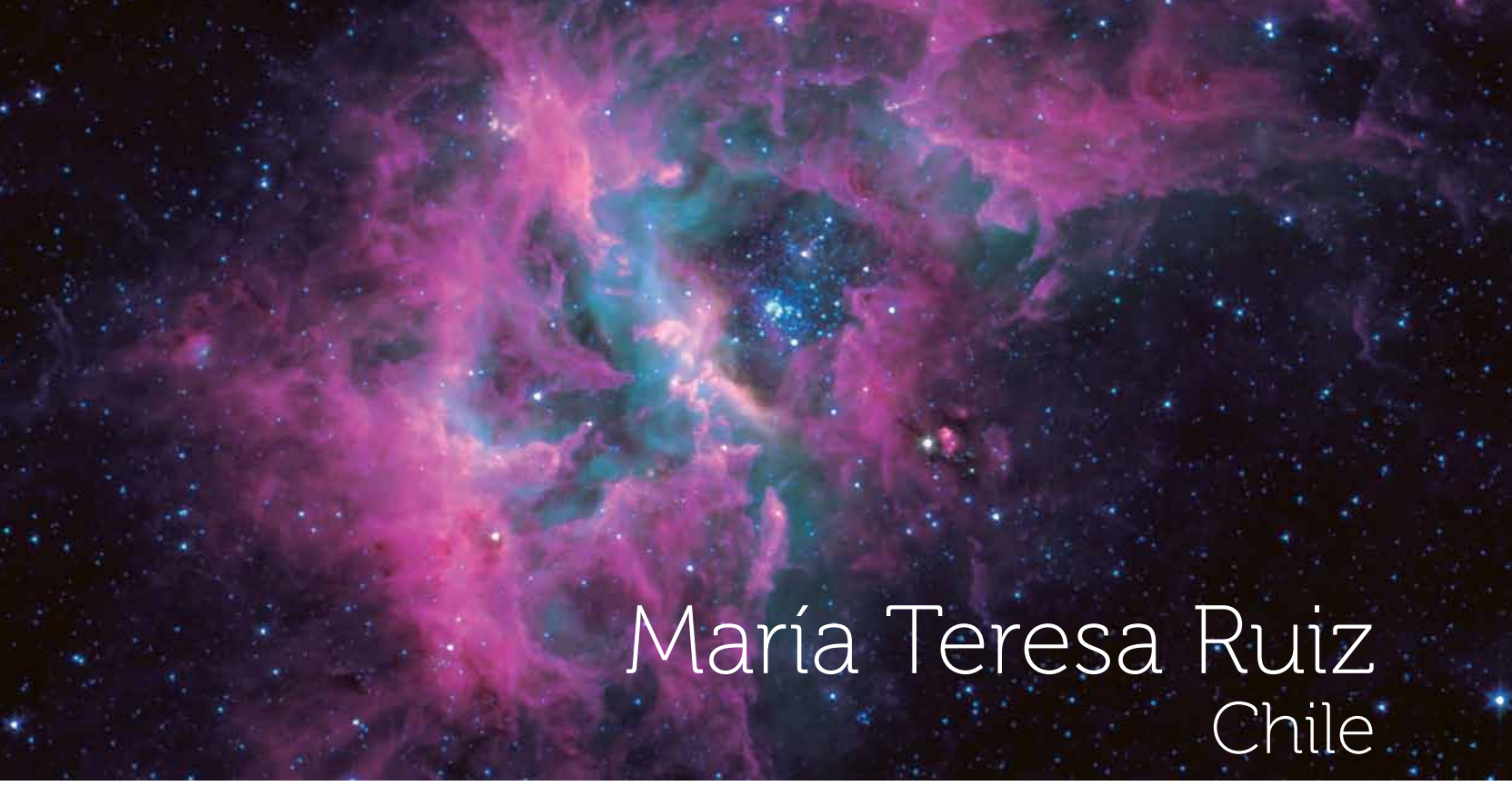


María Teresa Ruiz
Chile

> “It is quite awe-inspiring to gaze at that wonderful dark sky, but even better to actually know what you are looking at...”

