last update: August 16, 2022 (click here for the live version)

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### Personal information

Full name Vinicius [vee-nee-cee-uh-s] Moris Placco Languages Portuguese (native), English (fluent),

Spanish (intermediate), Italian (basic)

Website http://vmplacco.github.io/ e-mail vmplacco@gmail.com

# **Employment / Appointments**

2020- Associate Scientist

Community Science & Data Center – US National Gemini Office NSF's National Optical-Infrared Astronomy Research Laboratory

2015-2020 Research Assistant Professor

Department of Physics University of Notre Dame

2018-2020 Faculty Fellow

Liu Institute for Asia and Asian Studies

University of Notre Dame

2014-2015 Science Fellow

Gemini Observatory – Northern Operations Center Association of Universities for Research in Astronomy

2013-2014 Postdoctoral Fellow

National Optical Astronomy Observatory

Association of Universities for Research in Astronomy

2010-2013 Postdoctoral Fellow

Instituto de Astronomia, Geofísica e Ciências Atmosféricas

Universidade de São Paulo

### Education

2007–2010 Doctorate degree in Astronomy

Search for very metal-poor stars based on carbon over-abundance

Instituto de Astronomia, Geofísica e Ciências Atmosféricas

Universidade de São Paulo

2005–2007 Master's degree in Astronomy

Abundance patterns among very metal-poor stars in the Galaxy: a statistical approach

Instituto de Astronomia, Geofísica e Ciências Atmosféricas

Universidade de São Paulo

2001–2005 Bachelor's degree in Physics (concentration: Astronomy)

Instituto de Física

Universidade de São Paulo

### **Awards**

2011 Featured Astronomy thesis of the year 2010

Instituto de Astronomia, Geofísica e Ciências Atmosféricas

Universidade de São Paulo

2005 Best Astronomy undergraduate project

Instituto de Astronomia, Geofísica e Ciências Atmosféricas

Universidade de São Paulo

# **Observatory Experience**

# Leardership roles/Service

2020-present	Hubble Space Telescope External Proposal reviewer
2018-present	Member of the J-PAS Survey Science Committee (Javalambre Physics of the Accelerating Universe Survey)
2018-present	Co-coordinator of the Resolved Stellar Population Working Group of the J-PAS Survey
2018-present	Member of the Maunakea Spectroscopic Explorer (MSE) Science Team
2017-present	Co-coordinator of the Stellar Parameters Value-Added Catalog Group of the J-PLUS Survey
2017-present	Subaru Telescope Proposal reviewer – category group: Normal Stars, Metal-Poor Stars
2017-present	Member of the S-PLUS Advisory Committee (Southern Photometric Local Universe Survey)
2017-present	Principal Investigator of the S-PLUS Short Survey
2019-2020	Member of the NSF's NOIR Lab Time Allocation Committee - Galactic Panel 2
2017-2020	US representative for the Gemini Observatory Users Committee
2018-2019	Member of the NOAO Time Allocation Committee - Galactic Panel 2
2017-2018	Member of the Gemini OCS Upgrades Working Group
2018	US Extremely Large Telescope Program – First Stars Key Science Project

# Operations and Instrument/User Support

2020-present NSF's NOIRLab: Community Science & Data Center - US National Gemini Office

Product development for the Gemini user community:

Twitter account bots – daily completion, weekly paper, monthly completion, other metrics GitHub repositories – DRAGONS Imaging tutorials, IRAF Spectroscopy tutorials, users dashboard

Co-organization of AAS Splinter Meetings

Migration and maintenance of the US NGO Portal Migration and maintenance of the GMOS Cookbook

Gemini HelpDesk - Responsible for selected Tiers 2 and 3 inquiries

2021-present NSF's NOIRLab: Gemini Observatory - Science User Support Department

Part of the Science Verification effort for the DRAGONS spectroscopic routines

Early testing of the quick-look and interactive tools for DRAGONS Performance comparison between Gemini/IRAF and DRAGONS packages

2021-present NSF's NOIRLab: Communications, Education & Engagement

Supported the migration of the NOAO Science website to the new NOIRLab Science website

Developed, revised, and curated content for the NOIRLab Science website

Serve as a liaison between RSS and CEE

Support science staff in adding/editing content on the science webpages

Responding/routing science inquiries from usercomms@noirlab.edu and info@noirlab.edu

Add/moderate content for scientific meetings in the Science Events database

2014–2015 **Gemini-North**: Operations

Support Scientist for Phase II programs Backup support for instrument teams

Interface between observatory and visitors (staff, scientists, and others) Interactions with astronomers, engineers, IT personnel, and facilities staff

Community support (help-desk and troubleshooting) Write/edit/update internal and external webpages

Weekly operations meetings

Queue observer Data reductions

2014–2015 Gemini-North: GMOS Instrument Team

Instrument performance monitoring pipeline

Throughput characterization

Commissioning of AO capabilities

Write/edit/update internal and external instrument webpages

Data quality assessment

Commissioning of Hamamatsu CCD at GMOS-S

2014–2015 **Gemini-North**: GRACES Instrument Team

Commissioning of the instrument

Developed early data-reduction pipeline

Write/edit/update internal and external instrument webpages Developed exposure time calculator (GRACES ITC v0.1 Beta)

2008–2012 **SOAR Telescope**: remote observing station – University of São Paulo

Responsible for operations and maintenance

Develop data reduction tools

Edit/write manuals and data analysis cookbooks

User support and troubleshooting

Configure, quote, and purchase new workstations and teleconference hardware

Work with university staff and IT personel to ensure physical access to buildings and computers

Support daytime calibrations / nighttime observations

# Observing Experience

Period	Telescope	# of nights	instrument	mode
2019-present	CTIO/Blanco	16	COSMOS	remote
2011-present	ESO/NTT	12	EFOSC2	visitor
2008-present	SOAR	40+	Goodman OSIRIS	remote
2013–2018	KPNO/Mayall	20+	RCSPEC KOSMOS	visitor/remote
2014–2015	Gemini North	12	GMOS GRACES GNIRS NIRI NIFS	queue observer
2014–2015	Gemini South	2	GMOS	remote
2013	McDonald 2.1m	4	ES2 Spectrometer	visitor

# Research Experience

# **Funding**

Past (Total: USD 470,229)

2020–2022 Hubble Space Telescope (Co-I)

Testing r-process nucleosynthesis models with two r-process enhanced stars

Space Telescope Science Institute (USD 35,000)

