AT: Welcome to the Infinite Women podcast. I'm your host, Allison Tyra. And today I'm joined by Dr. Maria Antico, a postdoctoral fellow in medical image analysis at the Australian eHealth Research Center and adjunct lecturer at the Queensland University of Technology. And we'll dig more into her work later. But first, she wanted to tell us about one of her scientific forebears, Margherita Hack.

MA: Margherita Hack is one of Italy's most renowned scientists, in particular for her contributions to astrophysics. So she was born in 1922 and she grew up during the fascist regime. She attended the liceo classico and in 1945 she received her degree in physics from the University of Florence. Her thesis focused on Cepheid variable stars that are known for their extremely regular brightness variations. At that time, only a few such stars had been thoroughly studied and Hack was tasked with examining a new Cepheid. She demonstrated that from the luminosity variability of the stars, it is possible to calculate their distance from Earth. Her research extended also beyond this topic. She was particularly intrigued by a star called Epsilon Aurigae. Each 27 years, this star underwent an eclipse, reducing its brightness by half. Margherita hypothesized that this phenomenon could be explained by the presence of an unseen companion. So possibly a much smaller star, and that's why it was not visible, and a hotter star, thus emitting ultraviolet radiation. This theory remained unverified until 1978, when satellite technology allowed direct observation of stellar spectra from space across different wavelengths, including the ultraviolet. The confirmation of her theory came with the detection of this invisible companion star and a surrounding dust disk that was responsible for the eclipses. The turning point of her career came with her first research on the star Zeta Tauri, allowing her to begin independent research on stellar phenomena. Following this, her career continued to evolve, leading her to explore more complex astronomical phenomena, such as fossil radiation. So fossil radiation relates to the remnants of energy from early universe following the Big Bang. So this helps us understanding how the universe evolved. Additionally, Margherita co-wrote the influential work *Stellar Spectroscopy* with Struv, which is still considered a fundamental text. Another milestone in her professional life came in 1964. So she became a full-time astronomy professor at the University of Trieste and the first woman in Italy to direct an astronomical observatory. Under her leadership, the observatory would turn from a small provincial institute to a lively and active international research center. I also have a small personal anecdote that my husband studied astrophysics at the University of Trieste while she was leading the observatory. And he saw her many times going to work on her bike, which was one of her passions.

AT: And she's also part of a larger pattern that I've noticed, which is that a lot of the scientists that we talk about on the podcast were also science activists and science communicators.

MA: Yeah, so she was a true innovator and she bridged the gap between pure research and public outreach. So she brought astronomy and astrophysics to theaters, television programs, even comic strips. She wrote children's books and became a beloved figure in popular culture. She had a simple goal that was to explain complicated things with simple words. So she captivated audiences with powerful and straightforward language. And through her accessible communication, she made the magic of science and the mystery of the universe approachable to non-academic audiences. And this earned her widespread popularity, especially among young people. On July 26, 2018, the Fondazione Margherita Hack was established with the goal of cataloging the remarkable collection of 18,000 books belonging to Margherita and to her husband, Aldo De Rosa. The collection is now housed in the Trieste library, which has been named after the scientist. And the foundation was created by Marco Santarelli, with whom Hack collaborated for over 10 years.

AT: Now, to bring us into the present, you're working on developing wearable ultrasound technology for use in space, which to me sounds like a couple different layers of high tech. So can you explain what that means and how that works?

MA: So ultrasound imaging is one of the most commonly used modalities to capture images of our internal body anatomy. It's portable, it's real time, can be volumetric, there are no reported cases of harm from it. In fact, it is used to scan pregnant women. Besides this, ultrasound can be used for whole body imaging, so to scan muscles, to see tendons, abdomen, heart and much more. It typically consists of a workstation and an ultrasound probe that uses sound waves to capture images inside our body by placing the probe on the body parts that we want to scan. I'm making this sound easy, but in reality, ultrasound image acquisition is complex and it requires highly trained specialists to both acquire the images and to interpret them. So one needs to know exactly how and where to position the probe on the body, which only covers a small field of view of the anatomy. And also, the resulting images are not user friendly at all. So for a non-expert, they may look like some sort of grey noise.

Ultrasound imaging is also the primary imaging modality used in space, where it's used to diagnose and to monitor various conditions of astronauts during space operations. Presently, the crew on the International Space Station receive a minimum amount of training in ultrasound imaging, which could be around three hours. And while they're on a mission, astronauts can either scan themselves or scan each other. But this typically happens under the guidance of ground-based ultrasound experts in real time. So this means that the experts on the ground, they guide the astronauts on how to position the ultrasound probe and also receive the stream of images collected in real time for interpretation. Now, as you can imagine, astronauts have an incredible amount of training on a wide range of subjects. And so having this remote guidance eliminates the need for the crew to acquire and to retain detailed knowledge on ultrasound imaging and on specific scanning protocols. But the problem is, what will happen during future exploration missions where ground support may not be available or may not be available in real time? For example, if we think of future missions to Mars, they could have communication delays with Earth of about 20 minutes. And so how can the crew perform successful scanning or manage emergency situation without having that ground support? So that's where we come in with our solution. What we're proposing is a fully automated wearable technology that astronauts could use without having any specific anatomical, clinical or ultrasound knowledge. This means that instead of using a probe that needs to be positioned on a specific area of the body, we are creating a wearable technology that consists of multiple miniaturized ultrasound probes that are embedded on a flexible substrate that could take the form of a belt, of a T-shirt, of a patch, depending on the specific application, which can be placed on the anatomy to be scanned by a layperson.

