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Amina Helmi

Star of the Milky Way

NWO
Spinoza Prize
2019

Astronomer Amina Helmi has been awarded the Spinoza Prize 2019. It is the highest scientific award in the Netherlands. The prize is a grant of EUR 2.5 million, to be spent on new research.

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Perfect timing

It was astronomy that drew Amina Helmi to the Netherlands. Astronomy had always been her life-long passion, and as it turned out, it was a good choice. Her academic career can best be described as cosmic. The Netherlands Organisation for Scientific Research (NWO) interviewed Helmi about winning the Spinoza Prize, which is worth € 2.5 million.

Congratulations! What was the first thing that crossed your mind when you received the phone call?
'That it's an incredible honour to receive the Spinoza Prize. To be honest, I can still hardly believe it. As I look back, I'm amazed at the space and opportunities I've received to develop myself this far.'

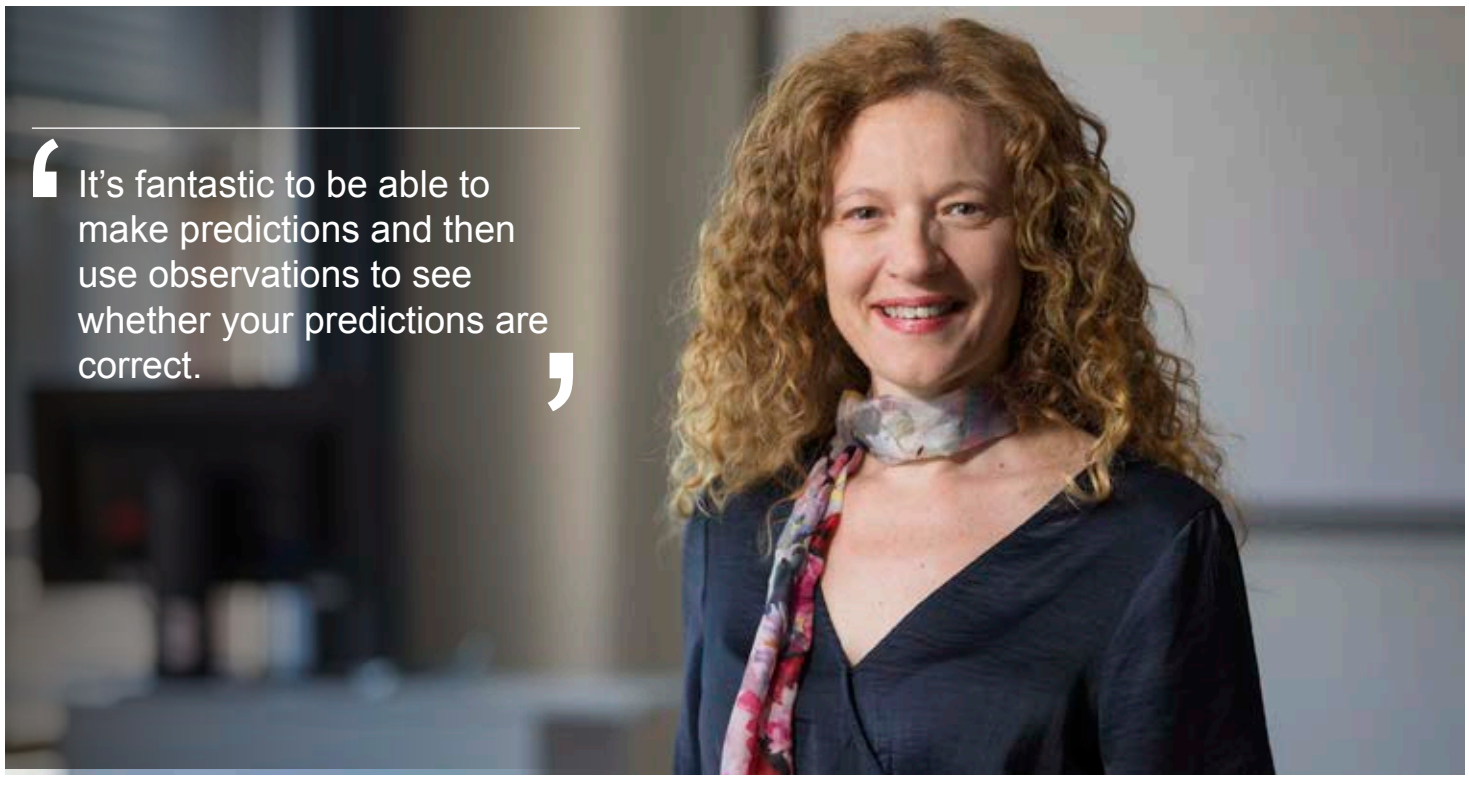
You are originally from Argentina, and you have worked in Argentina, Germany and the Netherlands. Why did you eventually settle in the Netherlands?
'The Netherlands is extremely good at astronomy. In fact, it's one of the three leading countries in the world. That was why I came to the Netherlands to do my doctoral research after I had finished my undergraduate studies in Argentina. Also, my mother is originally from the Netherlands, so I'm hardly a stranger here. This is a great country to live in but also for doing research. Here, I don't have to worry about whether I can get to the office or whether the printer will work once I get there. Instead, I can focus on my research. And I really appreciate the freedom I have to choose my own path as well as the recognition I receive for what I do. Science is still quite respected here. Take the Dutch television programme De Wereld Draait Door, for example, which asks scientists to explain current developments based on their expertise.'