Interview by Richard García*

María Teresa Ruiz clearly fell in love with stars at first sight. The Chilean astronomer has earned international renown for having discovered the first brown dwarf, a type of star unable to burn and of a similar size to extrasolar superplanets. She is also a pioneer among Chilean female astronomers, having graduated forty years ago, and was the first to be awarded a doctorate from Princeton in the United States. Her prestige was confirmed by the fact that she was the first Chilean woman to receive the country's National Science Prize in 1997.

What was your first real contact with the cosmos?

It happened in my first year at college in 1966, during an engineering summer course. We spent a lot of time in machining workshops making metal pieces, and that was when I realized that it did not suit me. The atmosphere was actually rather unpleasant and oppressive, so I began to look for something different and found the practical astronomy summer course that was being taught at Cerro Calán (a hill in the east of Santiago, where the Astronomy department of the University of Chile is located). There I gained some basic knowledge of astronomy. But the best part was when they took us to the Cerro Tololo Inter-American Observatory (AURA and NSF), 500 kilometers north of Santiago. It was spectacular. They gave one of my classmates and me a small 16-inch telescope to measure variable stars. It was my first contact and I fell in love with the subject. I decided that I wanted to become an astronomer.

Why was astronomy so appealing to you?

We did our observations with a telescope that was tiny but actually relatively good for the time. I worked with that professional telescope for about a week and it was a revelation for me, because, strangely enough, though I had always been interested in Nature, I preferred myths and natural phenomena such as rock formation and climate to stars. For some reason I had never felt curious about the sky. But after visiting Tololo and doing observations with absolutely minimal knowledge - they had given us a week-long crash course in astronomy - everything changed. It was awe-inspiring to gaze up at that wonderful dark sky, but this time I actually knew what I was looking at.

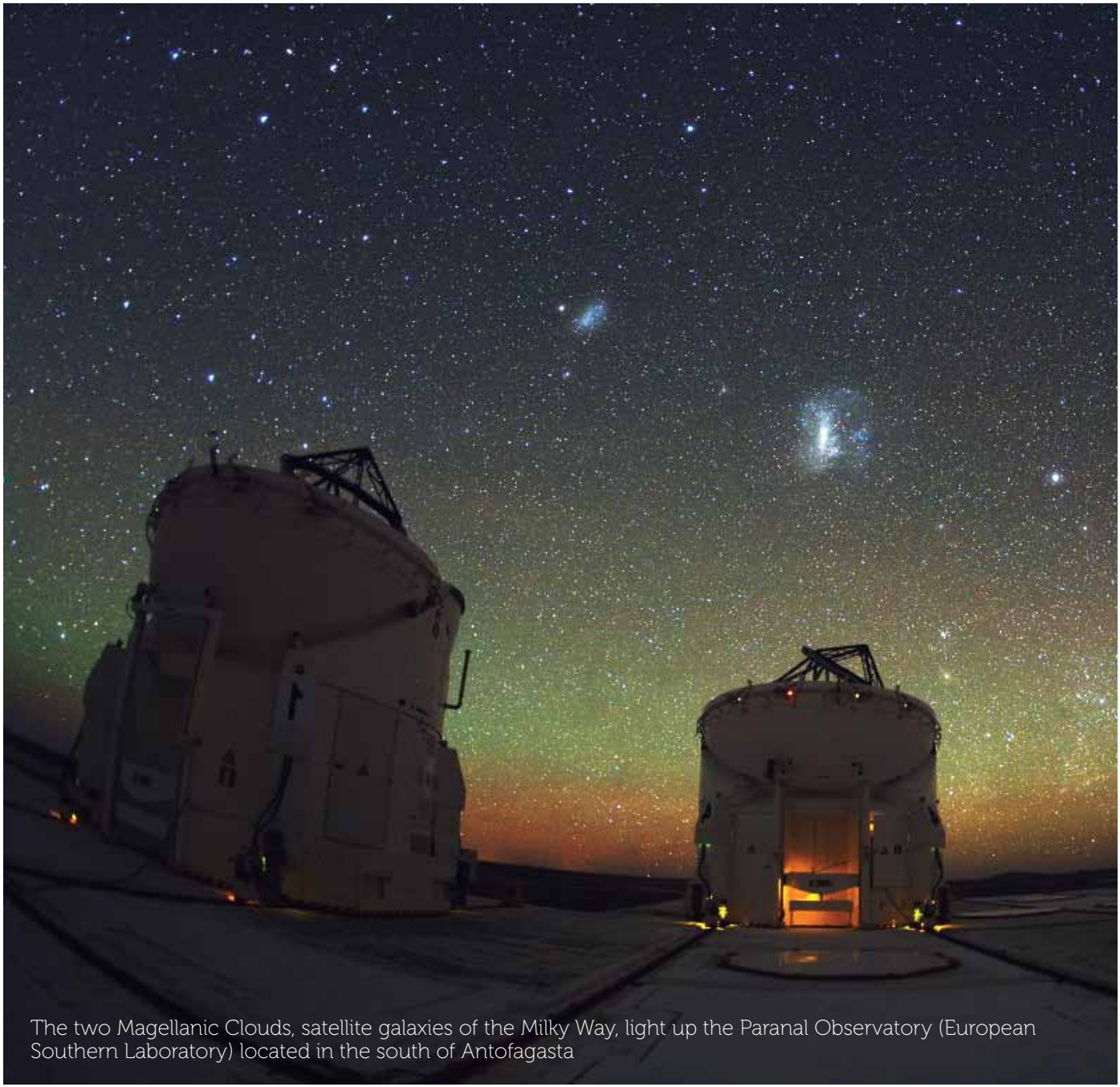
After that practical course, how did you pursue your interest in astronomy?