2019–2021 Hubble Space Telescope (Co-PI)

HD 222925: A unique opportunity to study the full range of nuclei produced by a single r-process event

Space Telescope Science Institute (USD 60,732)

2018–2020 Hubble Space Telescope (Co-PI)

The Unexplored Domains of the s-Process

Space Telescope Science Institute (USD 119,104)

2018 Liu Institute for Asia & Asian Studies (PI)

Stellar Archaeology as a Time Machine to the First Stars

University of Notre Dame (USD 600 - Travel support for conference)

2018 Liu Institute for Asia & Asian Studies (PI)

TDLI Workshop on The Exploding Universe

University of Notre Dame (USD 2,600 - Travel support for conference)

2015–2017 Hubble Space Telescope (Co-I)

The First Detections of Phosphorus, Sulphur, and Zinc in a Bona-Fide Second-Generation Star

Space Telescope Science Institute (USD 85,293)

2016–2017 Faculty Research Support Program Initiation Grant (PI)

Identification of CEMP Stars from S-PLUS Photometry using Artificial Neural Networks

University of Notre Dame (USD 10,000)

2013–2014 FAPESP (State of São Paulo Research Foundation) – Postdoctorate

(re)discovery and analysis of metal-poor stars in the Milky Way

National Optical Astronomy Observatory (USD 71,400)

2010–2013 FAPESP (State of São Paulo Research Foundation) – Postdoctorate

The Milky Way Halo revisited

Universidade de São Paulo (USD 85,500)

# **Fellowships**

2007–2010 Doctorate – FAPESP (07/04356-3) – Universidade de São Paulo

Search for very metal-poor stars based on carbon over-abundance

2005–2007 Master's – FAPESP (05/01023-8) – Universidade de São Paulo

Abundance patterns among very metal-poor stars in the Galaxy: a statistical approach

2004–2005 Undergraduate research project – CNPq/PIBIC – Universidade de São Paulo

Descoberta e Análise de Objetos com Linhas em Emissão no Survey HK

2002–2004 Undergraduate research project – FAPESP (02/04704-8) – Universidade de São Paulo

Construção de câmara de alvo gasoso para produção de feixes radioativos

# Visiting Faculty/Postdoc/Graduate Student

2018 Universidade de São Paulo

Instituto de Astronomia, Geofísica e Ciências Atmosféricas

Funding: USP/FAPESP/JINA-CEE

2018 Chungnam National University

Department of Astronomy & Space Science

Funding: CNU

2014 University of Notre Dame

Department of Physics

Funding: Gemini Observatory and JINA (Joint Institute for Nuclear Asthophysics)

2014/2012 Massachusetts Institute of Technology

Kavli Institute for Astrophysics and Space Research

Funding: Gemini Observatory, FAPESP (The State of São Paulo Research Foundation - Brazil)

2013/2012 National Optical Astronomy Observatory

Kitt Peak National Observatory Funding: FAPESP (Brazil)

2013 New Mexico State University

Department of Astronomy Funding: FAPESP (Brazil)

2010/2008 Universität Heidelberg

Zentrum für Astronomie

Funding: Universität Heidelberg (Germany), FAPESP, PROEX (Brazil)

2010/2009 Michigan State University

2007 Physics and Astronomy Department

Funding: JINA (USA), FAPESP, PROEX (Brazil)

