

## Chapter 19

Beatriz Barbuy (PhD, 1982)

*From Stargazing the Southern Cross  
to Probing the Depths of the History  
of the Milky Way*

**Beatriz Barbuy**, now a professor at the Instituto de Astronomia, Geofísica e Ciências Atmosféricas at the University of São Paulo, has conducted research on metal-poor stars that has deepened our knowledge about the oldest stars in the Milky Way and about the chemical changes that have occurred in stars over billions of years. She is a member of the Academia Brasileira de Ciências (Brazil), the Académie des Sciences (France), and the TWAS, has been honored as Commandeur de l'Ordre National du Mérite, and has received the Trieste Science Prize of the TWAS in 2008 and the L'Oréal-UNESCO prize for Women in Science in 2009. She has been a vice president of the IAU and President of IAU Commission 29 (Stellar Spectra) and IAU Division IV (Stars), and played a major role in establishing 2009 as the International Year of Astronomy.

I grew up in a favorable situation, as both my father and mother were university professors of philosophy, my father at Universidade de São Paulo and my mother at Pontificia Universidade Catolica de São Paulo. Their example, by spending time reading and discussing, naturally directed me toward an academic career. From when I was as young as

fourteen I was reading books by philosophers (e.g., Max Scheler) in addition to romances (e.g., Victor Hugo), and doing so in different languages (mainly French, since I was studying in a French school).

Why in the end I chose a career in the hard sciences and not in the humanities was probably due to a combination of two reasons. The first was described superbly by the journalist Yudhijit Bhattacharjee, based on an interview during the 2009 General Assembly of the International Astronomical Union in Rio de Janeiro. With his British-like humor, he wrote: “She took up astronomy because she couldn’t handle philosophy . . . when she tried to read Hegel as a teenager, the German thinker’s ruminations on mind, spirit, and logic made Barbuy’s head spin.” The second reason was that I had an admiration for the sciences, including mathematics, physics, and biology. I very much wanted to engage more deeply in academic learning but struggled to choose a direction, and so I read many outreach books about different fields. When I was about sixteen years old, my brother won as a prize at his school the book *One, Two, Three . . . Infinity*, by George Gamow. After reading it my decision was firm, with no doubts: I would become an astronomer.

An earlier reason for my interest in astronomy might have been the fact that, at the age of around eight or ten, when arriving home after school at around 5:30 in the afternoon, I would climb to the highest branch of a loquat tree, which was “my branch” in the tree, whereas my two brothers had lower, stronger branches. Up there, I used to look at the sky until dinnertime. Another very important ingredient is that, although it was evident that my grandmother and her sisters stayed at home, I did not understand the prejudice against women working outside the home that existed at that time. On the contrary, my father told me that it was crucially important to have a profession and never depend on anybody but oneself.

During my undergraduate studies at the Institute of Physics (IF) of the University of São Paulo (USP), besides attending the lectures on courses in astrophysics and relativity, I attended weekly meetings under the supervision of the same professor. And before I had earned my diploma in physics from IF-USP, an astronomy group had formed at the Instituto Astronômico e Geofísico (IAG-USP), which met at a beautiful

park on the other side of town. This group had only three astronomers; one of them, Sayd Jose Codina Landaberry, was assigned to be my supervisor for my master's degree work. During this period of time, I realized that I would need to go abroad to complete my education in order to start my career in astronomy.

The most important and decisive step in getting me started occurred when, in 1976, I obtained two complementary fellowships to pursue a PhD in France, one from the French Consulate and the other from the national Agency Conselho Nacional de Pesquisas (CNPq). Both were small, equivalent to about \$400 each, and I was allowed to keep both. Previous to this, in the 1960s, Abrahão de Moraes, at the time the director of IAG-USP, together with Jean Delhaye, the director of the Observatory of Paris, and representative from CNRS to CNPq, had done important "political" work that was intended to boost astronomy in the country. First, as Brazilian representative in 1961 in Berkeley, Abrahão de Moraes had brought Brazil into the International Astronomical Union (IAU); second, in the 1960s they argued that training Brazilian astronomers was among the highest priorities, both at the French Consulate and at the CNPq, and succeeded in implementing this strategy. It is interesting to note that Roger Cayrel was a visitor in a mission to São Paulo in the late 1960s, and he later made important contributions to my knowledge in astronomy through collaborations we developed over the years.