I was fortunate in that year the University of Chile had introduced a degree course in astronomy. It worked perfectly: I was in the first class, and the first student to graduate in astronomy in 1971, before any of my male classmates.

María Teresa Ruiz at the Paranal Observatory with the presidents of Colombia, Mexico and Chile on the occasion of the signing of the Pacific Alliance

Were you the only woman?

Yes, there were very few students, and I was the only woman. The astronomy teachers were physicists: Claudio Anguita, Hugo Moreno, and Adelina Gutiérrez. She had just obtained a doctorate in astronomy from the University of Indiana in the United States. We were also exceptionally lucky because the director of the Cerro Tololo Observatory



The two Magellanic Clouds, satellite galaxies of the Milky Way, light up the Paranal Observatory (European Southern Laboratory) located in the south of Antofagasta

helped us. He was a Puerto Rican called Victor Blanco and he was very keen for astronomy to develop in Chile. He would come to give us classes on the solar system because there were no Chilean experts on the subject. He would drive every Friday from La Serena, which would take him about seven or eight hours as the road was in a dreadful condition. He would teach us for several hours, then give us homework and reading and return to Tololo. He was a first-rate teacher. Then, since the European Austral Observatory (ESO) was based in Santiago (Vitacura), I was taught by European astronomers. So we had brilliant astronomy teachers and that degree gave us a really good foundation. My thesis was supervised by Dr. Johann Graham, one of the most important astronomers at the Tololo Observatory at the time.

At that time, there were no computers so how did you work?

We used Sriden machines that cost a lot more than a computer does today. They could work out a square root and do calculations with numbers with many decimal places, but they were terrible. I asked to borrow one of those machines to write my thesis, and took it home. I had a tiny flat back then as I had just gotten married, and I worked all day on my thesis. I had just been accepted at Princeton and I had to finish it before leaving. The neighbors complained about the dreadful racket it made, so I had to take it back to the office. I easily had time to make myself a cup of coffee as it was working away calculating a square root.

Was it like a typewriter?

It was like a giant typewriter but it did calculations, the kind you can solve in a second nowadays. To calculate logarithms we used these giant log tables, but they were only available in few places, such as libraries. Conditions have changed so much, so fast.