# Academic Experience

# Student/Postdoc supervision

```
Postdoctoral level
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2022–2023 Felipe de Almeida Fernandes (Universidade de São Paulo - Visiting Fellow at NSF's NOIRLab)

# Graduate Level (co-advisor) - University of Notre Dame

- 2019-2022 Carlos Andrés Galarza Arevalo (Observatório Nacional - Brazil)
- 2019-2022 Joseph Zepeda
- 2019-2022 Derek Shank
- Sarah Dietz 2015-2020
- 2015-2020 Dmitrii Gudin
- Devin Whitten 2015-2020
- 2015-2020 Kaitlin Rasmussen
- 2015-2017 Geoffrey Lentner
- Rafael Santucci (M.Sc. and Ph.D. Universidade de São Paulo) 2010-2016

### Undergraduate Level (advisor) - University of Notre Dame

- 2020 Dante Komater (Physics Major)
- Lucas Pinheiro (Engineering Major) 2019-2020
  - 2019 Shenghua Liu (Physics Major)
  - 2019 Winter Allen (Arkansas Tech University - REU)
  - 2019 Yihao Zhou (Shanghai Jiao Tong University - REU)
- 2018-2020 Guilherme Limberg (Universidade de São Paulo)
- Erik Peterson 2016-2018
- 2016-2018 David Kalamarides
- 2015-2018 Spencer Clark (Glynn Family Honors Program) - Senior Thesis
- John Roach 2016-2017
- 2016-2017 Cristobal Gonzales
- Michael Kurkowski 2016-2017
  - 2017 Jazmine Jefferson (University of Kansas - REU)
  - 2017 Derek Shank (Ohio Wesleyan University - DISC/REU) - video report
  - 2017 Diego Fernandez (University of Oregon - REU)
  - 2016 Travis Hodges (Austin Peay State University - DISC/REU)
  - Miguel Correa (San Diego State University REU) 2016
  - 2015 Siyu He (Xi'an Jiaotong University - REU)
- 2012-2014 William Alves (Universidade de São Paulo)
- 2008-2010 Rafael Santucci (Universidade de São Paulo)

## Committee Service - University of Norte Dame

- 2019-2020 Undergraduate Research, Department of Physics
- Graduate Recruitment, Department of Physics 2016-2018
- 2015-2018 Preliminary Exam Committee, Department of Physics
- 2015-2018 University Committee on Research & Sponsored Programs, Notre Dame Research

### Thesis Defense Committee

- 2018-2022 Heitor Ernandes (Ph.D. - committee chair)
  - Universidade de São Paulo
  - Raphaela Fernandes de Melo (M.Sc.) 2021
    - Observatório Nacional
  - 2019 Henrique Reggiani (Ph.D.)
    - Universidade de São Paulo
  - 2016 Rafael Miloni Santucci (Ph.D.)
    - Universidade de São Paulo
  - 2016 Camilo Francisco Javier Muñoz Peña (M.Sc.)

Universidade de São Paulo

# **Teaching**

# Lead Instructor (LI) / Co-Instructor (CI) / Guest Lecturer (GL)

# Undergraduate

			University of Notre Dame
2	020	(LI)	Descriptive Astronomy (SU20-PHYS-10140)
			Course Instructor Feedback: 5.0/5.0 - link to full report
		(LI)	Descriptive Astronomy (SP20-PHYS-10140)
			Course Instructor Feedback: 5.0/5.0 - link to full report
		(LI)	General Physics B - E & M Laboratory (SP20-PHYS-11422)
			Course Instructor Feedback: 5.0/5.0 - link to full report
		(GL)	Engineering Physics II Laboratory (SP20-PHYS-11320)
		(GL)	Engineering Physics I Laboratory (SP20-PHYS-11310)
2	019	(LI)	Physics A - Mechanics Laboratory (FA19-PHYS-11411)
			Course Instructor Feedback: 5.0/5.0 - link to full report
		(LI)	Descriptive Astronomy (SU19-PHYS-10140)
			Course Instructor Feedback: 5.0/5.0 - link to full report
2	018	(GL)	Descriptive Astronomy (FA18-PHYS-10140)
2	017	(CI)	Descriptive Astronomy (FA17-PHYS-10140)
		(LI)	General Physics B - E $\&$ M Laboratory (SP17-PHYS-11422)
			Course Instructor Feedback: 4.8/5.0 - link to full report
2	016	(GL)	Descriptive Astronomy (FA16-PHYS-10140)
2	015	(GL)	Modern Observational Techniques (FA15-PHYS-30481)
			Universidade Virtual do Estado de São Paulo
2	012	(LI)	Sky and Stars: An introduction
		(LI)	Galaxies: An introduction
2	011	(LI)	Sky and Stars: An introduction
		(LI)	Galaxies: An introduction
Gradu	ate		
			University of Notre Dame
2	017	(CI)	Astrophysics: Stars (SP17-PHYS-80202)
2	016	(CI)	Large-Scale Astronomical Surveys (SP16-PHYS-70210)
2	015	(GL)	Astrophysics: Stars (SP15-PHYS-80202)
			Universidade de São Paulo
2	012	(GL)	Observational Astronomy
		-	

# Teaching Assistant - Universidade de São Paulo

2009	Introduction to Astronomy
	Fundamental Astronomy
2008	Introduction to Astronomy
2007	Fundamental Astronomy

### Other relevant information

# Computing skills

Linux/Unix/MACOSX/Windows operating systems

Shell Scripting (sh, bash, tcsh, zsh)

LATEX, OpenOffice, MS Office. Co-author of the LATEX template IAGTESE

Python (iPython/Jupyter Notebooks): scipy, numpy, pandas, scikitlearn, pyfits, astropy

R-project (terminal/RStudio): FITSio, tidyverse, cluster, sciviews

Databases: SQL (PostgreSQL/pgAdmin3), SDSS CasJobs, ADQL (J-PLUS/J-PAS/TAPVizieR) Web: html, ccs, wordpress, apache, curl, wget, ssh, ftp, drupal, Google Analytics, Matomo

Graphics: Gnuplot, ggplot2, matplotlib, bokeh, tableau

Data reduction: IRAF/Pyraf packages, DRAGONS, ESO Reflex/Gasgano

Astronomy tools: WCSTools, CDSclient, STILTS, SkyCalc

Documentation: Sphinx, readthedocs

Version control and DevOps: Git, gitHub, GitLab

## Online Resources

Webpage: http://vmplacco.github.io/

LinkedIn: https://www.linkedin.com/in/vinicius-placco/

GitHub: https://github.com/vmplacco/

stackoverflow: https://stackoverflow.com/users/5964833/vinicius-placco

pythonanywhere: https://vplacco.pythonanywhere.com/

Sample webpages/

side projects: http://vmplacco.github.io/#resources

# Professional Affiliations/Service

Member of the American Astronomical Society

Member of the Brazilian Astronomical Society

Member of the Brazilian Physical Society

Member of the JINA Center for the Evolution of the Elements

Referee for the American Astronomical Society Journals

Referee for the AAAS Science Magazine

Referee for Astronomy & Astrophysics

Referee for Monthly Notices of the Royal Astronomical Society

# \* Invited / Contributed talks

### 2022

Gemini Observatory Science Meeting 2022
Making good use of bad weather: a chemically pristine star found through the clouds with Gemini