It is clear that earning the PhD in France was crucial and that if I had stayed in Brazil I would have had no future in astronomy. At that time I had already expressed the intention to work on the chemical evolution of the Galaxy. The person who helped me get accepted into a degree program in France was Licio da Silva, an astronomer from Observatorio Nacional in Rio de Janeiro, to whom I am very grateful.

The group at the Observatory of Paris included several astronomers who were very important in nurturing my development, both professionally and as local family. Roger Cayrel, who initiated studies of atmospheres of low-mass old stars in France, was exceptional from two points of view. In addition to mentoring me in astronomy, he and Giusa Cayrel gave me strong support by inviting me to dinners throughout and

beyond my time as a PhD student. My advisor Monique Spite immediately gave me data to work on and was very attentive to my development. François Spite guided me on articles to read.

All was not roses immediately for me, however; it took three years until I started to appreciate the city of Paris. Some high-level French astronomers treated me very kindly, but others did not. They would comment that Brazilians cared only for carnival, football, coffee, and generals (Brazil was under a dictatorship at the time).

I successfully defended my PhD in January 1982 and accepted a position at the University of São Paulo immediately afterward, starting in early February. Why did I return to Brazil? I considered staying in Europe, but I had several reasons that compelled me to return: I had signed a contract with CNPq that required that I return to my home country for twice the length of time that I had stayed abroad with the support of their fellowship; I had lost my father while earning my PhD and I wanted to be close to home to support my mother; I did not want to feel like a foreigner for the rest of my life and, as some insinuated, be accused of taking a job from a French person; and, of course, Brazil has wonderful weather.

Upon my return to Brazil, I encountered a serious problem: the absence of good computers. A law had been approved that prevented the purchase of foreign-built computers for ten years. The intent of the order was to push the manufacturing sector to create Brazilian-built computers, but this never happened. This rule delayed progress in the country in several industrial and academic aspects, and for this reason I continued to go to the Observatory of Paris for several months per year, with grants from the Observatory, in order to be able to use the computers in France. In 1983 and 1984 I also spent five months at Lick Observatory, in 1986 three months at the University of Cambridge, and in 1987 two months at European Southern Observatory (ESO) headquarters in Garching, Germany.

All these activities greatly pushed my scientific work forward. I was promoted to associate professor in 1987 and full professor in 1997; then, in 1997, I was elected to the São Paulo Academy of Sciences and in 2002 to the Brazilian Academy of Sciences.



FIGURE 19.1. Beatriz Barbuy at her induction ceremony at the Académie des Sciences in France on December 6, 2006.

My yearly visits to the Observatory of Paris went on regularly until the early 2000s. In 2006 I was elected to the Académie des Sciences in France. Considering that this Academy has only 150 foreign members, I consider this a most important honor! Also the fact of having been nominated by Roger Cayrel, who has always had my greatest admiration, made the honor even more important to me. The ceremony took place in the well-known room under the “Coupole,” at the Institut de France, 23, quai de Conti, on December 6, 2006, which was, coincidentally, exactly thirty years after I had embarked for France in pursuit of my PhD.

Another important milestone for me was becoming President of the International Astronomical Union Commission 29 on Stellar Spectra (1997–2000). Subsequently, I was President of IAU Division IV on Stars (2000–2003) and then one of the six vice presidents of the IAU (2003–9). Here too, having David Lambert, an astronomer whom I greatly admire

and who was, at the time, President of Division IV, put forward my name to be President of Commission 29 was very significant to me.

In 2008 I was elected to the World Academy of Sciences and in the same year was awarded the Trieste Science Prize by the TWAS, in a ceremony held at the International Center for Theoretical Physics in Trieste. In 2009 I received the L'Oréal-UNESCO prize for Women in Science. The ceremony for this award took place at UNESCO headquarters in Paris, on March 8, 2009.

These prizes have had a very important, positive impact on my career. Particularly after receiving the L'Oréal prize, I (and my work) began to receive more public recognition. I made many appearances on TV shows and was interviewed by several newspapers, among other things.