As regards the observations themselves, were they with the naked eye?

Not exactly with the naked eye. We used photographic plates with emulsions like in photographic film, but designed for astronomy. We also had a photometer, a device that measures how much light from a star reached us. You could insert various filters to see the luminosity of a star in different colors. We had red, visual, blue and ultraviolet ones. We would use these to measure the distribution of energy in the star and how much the flow varied, because in that case I was observing a variable star. At the beginning of each observation you had to check that the light was going into the photometer properly, then keep it there. It was difficult work and also cold, because the telescope dome was open and gusts of wind would come through.

So you had to wear mountain climbing gear. You absolutely needed a thermos with coffee and a red flashlight, which was the least distracting kind. You had to use as little light as possible, so you would spend all night there in the cold darkness. Nowadays it is entirely different: you have your coffee, microwave, music, light. You can even put the heating or air conditioning on, as well as use computers.

So today astronomers see everything on a screen, they do not work with the naked eye?

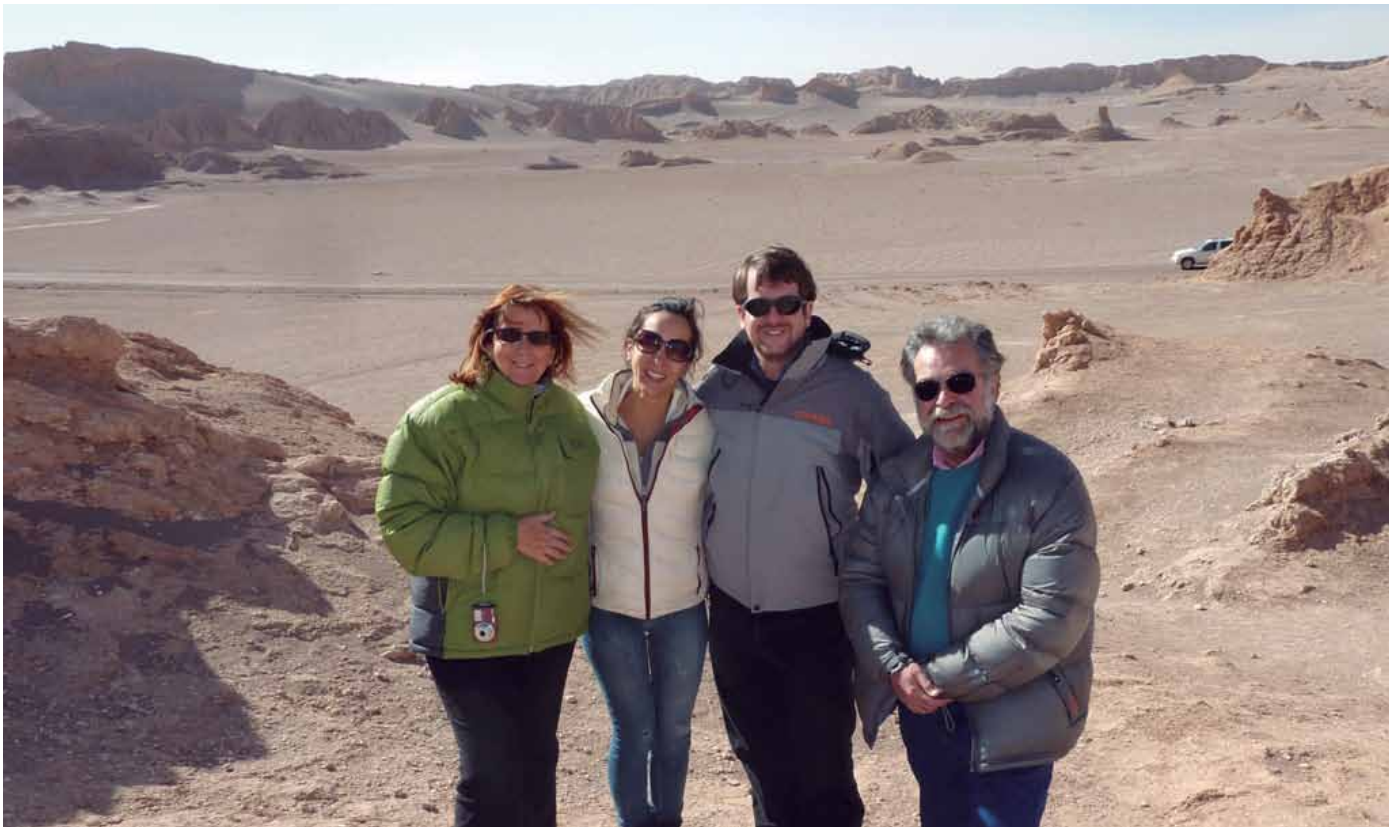
Yes, exactly. They actually work as far away from the telescope as possible, because it has been found that objects around it create heat and turbulence inside the dome itself, and that hinders the observations. Nowadays all modern telescopes are as far away as possible from the control rooms. After my son was born I had to go to do observations. That was very upsetting because I would sometimes be away for three weeks and there was no means of communication. There was no telephone line. My only option was calling the receptionist at the Tololo office on the radio, to ask her to call my husband at his office to make sure that the baby was all right.