\* Observatório Nacional – Seminário da Coordenação de Astronomia e Astrofísica Stellar Archaeology and Near-Field Cosmology: Understanding the Chemical Evolution of the Universe

#### 2021

Universidade de São Paulo – S-PLUS 16th Collaboration Meeting Mining the S-PLUS catalog to find chemically peculiar stars in the Galaxy

- \* Instituto Nacional de Pesquisas Espaciais Seminários da Divisão de Astrofísica (watch it on Youtube) Stellar Archaeology and Near-Field Cosmology: Understanding the Chemical Evolution of the Universe
- \* Universidade Federal de Santa Catarina IX Encontro de Física e Astronomia da UFSC Stellar Archaeology and Near-Field Cosmology: Understanding the Chemical Evolution of the Universe
- \* Joint Institute for Nuclear Astrophysics Physics of Atomic Nuclei High School Program The Age and Chemical Evolution of the Universe from Two Stars in the Milky Way

Universidade de São Paulo – S-PLUS 15th Collaboration Meeting Searching for low-metallicity stars in S-PLUS

\* NSF's National Optical-Infrared Astronomy Research Laboratory – Live from NOIRLab @ Hawai'i (watch it on Youtube) A chemically-peculiar star found from its colors

#### 2020

- \* NSF's National Optical-Infrared Astronomy Research Laboratory Live from NOIRLab @ Hawai'i (watch it on Youtube)
  The Age and Chemical Evolution of the Universe from Two Stars in the Milky Way
- \* NSF's National Optical-Infrared Astronomy Research Laboratory Gemini Observatory Science Coffee From R=40 to R=40,000: Mining narrow-band photometric catalogs in search of low-metallicity stars
- \* Joint Institute for Nuclear Astrophysics Physics of Atomic Nuclei High School Program The Age and Chemical Evolution of the Universe from Two Stars in the Milky Way
- \* Regional Center for Space Science and Technology Education for West Asia / Arab Union for Astronomy & Space Science Our eyes in the skies: How telescopes help us place ourselves in the Universe
- \* NSF's National Optical-Infrared Astronomy Research Laboratory
  Near-Field Cosmology with Narrow-Band Photometry and Spectroscopy of Low-Metallicity Stars
- \* Universidade de São Paulo Astrophysics Colloquium
  Near-Field Cosmology using Narrow-Band Photometry and Low-Metallicity Stars
- \* Universidade de São Paulo Astronomia ao Meio-dia (watch it on Youtube in Portuguese) Agulhas no palheiro: A evolução química e idade do Universo contadas por duas estrelas

## 2019

- \* National Optical Astronomy Observatory
  Stellar Archaeology: Understanding the Chemical Evolution of the Universe through Color Maps of the Night Sky
- \* Joint Institute for Nuclear Astrophysics Physics of Atomic Nuclei High School Program The Age and Chemical Evolution of the Universe from two stars in the Milky Way

Consejo Superior de Investigaciones Científicas – 17th J-PAS Collaboration Meeting Identification of Low-Metallicity Stars from Narrow-Band Photometry

\* San Francisco State University – Physics & Astronomy Colloquium
Stellar Archaeology: Origin of the Chemical Elements in the Universe through a 59-Color Map of the Sky

### 2018

\* Kavli IPMU at The University of Tokyo – Stellar Archaeology as a Time Machine to the First Stars The Mass Distribution of the First Stars revealed by Abundance Pattern Matching of Ultra Metal-Poor Stars

Kavli IPMU at The University of Tokyo – Introduction to Stellar Archaeology Radioactive Stellar Ages

- \* Texas A&M University Commerce Physics & Astronomy Colloquium
  Stellar Archaeology: Understanding the Origin of the Chemical Elements through a 59-Color Map of the Night Sky
- \* Chungnam National University Department of Astronomy & Space Science Seminar
  The Origin of the Chemical Elements in the Universe revealed by a 12-Color Map of the Night Sky
- \* Korea Astronomy and Space Science Institute Colloquium
  Constraints on Near-Field Cosmology through Abundance Pattern Matching of Ultra Metal-Poor Stars
- \* Universidade de São Paulo Astronomy Colloquium The Southern Photometric Local Universe Survey (S-PLUS): An Overview

Universidade de São Paulo – S-PLUS Meeting Short update on S-PLUS SHORTS

University of Notre Dame – Astronomy 1-minute talks (23 presenters) Organizer

\* University of Notre Dame – Our Universe Revealed A day in the life of an Astronomer

Kavli Institute for Cosmological Physics – Near-Field Cosmology with the Dark Energy Survey The Age Structure of the Milky Way Halo revealed by DES

\* Joint Institute for Nuclear Astrophysics – Physics of Atomic Nuclei High School Program
Can we talk about the Age and Chemical Evolution of the Universe by looking at only two stars?

Centro de Estudios de Física del Cosmos de Aragón – J-PLUS  $2^{\rm nd}$  Virtual Meeting *J-PLUS Stellar Parameter Value Added Catalog* 

- \* Shanghai Jiao Tong University Tsung-Dao Lee Institute Workshop on The Exploding Universe Probing the mass distribution of the first stars through abundance pattern matching of ultra metal-poor stars
- \* JINA-CEE Frontiers in Nuclear Astrophysics Main Conference Observational constraints on the origin of the elements: from First stars to Neutron-Star mergers
- Manhattan College Physics Department Understanding the Origin of the Elements in the Universe through a 12-Color Map of the Night Sky
- \* JINA-CEE Frontiers in Nuclear Astrophysics Junior Workshop Speaking Skills
- \* Centro de Estudios de Física del Cosmos de Aragón 16th J-PAS Collaboration Meeting Pathfinder science Constraints on First-Star Nucleosynthesis from J-PAS Photometry of Low-Metallicity Stars

Universidade de São Paulo – S-PLUS Collaboration Meeting (online) Updates on S-PLUS Short Survey(s)

### 2017

Universidade de São Paulo – S-PLUS Collaboration Meeting (online) Updates on S-PLUS Short Survey(s)

\* Michiana Astronomical Society – MAS monthly meeting speaker A Tale of Two Stars: Revealing the Age and Chemical Evolution of the Universe

University of Notre Dame – Astro-Skills Lunch *The do's and don'ts when plotting data* 

Red de Infraestructuras de Astronomia – Early Data Release and Scientific Exploitation of the J-PLUS Survey Identification of (Bright) Carbon-Enhanced Metal-Poor Stars with J-PLUS Photometry

