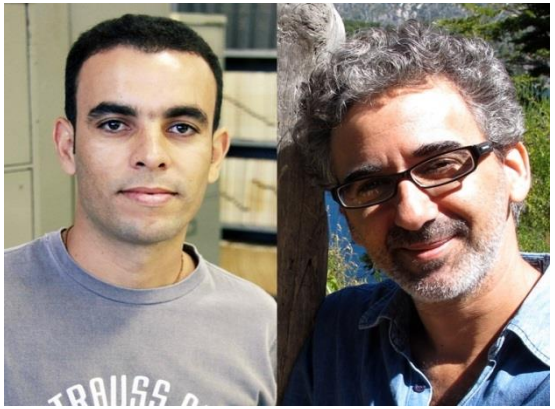
This article is a report of 25 years of Cosmic Microwave Background activities at INPE. Starting from balloon flights to measure the dipole anisotropy caused by the Earth's motion inside the CMB radiation field, whose radiometer was a prototype of the DMR radiometer on board COBE satellite, member of the group cross the 90s working both on CMB anisotropy and foreground measurements. In the 2000s, there was a shift to polarization measurements and to data analysis, mostly focusing on map cleaning, non-gaussianity studies and foreground characterization.

Collaboration INPE-University of California ⟶ Thyrso Villela

Formation of students – Carlos A. Wuensche, C. Tello, I.S. Ferreira

Projects to measure the spectrum (ARCADE 2 – 3-90 GHz) and the polarization of the CMB (COFE)

Cosmology at UFBA and UFPB



H.B. S.C.

Beginning of activities in cosmology at UFBA - early 90's

Cosmological models and nature of the dark energy

**** Saulo Carneiro***
**** Humberto Borges***
**** Cassio Pigozzo***

UFPB

Gravitation & Cosmology Seminar – 1988
Creation of the group of Cosmology & Gravitation – 1991

**** C.A. Romero Filho***
**** Valdir B. Bezerra***
**** E.M. do Monte***

Research on topological defects & quantum gravity

Large Telescopes in the New Century

Gemini South ϕ = 8.1m
International Consortium – Brazil (2.5%)
In operation since 2002

SOAR Telecope ϕ = 4.2m
Brazil – EUA collaboration
In operation since 2004

Example of collaborative work on Cosmology

Mon. Not. R. Astron. Soc. **000**, 1–?? (2013) Printed 26 April 2013 (MN LATEX style file v2.2)

The SOAR Gravitational Arc Survey – I. Survey overview and photometric catalogues⋆

Cristina Furlanetto[1,2]†, Basílio X. Santiago[1,2], Martín Makler[2,3], Eduardo S. Cypriano[2,4], Gabriel B. Caminha[2,3], Maria Elidaiana da Silva Pereira[2,3], Angelo Fausti Neto[2], Juan Estrada[5], Huan Lin[5], Jiangang Hao[5], Timothy A. McKay[6], Luiz Nicolaci da Costa[2,7] and Marcio A. G. Maia[2,7]

[1]*Departamento de Astronomia, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves 9500, Porto Alegre, RS 91501-970, Brazil*
[2]*Laboratório Interinstitucional de e-Astronomia, Rua Gen. José Cristino 77, Rio de Janeiro, RJ 20921-400, Brazil*
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[4]*Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, Rua do Matão 1226, São Paulo, SP 05508-090, Brazil*
[5]*Center for Particle Astrophysics, Fermi National Accelerator Laboratory, Batavia, IL 60510, USA*
[6]*Department of Physics, University of Michigan, Ann Arbor, MI 48109, USA*
[7]*Observatório Nacional, Rua Gen. José Cristino 77, Rio de Janeiro, RJ 20921-400, Brazil*