When did all of this change?

It changed rapidly. It all happened in the 1980s, when the first computers arrived. In 1982 I went to Arizona to do observations at the Kitt Peak Observatory, and a Chilean friend who was working there invited me to his home. His son was around five and had an Apple computer, one of the first that came out. He was learning to read by using one of the computer games. I got home very depressed and told my husband that Chile would be left seriously behind because children in the States were using computers, while even researchers in Chile did not have such sophisticated equipment. I think that the '80s began to change that. The first one to arrive in Tololo took up a whole wall; it was like the ones in the movies, covered in lights. One worked using special keys and the data was stored on enormous magnetic tapes. I am sure that it was less powerful than those little pocket calculators to calculate the currency exchange rate when you travel. I spent a lot of my time at the Tololo offices in La Serena because we had to calibrate the data that we had obtained before analyzing it, and there were no computers at the university for that purpose.

When did brown dwarf stars appear in your life?

One of the things that I realized upon returning in 1979 was that, though Chile had those large telescopes, the situation was still very different to today and we were far away from all the centers of astronomical



In Moon Valley, near San Pedro de Atacama, María Teresa with her husband Fernando Lund (right), her son Camilo Lund and her daughter in law Francisco Varela (center)

knowledge. We always ended up working on marginal projects, while scientists at first-world institutions such as Harvard and the Max Planck Institute received the most interesting ones. José Maza and I realized that one way to get around this was to do our own surveys, find our own interesting objects and observe them. We avoided observing the same ones as other scientists, as they had already creamed off all the interesting projects before their articles had even been published, and we were only left with minor ones. I devoted myself to looking for nearby dead stars, the white dwarves in the solar neighborhood, which are carcasses of stars or what is left after they have exhausted their fuel. They are very hot and bright at first, but then they cool down and become weaker and fainter, and you can hardly see them. When they die they are about the size of the Earth.

With Fernando and Camilo at ALMA (Atacama Large Millimeter Array)

I wanted to know how much they contributed to dark matter in the galaxy. It was a very relevant topic at the time and I thought that there were perhaps many of these cold white dwarf stars and nobody could see them.

It was during an observation with the La Silla telescope that we noticed a very weak object, which I thought was a very cold, old white dwarf. But its distribution of energy did not match our expectations for a star with those characteristics. I had already had significant experience with all kinds of stars and knew how to recognize them. I had never seen that distribution of energy before. First I thought that there must be something wrong, that I had not focused on the object correctly. I asked the technician to measure it again because something was not right. The same results appeared, and I then realized that it could be a brown dwarf, which I had heard about years before. For decades there had been uncertainty regarding objects with a lower weight than that required for a star, which is around 70 times the weight of Jupiter. A lower weight meant that there could not be nuclear

reactions in the center. They could not reach the necessary temperature and therefore did not have their own light. They are like giant planets, not stars. It was not yet known if there were many of these in the universe or in our galaxy in particular. Nobody had found any reason why they should not exist. Therefore there were many astronomers searching for them and numerous projects on them. They were thought to be very red. I also heard that they were supposed to have lithium in their atmosphere. Lithium is an element that formed soon after the Big Bang, which is destroyed by the heat of nuclear reactions in stars, but as the brown stars do not have nuclear reactions then they must have Lithium. The energy distribution clearly showed the presence of lithium.