GMT Community Science Meeting – Chemical Evolution of the Universe A Monte Carlo approach to find the Progenitors of Ultra Metal-Poor Stars (Rapid Poster Talk)

University of Notre Dame – The Great American Eclipse at Notre Dame Co-organizer / Astronomy faculty representative – 3,500 attendees

\* University of Notre Dame – Research Experiences for Undergraduates (REU) Program
A needle in a haystack: What one star can tell us about the age and chemical evolution of the entire Universe

Centro de Estudios de Física del Cosmos de Aragón – J-PLUS 1<sup>st</sup> Virtual Meeting *Identifying (Carbon-Enhanced) Metal-Poor Stars from J-PLUS Photometry* 

- \* Joint Institute for Nuclear Astrophysics Physics of Atomic Nuclei High School Program Stellar Archaeology: The Age and Chemistry of the Universe revealed by old Stars
- \* Universidade de São Paulo Astrophysics Colloquium Searching for the Origin of the Elements Using a 12-Color Map of the Night Sky

#### 2016

- \* University of Notre Dame Astrophysics Seminar
  A Monte Carlo approach to find the Progenitors of Ultra Metal-Poor Stars
- \* University of Notre Dame Department of Physics Colloquium Searching for the Origin of the Elements Using a 12-Color Map of the Night Sky

University of Notre Dame – Astronomy 1-minute talks (19 presenters) Organizer

Universidade de São Paulo – X-PLUS Collaboration Meeting Identifying Bright Carbon-Enhanced Metal-Poor Stars from S-PLUS Photometry

- University of Notre Dame Research Experiences for Undergraduates (REU) Program Near-Field Cosmology with Metal-Poor Stars
- \* University of Notre Dame Our Universe Revealed A day in the life of an Astronomer

University of Notre Dame – Our Universe Revealed Our eyes in the skies: How telescopes help us place ourselves in the Universe

227th Meeting of the American Astronomical Society Identifying Bright Carbon-Enhanced Metal-Poor Stars in the RAVE Catalog

#### 2015

University of Notre Dame – Our Universe Revealed The stuff we are made of: how do we determine the chemical elements in stars and the Universe?

University of Notre Dame – Astronomy 1-minute talks (15 presenters) Organizer

- \* Joint Institute for Nuclear Astrophysics / University of Notre Dame High School On Air Talk Stellar Archaeology: The Age and Chemistry of the Universe revealed by old Stars – YouTube video
- \* Michigan State University JINA-CEE Nuclear Astrophysics Lunch Research Discussions Observing the First Stars through the Atmospheres of Ultra Metal-Poor Stars

Universidade de São Paulo – X-PLUS Collaboration Meeting Identifying Carbon-Enhanced Metal-Poor Stars from S-PLUS Photometry

University of Notre Dame – Research Experiences for Undergraduates (REU) Program Galactic Archaeology: The Chemical Evolution and Age of the Universe revealed by old Stars

### 2014

- \* University of Notre Dame Astronomy Seminar Exploring the history of the Galactic halo with Carbon-Enhanced Metal-Poor stars
- \* Massachusetts Institute of Technology Kavli Institute Exploring the history of the Galactic halo with Carbon-Enhanced Metal-Poor stars

### 2013

National Optical Astronomy Observatory (Carbon Enhanced) metal-poor stars and the chemical evolution of the Universe

\* Gemini Observatory – Northern Operations Center Metal-poor stars as tracers of the chemical evolution of the Galaxy

### 2012

- \* Universidade Cruzeiro do Sul Astronomy Colloquium Search for Carbon-Enhanced Metal-Poor stars in the Halo(es) of the Galaxy
- \* Universidade de São Paulo Astronomy Colloquium Spectroscopy from R=300 to 30000: metal-poor stars and Galactic chemical evolution
- \* Universidade de São Paulo Invitation to Physics: undergraduate weekly seminar Galactic Archaeology: chemical evolution of the Universe revealed by metal-poor stars

Universidade de São Paulo - Astronomy at noon: undergraduate weekly seminar Census of the Milky Way

### 2011

Universidade de São Paulo - Chemical Evolution Group Seminar Rediscovering the Dual Halo of the Milky Way via Hierarquical Clustering

Universidade de São Paulo - Astronomy at noon: undergraduate weekly seminar  $Stellar\ Archaeology$ 

Universidade de São Paulo - Astronomy Colloquium Making good use of bad weather: finding extremely metal-poor stars in the clouds

\* ESO Headquarters - Santiago - Astronomy Colloquium Searches for Metal-Poor Stars from the Hamburg/ESO Survey using the CH G-band

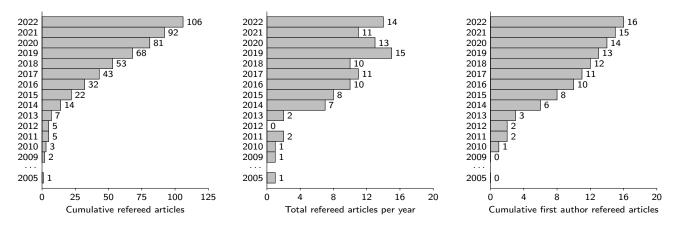
# Quantitative Indicators

- ADS: 6143 citations / h-index = 35 / i10-index = 82 (August 16, 2022 ADS link)
- Google Scholar: 7437 citations / h-index = 38 / i10-index = 83 (August 16, 2022 Google Scholar link)
- ADS Publication List (complete ADS link) / (refereed only ADS link)
- ORCID iD 0000-0003-4479-1265 / ResearcherID C-6864-2015

# **Publication list**

### Refereed articles

Total: 106 publications (incl. 16 first, 11 second, 13 third, and 15 fourth author articles)



- 106. Mardini, M., Frebel, A., Ezzeddine, R., Chiti, A., Meiron, Y., Ji, A., Placco, V. M., Roederer, I., Meléndez, J. The chemical abundance pattern of the extremely metal-poor thin disk star 2MASS J1808—5104 and its origins 2022, Monthly Notices of the Royal Astronomical Society, submitted
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  - 2022, The Astrophysical Journal, submitted
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# Telescope time allocations

Approved observing projects: 166 Total awarded: 6477.32 hours

## Principal Investigator

Approved observing projects: 48 Total awarded: 1725.55 hours

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48. 2022A - Gemini South - GS-2022A-Q-406 (Band 4): 30.0 hours
47. 2022A - CTIO Blanco - 2022A-210002: 5.0 nights
46. 2021A - Gemini South - GS-2021A-Q-419 (Band 4): 40.0 hours
45. 2021A - CTIO Blanco - 2021A-0000: 5.0 nights
44. 2020A - CTIO Blanco - 2020A-0032: 5.0 nights
43. 2019B - CTIO Blanco - 2019B-0069: 5.0 nights