This is different from using a probe because the patch will cover the entire area where the anatomy of interest is located. For example, we are working on a specific application to monitor the internal jugular vein in the neck, as there have been a few reported cases of blood clots in the vein in astronauts that would be otherwise healthy. This is due to the blood flow becoming stagnant in the internal jugular vein due to changes in the blood flow and microgravity when they are on their mission. So in this case, our aim would be to image the vein in the neck. And so what we do is using a wearable patch that covers the whole side of the neck so that we can make sure that the vein is visualized correctly, even though the patch is not positioned in any specific way. Another key feature of our solution is the automated interpretation of the images acquired through artificial intelligence algorithms. Currently, we are at the stage where artificial intelligence algorithms, if properly trained, can perform at a level similar to a clinician in detecting or outlining certain anatomical areas or diagnosing specific conditions. So in the case of the example that I just made, so the internal jugular vein imaging, the system could, for example, automatically detect blood clots whenever present and report this as an output to the astronaut. So ideally, our technology would enable astronauts to conduct ultrasound scans and analyze the images without relying on real time-expert advice. And by advancing this type of solution, we can ensure sustainability and safety of human spaceflight, providing astronauts with essential medical imaging when clinical support may not be available, especially when it comes to future exploration missions. It is also to be noted that this technology could be re-adapted to be used for terrestrial applications as well, such as pregnancy monitoring, cancer monitoring, hemorrhage detection for emergency applications, musculoskeletal applications, which means, for example, monitoring muscles and tendons as we move.

AT: Yea, I have to say, as you were describing it, as someone who lives in a regional area, my first thought was, can we get that in regional Victoria? Because I can think of applications much closer to home where because we have a shortage of medical personnel in our area, which is a big problem with a lot of regional and rural areas, I feel like something like this could be extremely useful, not just in space, but also here on Earth.

MA: Yes, I agree. So we are working on different fronts, not only to develop the solution for space, but also for terrestrial applications. And so, for example, we went through a program called ON Prime to try to understand for which applications this type of technology could have the most impact. And one of the outputs was exactly that it would be really useful for regional Australia. And in particular, we found out that, for example, one issue that is potentially solvable is rheumatic heart disease, which is an infection of the heart. And remote community presently have that undiagnosed and that can result in death of young people just because it's not diagnosed. And so we will be looking at that in the future. The only issue at the moment is that we are at the proof of concept stage. And so the solution is not ready yet to be tested in this type of communities. But we are definitely looking into that. For example, the terrestrial application we're working on is for hemorrhage detection, which could be very useful for emergency situations. For example, when there is a car accident, at the moment, the person is brought directly to the hospital. But that period of time can be very critical for saving the life of the person. So if we could have an easy-to-use solution like that, where we could detect automatically hemorrhage and how severe that is, we could potentially provide for the treatment before the person gets into the hospital. This is not going to replace sonographers in any way. It's more for alternative applications where clinicians may not be available or imaging technology might be limited. And the other feature, it's also the fact that it could enable continuous monitoring, which is presently not possible, which means having the solution in place while we do everyday life activities. And this could help us, for example, for early detection of issues or also understanding better the human body, because this has never been done before.

AT: And so obviously there are a couple of connections between what you're doing and what Margherita was doing. And it is fascinating that your husband was at the university while she was there as well. But was there any particular reason that you were inspired to talk about her today?

MA: Yes, there are a few reasons why I wanted to talk about her. So she inspires me not just as a scientist, but also as the remarkable person she was. So she carried out groundbreaking research during a time when academia in Italy was mostly dominated by men, but she never let that hold her back. So she built an international reputation by collaborating with universities in France, in the Netherlands, in the United States, all while pursuing her own interests. So I really admire her determination, how she never let others' opinions stand in her way. She's also a symbol of freedom and independent thought. So she openly identified as an atheist and chose not to have children, famously saying that she loved her cats more. And she never worried about how society judged her for these personal choices.
Another thing that I love about her is also her story on how she became an astrophysicist. So often we hear about great figures who seem destined for their path, like they were born with a special gift. And that's inspiring, but the reality is that for many, it's the random opportunities along the way that shape their journey. And Hack's story reflects that. So she initially studied literature, then she got bored and she decided to switch to physics because a friend had chosen it. And even her focus on stars was more by chance. Her professor wanted her to write a theoretical thesis, but she prefers something more practical. And so that's how she ended up studying Cepheids and the choice led to her extraordinary career. Finally, I also share Margherita's belief that many of the answers we seek lie among the stars. And so by studying the universe, we can better understand ourselves and our history. And as space exploration continues, I hope to contribute to making space travel safer, while also deepening our understanding of the cosmos and our place in it.

AT: Join us next time on the Infinite Women podcast, and remember, well-behaved women rarely make history.