Were you the first person to observe them officially?

Until that moment they had only been a hypothesis, and the one I discovered, Kelu, was the first "free floating Brown Dwarf", which was just there alone in space and not part of a system. In that respect it was like a star. I named it Kelu, which means red in Mapudungun. I published a paper on it with Sandy Leggett, a British colleague who worked with infrared and France Allard, a French Canadian expert on brown dwarf models. A few years ago, Sandy sent me a mail from Hawaii, where she works. She told me that the night before she had seen Kelu with the Kek telescope and new laser beam technology. It turns out that Kelu is not one but two brown dwarfs revolving around one other. This was lucky, because as they could observe the orbit they also managed to calculate the mass of each one very precisely. A year later, an English astronomer discovered that one of the two brown dwarfs is itself a double, very close together. So Kelu is actually a family of three brown dwarfs, which I had seen as one.

Can you describe brown dwarfs?

The coldest ones have an atmosphere very similar to that of Jupiter.

Have they been photographed from closer up to find out if they have spots or lines, like those planets do?

Not yet, but we will soon. We do know more and more about the composition of their atmospheres. Some are hot, others cold and we have found some as freezing cold as Jupiter.

We have also discovered that there is no clear division between an extrasolar planet located around other stars and a brown dwarf. It is a kind of continuum. The largest extrasolar planets could be brown dwarfs. Extrasolar planets have been found that have 20 to 30 times the mass of Jupiter, and brown dwarfs that are 15 times the weight of Jupiter, or even

less. There is overlap there. The difference could be the way they form. The brown dwarf that is alone in space probably formed in the same manner as a star: a cloud of gas that collapsed in on itself as a result of its own gravitational attraction. Planets, on the other hand, always form through the coalescence of debris. A disc of debris forms around the star, and the collisions between the debris produces larger and larger bodies that become planet.

Could they contain life?

We have not ruled out the possibility. All of this is such a challenge. The planets, which are formed in a protoplanetary disc through the coalescence of planetesimals (debris), tend to be more enriched in the basic chemical elements that permit life than the brown dwarfs, which form through the collapse of a gas cloud that is probably less enriched or contaminated by dead star matter. It is an entertaining topic for discussion, and one we are working on.

And are you still working on this topic?

I still publish on white and brown dwarfs. My post-doctoral students and I are trying to obtain a sample that is broad and large enough to make statistics and also to locate brown dwarfs that partners of other stars (in a binary system in which they both formed at the same time from the same material). By studying the partners we can measure their age and metallicity.

How far away are they?

Kelu is 49 light years away from the Sun.

What were the circumstances of the National Science Prize - were you expecting it so soon?

Not at all. I was actually in the Calán office and suddenly José Maza, Leonardo Bronfman and Guido Gara gathered in the office. They were photocopying things, going in and out, and I watched them discreetly. A long time ago I learned that the less you know, the better, so I did not even ask. Otherwise they often ask you to do some boring task. Then one day they called me and told me that I was a candidate for the National Science Prize. They did not want me to hear from the press, so they told me a week or two before. They had already spoken to my ex-students and people who had sent letters to support my application. I was really surprised but also satisfied, in particular in a country where colleagues do not tend to support each other.

I did not know what chance I had of winning, but simply having been proposed was a prize in itself.

I did not imagine that they could give it to me. I had booked a holiday with my husband, my son

Outside the Magellan telescope, observing the daytime sky and hoping for a clear night, with no wind or humidity, a perfect night

and a nephew. We were going to the Caribbean, to the Riviera Maya. We had packed our suitcases and were waiting for the taxi to the airport. At that moment the minister called to tell me to come immediately because I was about to receive the National Prize. I could not believe it.