42. 2019A - Gemini South - GS-2019A-Q-408 (Band 4): 21.0 hours
41. 2019A - Gemini North - GN-2019A-Q-402 (Band 4): 27.0 hours
40. 2018B - Gemini North - GN-2018B-Q-403 (Band 4): 20.0 hours
39. 2018B - Gemini South - GS-2018B-Q-402 (Band 4): 20.0 hours
38. 2018A - Gemini South - GS-2018A-Q-402 (Band 4): 30.0 hours
37. 2017B - Gemini North - GN-2017B-Q-84 (Band 4): 39.0 hours
36. 2017A - Gemini South - GS-2017A-FT-3: 5.5 hours
35. 2017A - KPNO Mayall - 2017A-0295: 7.0 nights
34. 2016B - Gemini North - GN-2016B-Q-85 (Band 4): 50.0 hours
33. 2016B - Gemini South - GS-2016B-Q-86 (Band 4): 50.0 hours
32. 2016A - Gemini South - GS-2016A-Q-107 (Band 4): 50.0 hours
31. 2015B - Gemini North - GN-2015B-Q-100 (Band 4): 30.0 hours
30. 2015B - Gemini South - GS-2015B-Q-104 (Band 4): 50.0 hours
29. 2015B - ESO/NTT - 096.D-0018(A): 5.0 nights
28. 2015A - Gemini North - GN-2015A-Q-401 (Band 4): 30.0 hours
27. 2015A - Gemini South - GS-2015A-Q-205 (Band 4): 50.0 hours
26. 2015A - ESO/NTT - 095.D-0202(A): 4.0 nights
25. 2015A - KPNO Mayall - 2015A-0071: 6.0 nights
24. 2015A - SOAR - 2015A-0071: 5.0 nights
23. 2014B - Gemini South - GS-2014B-Q-85 (Band 4): 30.0 hours
22. 2014B - Gemini North - GN-2014B-Q-102 (Band 4): 30.0 hours
21. 2014A - Gemini South - GS-2014A-Q-92 (Band 4): 33.3 hours
20. 2014A - Gemini North - GN-2014A-Q-101 (Band 3): 16.7 hours
19. 2014A - Gemini North - GN-2014A-Q-105 (Band 4): 33.3 hours
18. 2013B - Gemini South - GS-2013B-Q-89 (Band 4): 25.0 hours
17. 2013B - Gemini North - GN-2013B-Q-105 (Band 4): 25.0 hours
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16. 2013B - SOAR - SO2013B-001: 30.0 hours

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15. 2013A - SOAR - SO2013A-018: 34.0 hours
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- 14. 2012B Gemini South GS-2012B-Q-65 (Band 3): 10.0 hours queue
- 13. 2012B Gemini South GS-2012B-Q-84 (Band 4): 70.0 hours queue
- 12. 2012B Gemini North GN-2012B-Q-284 (Band 4): 70.0 hours queue
- 11. 2012B ESO/NTT 090.D-0275(A): 4 nights classical
- 10. 2012B SOAR SO2012B-001: 24.0 hours remote
- 9. 2012A Gemini South GS-2012A-Q-76 (Band 3): 6.0 hours queue
- 8. 2012A ESO/NTT 089.D-0331(A): 4 nights classical
- 7. 2012A SOAR SO2012A-003: 24.0 hours remote
- 6. 2011B ESO/NTT 088.D-0344(A): 4 nights classical
- 5. 2011B SOAR SO2011B-002: 24.0 hours remote
- 4. 2011A Gemini South GS-2011A-Q-86 (Band 4): 4.0 hours queue
- 3. 2011A Gemini North GN-2011A-Q-88 (Band 3): 1.3 hours queue
- 2. 2011A Gemini North GN-2011A-Q-122 (Band 4): 6.7 hours queue
- 1. 2011A SOAR SO2011A-010: 17.0 hours remote

# Co-Investigator

# Approved observing projects: 118 Total awarded: 4751.77 hours

- 118. 2022B Gemini South GS-2022B-Q-227 (Band 2): 7.10 hours
- 117. 2022B Gemini South GS-2022B-Q-318 (Band 3): 10.96 hours
- 116. 2022A SOAR 2022A-001: 8 hours
- 115. 2022A SOAR 2022A-006: 40 hours
- 114. 2022A Subaru KR-2022A-008: 10.00 hours
- 113. 2022A Gemini South GS-2022A-Q-128 (Band 1): 1.20 hours
- 112. 2022A Gemini South GS-2022A-Q-132 (Band 1): 4.60 hours
- 111. 2022A Gemini South GS-2022A-Q-234 (Band 2): 3.10 hours
- 110. 2022A Gemini South GS-2022A-Q-233 (Band 2): 11.60 hours
- 109. 2022A Gemini South GS-2022A-Q-238 (Band 2): 4.00 hours
- 108. 2022A Gemini South GS-2022A-Q-322 (Band 3): 5.20 hours
- 107. 2022A Gemini South GS-2022A-Q-323 (Band 3): 2.20 hours
- 106. 2022A Gemini South GS-2022A-Q-325 (Band 3): 9.40 hours
- 105. 2021B Gemini North GN-2021B-Q-111 (Band 1): 9.70 hours
- 104. 2021B Gemini South GS-2021B-Q-127 (Band 1): 2.20 hours
- 103. 2021B Gemini South GS-2021B-Q-232 (Band 2): 6.10 hours
- 102. 2021B Gemini South GS-2021B-Q-130 (Band 1): 3.60 hours
- 101. 2021B Gemini South GS-2021B-Q-321 (Band 3): 16.60 hours
- 100. 2021A Gemini North GN-2021A-FT-209 (Band 1): 2.20 hours
- 99. 2021A Gemini North GN-2021A-FT-205 (Band 1): 3.00 hours
- 98. 2021A Gemini North GN-2021A-Q-111 (Band 1): 14.20 hours

- 97. 2021A Gemini South GS-2021A-Q-230 (Band 2): 10.00 hours
- 96. 2021A SOAR 2021A-007: 40 hours
- 95. 2020A McDonald 2.7m McD20-1-2.7-7: 7.0 nights
- 94. 2019B Gemini North GN-2019B-Q-403 (Band 4): 9.40 hours
- 93. 2019B McDonald 2.7m McD19-3-2.7-1: 7.0 nights
- 92. 2019B SOAR 2019B-0013: 26 hours
- 91. 2019A Gemini North GN-2019A-Q-309 (Band 3): 22.73 hours
- 90. 2019A McDonald 2.7m McD19-1-2.7-3: 17.0 nights
- 89. 2019A McDonald 2.1m McD19-1-2.7-1: 5.0 nights
- 88. 2018B Gemini North GN-2018B-Q-122 (Band 1): 10.0 hours
- 87. 2018B Gemini North GN-2018B-Q-316 (Band 3): 25.00 hours
- 86. 2018B Gemini South GS-2018B-Q-315 (Band 3): 47.27 hours
- 85. 2018B SOAR 2018B-0010: 26 hours
- 84. 2018A Gemini North GN-2018A-Q-403 (Band 4): 89.10 hours
- 83. 2018A Gemini South GS-2018A-Q-406 (Band 4): 7.90 hours
- 82. 2018A LCO/Magellan Telescope Carnegie Time: 2 nights
- 81. 2018A LCO/duPont Telescope Carnegie Time: 18 nights
- 80. 2018A Apache Point Observatory UW08: 5.0 nights
- 79. 2018A LCO/Magellan Telescope Chilean Time: 3 nights
- 78. 2018A SOAR 2018A-0021: 36 hours
- 77. 2018A McDonald 2.7m McD18-1-2.7-3: 7.0 nights
- 76. 2017B LCO/Magellan Telescope Michigan Time: 2.5 nights
- 75. 2017B Gemini North GN-2017B-Q-18 (Band 1): 10.2 hours
- 74. 2017B Gemini North GN-2017B-FT-7: 6.28 hours
- 73. 2017B Gemini North GN-2017B-Q-75 (Band 3): 41.82 hours
- 72. 2017B Gemini North GN-2017B-Q-79 (Band 4): 63.64 hours
- 71. 2017B Gemini South GS-2017B-Q-75 (Band 3): 20.91 hours
- 70. 2017B Gemini South GS-2017B-Q-84 (Band 4): 107.82 hours
- 69. 2017A Southern African Large Telescope 2017-1-MLT-012: 55.6 hours
- 68. 2017A Gemini North GN-2017A-Q-82 (Band 3): 202.0 hours
- 67. 2017A Gemini South GS-2017A-Q-86 (Band 3): 142.5 hours
- 66. 2017A ESO/NTT 099.D-0428: 5.0 nights
- 65. 2017A LCO/Magellan Telescope Carnegie Time: 3 nights
- 64. 2017A LCO/duPont Telescope Carnegie Time: 19 nights
- 63. 2017A SOAR 2017A-0016: 40 hours
- 62. 2016B Gemini North GN-2016B-Q-77 (Band 3): 6.4 hours
- 61. 2016B Gemini South GS-2016B-Q-81 (Band 3): 32.3 hours