Since 2009–10, I have become even more active on committees than before, serving as a member of the Haut Comité Scientifique de l'Observatoire de Paris (2010–15) and the Jury of the Initiatives d'Excellence within the Agence Nationale de la Recherche (ANR) (2011–24), as a member of the jury of the L'Oréal-UNESCO prize (international) (2011–18), a member of the Associated Universities for Research in Astronomy (AURA) Oversight Council for Gemini (2011–17), and a member of the Steering Committee of the Cherenkov Telescope Array (2013–20). Also, during this period I was associate editor of the *Publications of the Astronomical Society of Australia* (2013–19).

Beginning with my move to France in 1976, I have studied metal-poor stars, which was the main subject of interest of my advisor Monique Spite. I started by analyzing stellar spectra and learning about nucleosynthesis. France was very active in these fields, in particular at that time when seminars by Canadian astrophysicist Hubert Reeves used to fill the conference rooms. The scientific ambiance in Paris also was very important: seminars at the Observatoire de Paris-Meudon, the Institut d'Astrophysique, the Collège de France, and sometimes also at the CEA-Saclay included presentations by some of the most important astronomers from all over the world.

Upon my return to Brazil in 1982, I started writing proposals to obtain observing time with the instrument CES at the 1.4-meter CAT telescope

at ESO in Chile. My observations led, in 1988, to my first major work, which dealt with oxygen abundances in 20 metal-poor stars.

Beginning with my PhD work and continuing in following years, one of my main activities has been working to include molecular lines in the code of synthetic spectra. This work expanded into different wavelength regions, starting with my work in the optical, then, in the PhD theses of my students Bruno Castilho, Ricardo Schiavon, and Jorge Meléndez, into the near-ultraviolet, the red, and the near-infrared, respectively; finally, in the thesis by Paula Coelho all of this was gathered into a unified line list. This work was entirely rewritten in Fortran 2003, thanks to software expert Julio Trevisan.

My work on metal-poor halo stars continued through the years, and the data for a particularly important project entitled “First Stars,” headed by Roger Cayrel and Monique Spite, were obtained at ESO, with thirty-seven nights on the Very Large Telescope equipped with the UVES spectrograph. In these data, we detected a uranium line in a metal-poor star and derived the age of the star from the uranium-thorium abundance ratio. This discovery allowed us to obtain data from 60 orbits on the Hubble Space Telescope (HST) for observations of the metal-poor uranium-rich star CS 31082–001 and to produce papers XV and XVI in the First Stars paper series.

Another extremely important scientific activity, which began in 1990, is my collaboration with Sergio Ortolani (University of Padova), and Eduardo Bica (Federal University of Rio Grande do Sul) on colour-magnitude diagrams of globular clusters. Using data from ESO and from HST, we achieved a breakthrough when we found evidence of the presence of a population of old stars in the Galactic bulge, since at the time there were papers indicating that the bulge was too young to have such stars. In more recent years we have been particularly interested in the moderately metal-poor globular clusters in the bulge that constitute probably the oldest stellar population in the Galaxy. The image in figure 19.2 combines data from three near-infrared colours, J, H, and K bands, all obtained as part of the Vista Variables in the Via Lactea (VVV) survey done at ESO. Since then, a combination of photometric and spectroscopic work, using several telescopes including the New



FIGURE 19.2. The very old, metal-poor globular cluster HP1, as seen in the near-infrared colour bands J, H, and K (Barbuy et al., *A&A* 591, A53 [2016]).

Technology Telescope and the Very Large Telescope (VLT) at ESO, and HST resulted in about 150 papers from this collaboration. This work led to me receiving an invitation to be the lead author on “Chemodynamical History of the Galactic Bulge,” published in the *Annual Review of Astronomy & Astrophysics*.

One of the aims of having a job as a university professor of astronomy is to educate students to obtain their PhDs in order for them to become professional astronomers. Doing this is also my most important immediate contribution to society. A good side of the Brazilian system of graduate studies is (so far) the availability of fellowships for the support



of PhD students. I have been able to supervise excellent students, and most of them are now active in universities and observatories. Bruno Castilho has been the director at Laboratório Nacional de Astrofísica, Minas Geraes, since 2013; Silvia Rossi, Jorge Meléndez, and Paula Coelho are now my colleagues at IAG-USP; Alan Alves-Brito and Marina Trevisan are professors at Universidade Federal do Rio Grande do Sul (UFRGS); Rodolfo Smiljanic has a permanent job at Nicolaus Copernicus at the Polish Academy of Sciences in Poland; Ricardo Schiavon is professor at Liverpool John Moores University; André Milone is a researcher at Instituto Nacional de Pesquisas Espaciais (INPE); and Bruno Dias is a postdoctoral fellow in Chile. Three other students directed their lives into teaching in colleges or to software development, and four of my female students abandoned astronomy. My present students, Heitor Ernandes, Stefano Souza, Raphael Oliveira, and Roberta Razera, are also very promising.