My husband told me to take a taxi to the ministry, and that meanwhile they would go to the airport. I went there alone, in my travelling clothes. I hailed the first taxi that went by, but the driver did not know where the ministry was. I was so nervous that I could not remember either, and had to call my husband to ask for directions. The press was already there. It is all still a little dream-like because it was so strange. Afterwards, they sent me to the airport in the ministry car, with the lights flashing to avoid the traffic. I arrived just before they closed the boarding gate. I always ask for the window seat because I sleep on flights, but that time I could not. My husband, my son and my nephew were asleep, but I kept staring at my reflection in the window in disbelief. It all felt like a dream. When I arrived in Akumal, which is quite a remote place, somehow people had found a fax machine and I received heaps of congratulations. The hotel manager was waiting and already knew. It was all absolutely magic.

Did winning the prize change your life?

Yes it did, because suddenly people were taking ideas seriously that they had previously considered nonsense. It also changed me because people began to wonder, "Now that she has won the prize, what is she going to do in the time she has left?" I had always worked thinking that life was infinite, and had never given myself an expiry date. But suddenly I realized that I would need at least two decades to finish my research, and that paralyzed me until I realized that living that way was not enjoyable. I had to live as though life were infinite because if it ended, that would be that. I hope that when I get to that stage I will be enjoying myself.

Have you ever suffered any discrimination for being a woman?

Rather than being discriminated against, I feel that I was not included. I was the only woman studying astronomy at Princeton. They had begun to accept women there not long before, and there were not yet any female astrophysicists. So the college was not used to dealing with women. Being a foreigner as well as a woman, I had to make twice the effort to feel part of the group. But in the end everything went fine and I had no problems.

I do not remember any blatant, severe incidents of discrimination. I myself have managed to survive because I have not focused on that issue too much. If others do not include me I simply carry on with my work. Historically there has been terrible discrimination against women, but men also suffer from discrimination for other reasons. Being a woman has also been of some benefit to me, because sometimes people will treat you better or give you some kind of advantage. I think the two things have cancelled each other out.

Unless you have a specific personality then discrimination can paralyze you. Many women do not have that personality. It is tough if a woman is very shy, because they overlook you. Women like myself, who have reached decision-making levels, have a mission: we keep on our toes to prevent these things from happening.

Do you feel that you have become a symbol in Chile in the sphere of female scientists?

When I became the first woman to receive the National Science Prize, that was a significant moment, partly as women could see that a barrier had been removed. overcome. I also believe that astronomy is a subject that can reach people easily, both children and the general public. The topics can be appealing and entertaining, and this has given me an advantage. It may be why I am better known than other women who may be more entitled to that recognition.

As regards your personal life, does being married to a scientist make your life different from that of your colleagues?

Female scientists do not have many alternatives. It has made it easier for me because working in scientific subjects gives you specific priorities. When I have had to speak at conferences abroad it has helped to have a partner who understands my priorities and is willing to accept the consequences. Sometimes this meant he had to take care of our son and take him to nursery school. I have a few astronomer colleagues who are married to businessmen, and this has been difficult for them. Their husbands do not understand the priorities implied by their scientific work.

Has your son chosen to study science?

He is an industrial civil engineer at the University of Chile, so he is involved in the business and financial aspects. I think that is great; having two scientists in the family is quite enough. Someone needs to deal with the financial aspects. ■

*Richard García has worked for *El Mercurio* Newspaper in Chile since 1988. His relationship with science started when he published in *Revista del Domingo* a story about the Abalon´s Hatcheries in Chile. During 1993 he won an scholarship for the International Institute of Journalism in Berlin. He wrote stories about biodiversity, climate change, energy and also started to write about astronomy, archaeology and paleonthology. In 2001 he started to write to the new section Ciencia y Tecnología. In 2004 he was selected to participate in the Jack Ealy Workshop on science journalism at Instituto de las Americas in San Diego, California.