- 60. 2016B ESO/NTT 098.D-0434: 4.0 nights
- 59. 2016B Hubble Space Telescope Cycle 24 HST-GO-14765: 40 orbits
- 58. 2016B LCO/duPont Telescope Carnegie Time: 5 nights

- 57. 2016A ESO/NTT 097.D-0196: 7.0 nights
- 56. 2016A Apache Point Observatory UW07: 2.5 nights
- 55. 2016A Gemini North GN-2016A-Q-17 (Band 1): 9.8 hours
- 54. 2016A Gemini North GN-2016A-Q-75 (Band 3): 79.4 hours
- 53. 2016A Gemini South GS-2016A-Q-76 (Band 3): 74.0 hours
- 52. 2016A SOAR 2016A-0019: 4.0 nights
- 51. 2015B Southern African Large Telescope 2015-2-SCI-056: 117.8 hours
- 50. 2015B Hubble Space Telescope Cycle 23 HST-GO-14231: 18 orbits
- 49. 2015B Gemini North GN-2015B-Q-86 (Band 3): 26.5 hours
- 48. 2015B Gemini South GS-2015B-Q-71 (Band 3): 42.9 hours
- 47. 2015B SOAR 2015B-0020: 5.0 nights
- 46. 2015A ESO/VLT 095.D-0504(A): 30.0 hours
- 45. 2015A Gemini North GN-2015A-Q-76 (Band 3): 45.8 hours
- 44. 2015A Gemini South GS-2015A-Q-77 (Band 3): 42.8 hours
- 43. 2015A Gemini South GS-2015A-Q-92 (Band 4): 26.0 hours
- 42. 2014B ESO/VLT DDT293.D-5036(A): 2.4 hours
- 41. 2014B Gemini South GS-2014B-Q-67 (Band 3): 55.0 hours
- 40. 2014B Gemini North GN-2014B-Q-85 (Band 3): 55.0 hours
- 39. 2014B KPNO Mayall 2014B-0231: 3.0 nights
- 38. 2014B SOAR 2014B-0231: 3.0 nights
- 37. 2014A Gemini South GS-2014A-Q-88 (Band 3): 66.7 hours
- 36. 2014A KPNO Mayall 2014A-0323: 8.0 nights
- 35. 2013B KPNO Mayall 2013B-0046: 6.5 nights
- 34. 2013B Gemini South GS-2013B-Q-75 (Band 3): 50.0 hours
- 33. 2013B Gemini North GN-2013B-Q-81 (Band 3): 50.0 hours
- 32. 2013B SOAR SO2013B-S102: 17.0 hours (long term)
- 31. 2013B ESO/NTT 092.D-0308(A): 6 nights
- 30. 2013B McDonald 2.1m McD13-3: 5 nights
- 29. 2013B LNA/Brazil 2013B-P012: 6 nights
- 28. 2013B NOT (Nordic Optical Telescope) 48-031: 3.5 nights
- 27. 2013A Gemini North GN-2013A-Q-113 (Band 4): 54.5 hours
- 26. 2013A Gemini South GS-2013A-Q-91 (Band 3): 54.6 hours
- 25. 2013A Gemini South GS-2013A-Q-95 (Band 4): 10.9 hours
- 24. 2013A ESO/NTT 091.D-0292(A): 6 nights
- 23. 2013A LNA/Brazil 2013A-P030: 4 nights
- 22. 2013A SOAR SO2013A-LP2: 17.0 hours (long term)
- 21. 2013A NOT (Nordic Optical Telescope) 47-003: 3.0 nights
- 20. 2012B NOT (Nordic Optical Telescope) 46-011: 2.5 nights
- 19. 2012B ESO/VLT (X-Shooter) 090.D-0321(A): 12 hours
- 18. 2012B LCO/Magellan MAG/12B/9: 2 nights

- 17. 2012B AAO/AAT AAT/12B/032: 6 nights
- 16. 2012B SOAR SO2012B-005: 8.0 hours (long term)
- 15. 2012A Gemini South GS-2012A-Q-81 (Band 4): 74.0 hours
- 14. 2012A AAO/AAT AAT/12A/011: 4 nights
- 13. 2012A LCO/Magellan MAG/12A/7: 2 nights
- 12. 2012A SOAR SO2012A-002: 16.0 hours
- 11. 2011B Gemini South GS-2011B-Q-91 (Band 4): 75.0 hours
- 10. 2011B SOAR (SO2011B-008): 24.0 hours
- 9. 2011A Gemini South GS-2011A-Q-85 (Band 3): 63.4 hours
- 8. 2011A CFHT CF2011A-002: 13.9 hours
- 7. 2010B CFHT 10BB05A/10BB99B: 13.9 hours
- 6. 2010A Gemini South GS-2010A-Q-78 (Band 4): 25.0 hours
- 5. 2009B SOAR SO2009B-004: 17.0 hours
- 4. 2009A SOAR SO2009A-0249: 6 nights
- 3. 2009A SOAR SO2009A-014: 32.0 hours
- 2. 2008A SOAR SO2008A-006: 3 nights
- 1. 2007B SOAR SO2007B-006: 3 nights

# Press releases, articles, and media resources

### 2022

#### Space.com

Stunning time-lapse videos show the Super Flower Blood Moon in bloom

#### digg

Footage From Gemini Observatory's Fisheye Lens Captures A Stunning Glimpse Of The Milky Way

### Associated Press

Twinkle, twinkle giant star, astronomers see how far you are (external opinion)

#### 2021

#### **NBC News**

An ancient star casts new light on the birth of the universe

#### Phys.org

Reseachers detect a new ultra-metal-poor star

#### **NOIRLab Stories**

Ultra Metal-Poor Star Discovery

### Revista FAPESP (featured article)

Star Fossil

#### S-PLUS Press Release

Astronomers discover an ultra metal-poor star that challenges models for the evolution of the first stars

### India Education Diary

University Of São Paulo: Astronomers Discover Star That Challenges Current Models Of Evolution Of The Universe

### Jornal da USP (in Portuguese)

Astrônomos descobrem estrela que desafía modelos atuais de evolução do Universo

### Ravista FAPESP (in Portuguese)

Fóssil Estelar

### Observatório Nacional (in Portuguese) - Audio interview

Astrônomos descobrem estrela que desafía modelos atuais de evolução do Universo

### Revista Planeta (in Portuguese)

Achada estrela que desafia modelos atuais de evolução do universo

## tilt UOL (in Portuguese)

"Ultrapobre": brasileiros encontram uma das estrelas mais raras do universo

### Sputnik News Brasil (in Portuguese)

Detectada estrela recordista em carência metálica que pode explicar evolução inicial do Universo

### Hypeness (in Portuguese)

Telescópio com tecnologia brasileira localiza estrela mais velha que o Sol

### Notícias da Universidade Federal de Santa Catarina (in Portuguese)

Projeto internacional de astronomia com participação da UFSC descobre estrela rara

### Agência Brasil - Rádio Nacional (in Portuguese - with audio interview)

Universo: cientistas descobrem estrela rara e considerada ultrapobre

#### CAPES - Ministério da Educação (in Portuguese)

Estrela rara desafia lógica da astrofísica

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La humanidad podría haber descubierto una de las estrellas más antiguas del universo

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Descubrimiento de una estrella ultra pobre en metal

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Peculiar chemical abundance pattern detected in the star RAVE J183013.5-455510

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The rise of the remote Ph.D. defense

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Making Good Use of Bad Weather: Finding Metal-poor Stars Through the Clouds

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MIT News (online)

Explosions of universe's first stars spewed powerful jets

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Notre Dame Science - Department of Physics News (online)