Instrumentation is another area to which I tried to contribute, given our need to develop observational astronomy in Brazil. As for international participation, I have been a member of the board of the Gemini Observatory telescopes consortium, been on the scientific advisory committee of the SOAR telescope, and attended the ESO Council meetings during the period of temporary membership of Brazil to ESO (2011–18). In the 2000s I was able to obtain the funds for construction of the SOAR Integral Field Unit spectrograph. This spectrograph, whose design and construction took more than ten years, is now in use at the SOAR telescope. It is important to acknowledge the constancy and seriousness of the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), which over the years has provided funds for astronomical instrumentation. The same applies to computers—since the 1990s, when FAPESP first provided IAG with a VAX computer, we have never had a problem with getting the needed computers for our work. My present activities in instrumentation involve two instruments: (1) as I worked as PI of the CUBES spectrograph for the VLT, a group of Brazilians continues to be part of the project, which was recently relaunched and is now led by Italy; and (2) we are working to also be part of the MOSAIC spectrograph for the Extremely Large Telescope

(ELT), of which we have been a partner since 2011, and of which I am the local Brazilian PI. Work on the Brazilian side with optical fibers and robots for optical fiber positioning is being planned.

Among the activities I was involved with as a vice president of the IAU, one of the most important was to support the initiative of Franco Pacini, President of the IAU at the time, for declaring 2009 as the Year of Astronomy in celebration of the 400th anniversary of Galileo's first recorded telescopic observations. My work with the Brazilian Ministry of Foreign Affairs was a very rewarding activity, given the high level of the involved Ministry personnel and my work to gain their support. In fact, Brazilian support was important because countries like Australia, the United States, and other first world countries were against having "Year of Something" altogether. My visit to the United Nations in New York, when we essentially obtained the approval for the Year of Astronomy concept, was memorable, rewarding, and interesting. Also, as far back as 1994 we had proposed the idea of hosting the IAU General Assembly in Brazil, and this occurred in 2009 in Rio de Janeiro, in the Year of Astronomy.

I realized, over the years, that working with low-quality astronomical data is not worthwhile, which is why I have dedicated so much effort in support of efforts to fund, plan, and build high-performance telescopes and their associated instruments. In the years 2009–10, when Brazil appeared to be experiencing a period of very good economic growth and improving from all points of view, we began discussions about joining ESO as a member, which previously had seemed impossible. An agreement was signed in December 2010, making Brazil a temporary member from 2011 to early 2018. During this seven-year period, I and a few colleagues engaged in a series of activities to move this proposal to join ESO through different committees at the National Congress in Brasilia. It was extremely interesting to have discussed this proposal with dozens of congresspersons. The project was approved and published by the Congress on May 19, 2015. The subsequent economic crisis in Brazil, however, prevented this proposal from being implemented. Although Brazil did not, in the end, join ESO, our temporary membership for seven years was extremely important, and I hope my country will

continue to be somewhat involved with this admirable and efficient organization. In the long term, the Brazilian astronomy community hopes that when our country is more stable we will be able to join the organization.

Through my nomination by the Académie des Sciences, my participation in the Jury of the Initiatives d'Excellence projects, coordinated by the Agence Nationale de la Recherche, extends from 2010 to 2024. This extremely important process aims at reorganizing French universities and higher-level teaching institutions.

In conclusion, I recommend that each of us make dedicated efforts to develop our interests and abilities. Firstly, constructive and progressive work, which is the job of a scientist, or any intellectual, artist, technical worker, or other highly trained professional, forms your identity. Such jobs are extremely enriching and important for personal development and satisfaction. Secondly, the life of a scientist, in particular being an astronomer and part of an international community with rather constant contacts throughout my life, has been a privilege. It is normal for an astronomer, for example, to sit on the panels of the HST or other international telescope panels, to observe in Chile and Hawai'i, and to take part in international high-level scientific and administrative committees composed of scientists from all over the world. Not only are these pleasant activities, but they raise both our scientific and personal profiles.