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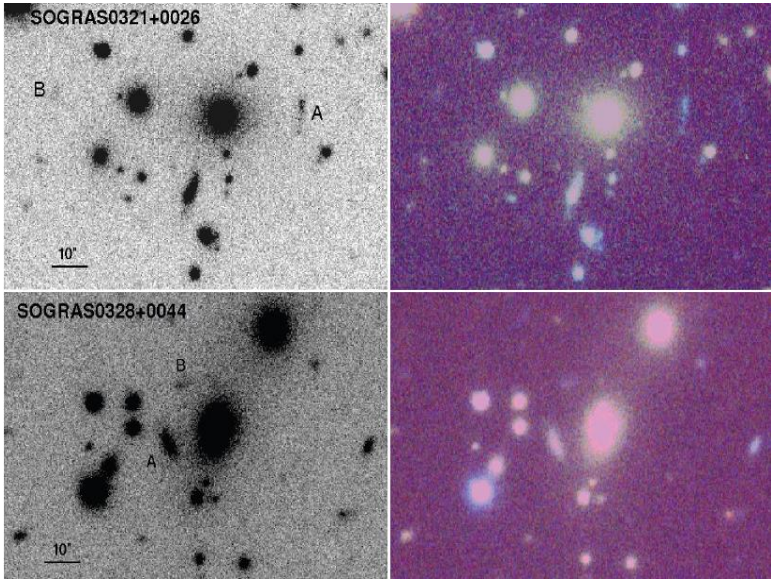

ABSTRACT

We present the first results of the SOAR (Southern Astrophysical Research) Gravitational Arc Survey (SOGRAS). The survey imaged 47 clusters in two redshift intervals centered at $z = 0.27$ and $z = 0.55$, targeting the richest clusters in each interval. Images were obtained in the g', r' and i' bands using the SOAR Optical Imager (SOI), with a median seeing of 0.83, 0.76 and 0.71 arcsec, respectively, in these filters. Most of the survey clusters are located within the Sloan Digital Sky Survey (SDSS) Stripe 82 region and all of them are in the SDSS footprint. Photometric calibration was therefore performed using SDSS stars located in our SOI fields. We reached for galaxies in all fields the detection limits of $g \sim 23.5$, $r \sim 23$ and $i \sim 22.5$ for a signal-to-noise ratio (S/N) = 3. As a by-product of the image processing, we generated a source catalogue with 19760 entries, the vast majority of which are galaxies, where we list their positions, magnitudes and shape parameters. We compared our galaxy shape measurements to those of local galaxies and concluded that they were not strongly affected by seeing. From the catalogue data, we are able to identify a red sequence of galaxies in most clusters in the lower z range. We found 16 gravitational arc candidates around 8 clusters in our sample. They tend to be bluer than the central galaxies in the lensing cluster. A preliminary analysis indicates that $\sim 10\%$ of the clusters have arcs around them, with a possible indication of a larger efficiency associated to the high-z systems when compared to the low-z ones. Deeper follow-up images with Gemini strengthen the case for the strong lensing nature of the candidates found in this survey.

Key words: gravitational lensing: strong – surveys – galaxies: clusters: general

Perspectives

- ***Research in cosmology exists in about 12 different institutions in Brazil***
- ***About 46 (PhD) cosmologists are involved (and up to 60 students)***
- ***Participation in the Dark Energy Survey (DES) - Brazil represented by ON, CBPF, LNCC, IF-UFRGS***
- ***J-PAS – Spain – Brazil collaboration (IAG-USP, IF-USP, CBPF, ON, IF-UFRJ, OV-UFRJ, INPE, UFSC)***
- ***Projects for studying the CMB and cosmology with GW (INPE)***
- ***Association to ESO and to CERN***

Weak Points & Organization

- ***Absence of tradition in developing astronomical instruments***
- ***Absence of expertise in new techniques related to high resolution observations (interferometry, nulling-interferometry)***
- ***Absence of adequate engineering groups to perform studies and realization of instrumental projects***
- ***Inadequate organization of astronomy at the national level***
- ***Inexistence of a long term planning***