Summertime Stargazing event draws large crowd

Notre Dame Stories (online)

Heavy Metals

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Fonte de ouro e régua do universo

Agência FAPESP (in Portuguese - online)

Nova fonte de ondas gravitacionais é observada

Notre Dame News (online)

Students in right place, right time witness first-ever detected neutron star collision

Notre Dame College of Science News (online)

Astrophysics graduate students witness first-ever detected neutron star collision

Agência FAPESP (in Portuguese - online)

Estudo detecta elétrons duplamente acelerados no choque de aglomerados de galáxias

École Polytechnique News (online)

The inaugural issue of Nature Astronomy features the work of F. Andrade-Santos

Jornal da USP (in Portuguese - online)

Cientistas descobrem poderosa colisão cósmica dupla

Folha de São Paulo (in Portuguese - online)

Quando aglomerados de galáxias colidem e um buraco negro gigante entra no meio da história

Nature Astronomy (online - issue cover)

The case for electron re-acceleration at galaxy cluster shocks

Chandra X-ray Observatory Blog (online)

The Discovery of Particle Re-acceleration in a Galaxy Cluster Collision

Notre Dame News (online)

Notre Dame astrophysicist confirms source of galaxy collision

2016

Nature Physics (online - issue cover)

The age structure of the Milky Way's halo

Notre Dame News (online)

Second-generation stars identified, giving clues about their predecessors

Science Alert (online)

Astronomers have created the most detailed age map of the Milky Way yet

Universe Today (online)

Best picture yet of Milky Way's formation 13.5 billion years ago

Notre Dame News (online)

Detailed age map shows how Milky Way came together

Daily Mail (online)

How the Milky Way formed: Stunning 3D maps show how 130,000 stars came together 13.5 billion years ago

Daily Mail (online)

Graphic shows age structure of the Milky Way's halo

Astrobites (online)

Our halo is getting younger, spatially speaking

UPI (online)

New map details formation of the Milky Way galaxy

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How Did The Milky Way Form? New Chronographic Map Provides Answers

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Science Newsline (online)

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MSU Today (online)

Astronomers pinpoint how Milky Way Galaxy was formed

Ancient Code (online)

How the Milky Way formed: Awesome 3D map shows how 130,000 stars merged

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Detailed Age Map Shows How Milky Way Came Together

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Astrônomos brasileiros mapeiam estrutura de idades do halo da Via Láctea

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Pesquisadores mapeiam a distribuição cronológica dos astros da Via Láctea

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Brasileiros confirmam que estrelas na borda da Via Láctea são as mais novas

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Como os astros da Via Láctea se distribuem?

Space Today TV (in Portuguese - online)

Como a Via Láctea Se Formou

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Así se formó la Vía Láctea

Geofísica Brasil (in Portuguese - online)

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Evidence for Multiple Progenitors of CEMP-no Stars

Space Daily (online)

Relics of the Milky Way's first generation of stars

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Relics of the Milky Way's first generation of stars

Notre Dame News (online)

Astrophysicists release new study of one of the first stars

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Physics team creates Milky Way galaxy map

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Via Láctea cresceu de dentro para fora

Exame.com (in Portuguese - online)

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Newly discovered star offers opportunity to explore origins of first stars in the early universe

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How the first stars sprung to life in early universe

Astronomy Now UK (online)

Ancient star provides insight into stellar origins in early universe

Empresa Brasil de Comunicação (in Portuguese - online)

História da Via Láctea ganha novos capítulos com descoberta de estrela por equipe da USP

Correio Braziliense (in Portuguese - online)

Astrônomos brasileiros identificam estrela rara na Via Láctea

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Professor da USP descobre estrela tão antiga quanto o Universo

G1.globo.com (in Portuguese - online)

Astrônomos identificam estrela antiga e rara na Via Láctea

Agência USP de Notícias (in Portuguese - online)

Estrela traz evidências do início da Via Láctea

Universidade de São Paulo - Notícias (in Portuguese - online)

Equipe liderada pela USP identifica estrela chave para entender o início da Via Láctea

Agência FAPESP (in Portuguese - online)

Astrônomos brasileiros identificam estrela rara na Via Láctea

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Galactic archeologists create the first map of Milky Way's stellar halo

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First-ever Milky Way age map shows oldest stars clustered in center

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Milky Way Age Map Created For The First Time, Confirming Past Assumptions In Astrophysics

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Astrophysicists furnish a initial age map of a Halo of a Milky Way

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First Ever Age Map of the Milky Way Galaxy Reveals History of the System

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Quanto è vecchia la Via Lattea?

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"Our Universe Revealed" lecture looks at chemical composition of stars

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