As a female professor of astronomy, you are something of an exception.
'That's an odd aspect of the Netherlands, and biases already start at primary school. My son came home one day from school with the announcement that boys are better than girls at maths. He definitely did not hear that from me! Some schoolbooks emphasise that there are differences between boys and girls when it comes to their disposition for the physical sciences. That simply does not happen in Argentina. But if kids hear such things from a young age, then the impact is considerable. People need to be aware of such mechanisms. And we need female role models as well. I therefore try to achieve gender balance in my group, although, in practice, that is not always easy. In high school, I only had female teachers for the exact sciences subjects. So I never questioned whether this discipline was something that women could do.'

Why do you find astronomy such a fascinating subject?
'I think that it's a combination of several factors. First of all, my fascination for the big and unknown. I find it really amazing that our small brains can understand something as big as the universe, in which the objects are so far away that we will never reach them ourselves. Furthermore, I'm fascinated by the fact that we can use the physical laws that apply here on earth to understand so much of what we see in the universe. I was really hooked when I heard the story of the 19th-century French astronomer and mathematician Le Verrier who calculated the existence of the eighth planet in our solar system before Neptune was even discovered. Based on his work, astronomers started searching in the region of the sky he predicted and indeed found the planet. I thought that was fantastic: being able to make predictions and then testing whether those predictions are correct through observations. That later became the golden thread throughout my research.'

What will you use the money from the Spinoza Prize for?
'Funnily enough, that prize comes at just the right moment. I had planned to use this summer to write a new proposal for an ERC Grant, but I'll no longer need to do that now.'

Which questions do you want to explore in the coming years?
'I have an awful lot of ideas. However, I remain fascinated by the history of our Milky Way. We discovered that ten billion years ago, the Milky Way merged with a large galaxy. But what happened before that? And what did the Milky Way look like back then? Which processes were important at that time? How many other galaxies has our Milky Way swallowed? And have all those interactions influenced the current shape of the Milky Way? Ultimately, I want to be able to build the Milky Way's family tree.'



Astronomy at the University of Groningen

Astronomy in Groningen has been highly regarded for more than 140 years, both in the Netherlands and abroad. International cooperation and the study of the Milky Way have always been high on the agenda.

The founding father of astronomy in Groningen is Jacobus Kapteyn (1851-1922). At the age of 26, he was appointed the first professor of astronomy and theoretical mechanics at the University. The government decreed that every university should teach astronomy, but Kapteyn was – literally – left empty-handed: there was no observatory in Groningen. It is for this reason that he contacted the Cape Town Observatory, marking the dawn of a tradition of international cooperation. The telescope on the Canary Island of La Palma and – of course – the University of Groningen's astronomical institute were named after him.

In 1921, Kapteyn was succeeded by Pieter van Rhijn. He was president of the International Astronomical Union (1932-1958) and involved in the Plan of Selected Areas, based on one of Kapteyn's ideas: The starry sky was divided into areas that would be studied by observatories all over the world.

The Groningen astronomical institute received a major boost under the leadership of Adriaan Blaauw, who succeeded Van Rhijn in 1956. The institute was expanded, among other things with the radio astronomy research group led by Hugo van Woerden. This group made intensive use of the radio telescope in Dwingeloo and later of the Westerbork Synthesis Radio Telescope. It was largely thanks to Blaauw that the European Southern Observatory (ESO) was established in Chile. The Blaauw Observatory in the Bernoulliborg building on the Zernike Campus, which opened in 2008, is named after him.

The list of Groningen astronomers is too long to mention everyone individually – famous alumni include Jan Hendrik Oort and Maarten Smidt – but one thing is absolutely certain: Amina Helmi continues the impressive tradition of world-class astronomers at our University. Like Kapteyn she uses observations made by colleagues: for more than a century astronomers produce more data than they can analyse...

Ace in astronomy

On 1 November 2018, a beaming Amina Helmi appeared on the TV programme *Nieuwsuur*. The previous day, she had published an article in *Nature* proving that the Milky Way as we know it today had once merged with another large galaxy. The Spinoza Prize is a provisional jewel in the crown of a highly successful academic career that has generated much global attention. She gave an account of her story in last December's alumni magazine *Broerstraat 5*.

In Professor Amina Helmi's office, the plastic film that covered her copy of *Nature* lies on the conference table bearing silent witness to her success. In late October, this leading journal published an article about a very important discovery made by Helmi and her research group: in its early existence, the Milky Way 'swallowed' another sizeable galaxy. Helmi is not afraid to refer to her discover as 'prodigious'. 'One of the most intriguing questions in astronomy is the matter of how galaxies evolve. There weren't any galaxies during the Big Bang, so where did a galaxy like the Milky Way come from? We now have a better idea of this.'

Animation

The merger they discovered looks simple in the animations: a huge cloud of stars, the Milky Way, uses its gravity to suck in a smaller cloud of stars before merging to form a single cloud. According to Helmi, we don't need to make it any more complicated than this. But whereas the animation shows the whole process in thirty seconds, in reality, it took two to three billion years. 'It might have been faster. We're currently modelling that process.'

Smoking gun

Helmi's enthusiastic explanation of how you can tell which stars originated in the Milky Way and which did not, is rather like listening to the plot of an episode of Crime Scene Investigation. 'The motion and chemical composition of the stars provide evidence of where they came from, in much the same way as fingerprints. Most of the stars in the Milky Way revolve in a clockwise direction; stars from the other galaxy revolve in an anti-clockwise direction. This is a clue. But what is referred to as the 'relative abundance' in these stars, in other words the volume of elements such as titanium, magnesium or calcium they contain in relation to the rest of the chemical elements, also differs greatly from that of other stars in the Milky Way. This is the real smoking gun, and it allows us to say with certainty that these stars originate from another galaxy.' Case closed.

> "The motion and chemical composition of the stars provide evidence of where they came from, in much the same way as fingerprints."

Fremdkörper

At a time when anyone who knew anything about astronomy thought that all the stars in the Milky Way were also born there, Helmi discovered the first 'fremdkörper' in the Milky Way. This was the subject of her PhD project in 2000. 'As I had also developed the models that show why we hadn't discovered this before, it was immediately obvious that mergers had played a significant role. The merger that I discovered didn't involve a huge number of stars, but it was the maximum that I could derive from the available data (provided by the Hipparcos satellite). After that, a lot of effort went into finding mergers, but I was always convinced that we should wait for data from the Gaia satellite, the successor to the Hipparcos.'

Gaia

Gaia is a satellite with two telescopes mounted at an angle to each other, which was launched by the European Space Agency (ESA) in 2013. Helmi had already been involved in this initiative for several years. As she said in 2016 when the first Gaia data on 1.1 billion stars was released: 'I will soon have data relating to a billion stars to aid my research into the evolution of the Milky Way. What's more, the Gaia data is around one hundred times more accurate than anything that was previously available.' Two years later, data relating to another 1.7 billion stars was published and Helmi made her biggest discovery to date. The huge volume of data generated by Gaia means that there will be more than enough to discover and understand in the years to come. In this respect, anything could happen, says Helmi. 'The difference between Gaia and other missions is that it enables us to study an enormous range of objects, from planets and stars to galaxies outside the Milky Way. Gaia observes everything with a high degree of clarity, so we are bound to discover objects that we didn't even know existed.'

Stardust

It is difficult to predict how Helmi's discovery will affect life on earth. 'The only thing you can say is that we, and the earth, are made from stardust. It's entirely possible that some of the iron in our bodies comes from a star that was born outside the Milky Way.'

New instrument will add to Gaia data

Astronomy professor Amina Helmi investigates how the Milky Way got its present shape. Detailed information on the movement and chemical composition of stars is vital to her work. The Gaia satellite mission, in which she plays an important role, provided a cornucopia of data. Helmi is involved in the building of a new instrument on an Earth based telescope, that will collect this vital information

The stars in the sky seem to have fixed positions. But in reality, they are moving around at high speeds. Some of the stars follow very peculiar) paths. 'That is because many of these stars were not born in the Milky Way, but in a different system that fused with our galaxy', explains Eduardo Balbinot, postdoc in the Helmi group. He studies the history of our Milky Way, and is also involved in the building of 4MOST, a new instrument that will provide even more information about the way our galaxy evolved.

> "4MOST is able to measure details on the chemical composition of stars. This chemical composition carries the fingerprint of the birthplace of these stars."

'Gaia has measured the movement of more than a billion stars', Balbinot explains. 'The most accurate measurements were done on relatively bright stars. 4MOST will add accurate information on the movement of fainter stars.' Furthermore, 4MOST is able to measure details on the chemical composition of stars. 'This chemical composition carries the fingerprint of the birthplace of these stars.' The movement of the stars in the halo of the Milky Way allows astronomers to calculate their origin. 'In this way, we can discover which stars originate from the same source, a small galaxy or a globular cluster that has been captured by the gravity pull of the Milky Way. The chemical composition can help us to confirm which stars belong together.'

Amina Helmi is Principal Investigator of one of the nine 4MOST core observational programs. The University of Groningen is partner in the development of the instrument, together with the national research school for Astronomy NOVA. 'The calibration unit is built by the NOVA group based in ASTRON in Dwingeloo', says Balbinot. 'My job is to give feedback on the development from the perspective of the future users.' In about two years' time, 4MOST will be mounted on the VISTA infrared survey telescope in Chile, to start a five-year observational survey of the southern skies. Just like with Gaia, Amina Helmi and her group will be at the forefront of this new observation program – to learn even more about how the Milky Way got its present shape.

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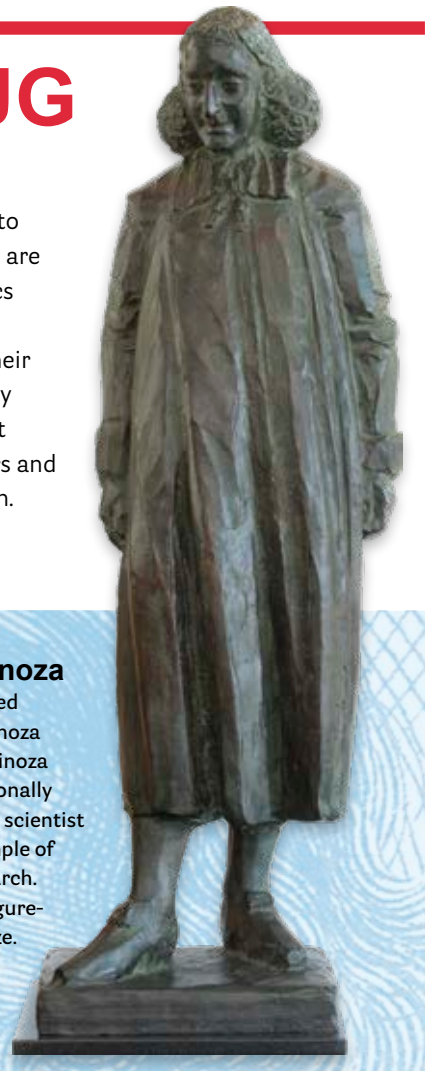
CV Amina Helmi

Amina Helmi (1970) was born in Argentina and has an Egyptian father and a Dutch mother. She graduated in astronomy at the National University of La Plata in Argentina, and was awarded a PhD with the distinction cum laude in 2000 by Leiden University, with a project entitled The formation of the Galactic halo, for which she was also presented with the Christiaan Huygens Prize in 2004. She worked as a post-doc researcher at the National University of La Plata and the Max Planck Institute in Garching, Germany, before being appointed as Professor of Dynamics, Structure and Formation of the Milky Way at the UG in 2003. She has published many prestigious articles, and in addition to winning the Spinoza Prize in 2019, she has also won several other important accolades, including a Vidi and a Vici research grant and an ERC grant. Helmi is a member of both the Royal Netherlands Academy of Arts and Sciences (KNAW) and the Royal Holland Society of Sciences and Humanities (KHMW).

NWO Spinoza prize at the UG

The Spinoza Award was introduced by the NWO, the Netherlands Organisation for Scientific Research. It is a national organization that funds and stimulates academic research in the Netherlands. As such, it invests hundreds of millions of euros in academic research each year in the form of indirect government funding. With the Spinoza Prize, NWO aims to increase the visibility of excellent academics. All Spinoza laureates perform excellent, ground-breaking research that has a high impact.

This makes them a source of inspiration to younger researchers. Three to five prizes are awarded annually. The winning academics receive EUR 2.5 million for research, and are given complete freedom to choose their research subject and involve other, mostly young, researchers. Thus, the prize is part recognition for accomplished researchers and part stimulus to conduct further research.



The NWO Spinoza Prize was introduced in 1995 and has been awarded to 88 researchers before 2019. Seven of these were associated with the University of Groningen:

- **George Sawatzky** (1996), Solid state physics
- **Dirkje Postma** (2000), Respiratory pathophysiology
- **Ben Feringa** (2004), Chemistry
- **Theunis Piersma** (2014), Global Flyway Ecology
- **Cisca Wijmenga** (2015), Human Genetics
- **Lodi Nauta** (2016), History of Philosophy
- **Bart van Wees** (2016), Applied Physics

Baruch Spinoza
The prize is named after Baruch Spinoza (1632–1677). Spinoza was an internationally renowned Dutch scientist and a clear example of freedom in research. A tremendous figure-head for this prize.

Theunis Piersma

Cisca Wijmenga

Lodi Nauta

Bart van Wees

Elmer Sterken
Former Rector Magnificus

> I am incredibly proud of Amina Helmi. She is a top-notch scientist in the field of Astronomy and an academic hero both within and outside the UG. Professor Helmi is not only a role model for many but also an extremely nice person. Her research on the origins of the Milky Way is of tremendous importance to us all.

Jouke de Vries
President of the Board

> The impact of the Spinoza Prize is enormous, both inside and outside the University. It has a bit of a Nobel Prize feel to it. It opens the doors to a totally different universe – one that is, in fact, quite familiar to Professor Helmi. Congratulations on this award!

Cisca Wijmenga
Rector Magnificus

> Another great day for the University! Amina Helmi is an outstanding astronomer and winning the Spinoza Prize is a well deserved tribute to the great and inspiring work of her and her team.

Give every child a Milky Way

Amina Helmi deplores the pollution of the night sky by artificial light and its effects. In large parts of the industrialized world few people will ever notice the brilliance of stars, experience their magic and feel connected with the cosmos. According to Helmi, being able to see the stars and the galaxies should be considered one of the basic human rights, especially for children.

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