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UNIVERSITY OF MANITOBA

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Star Search

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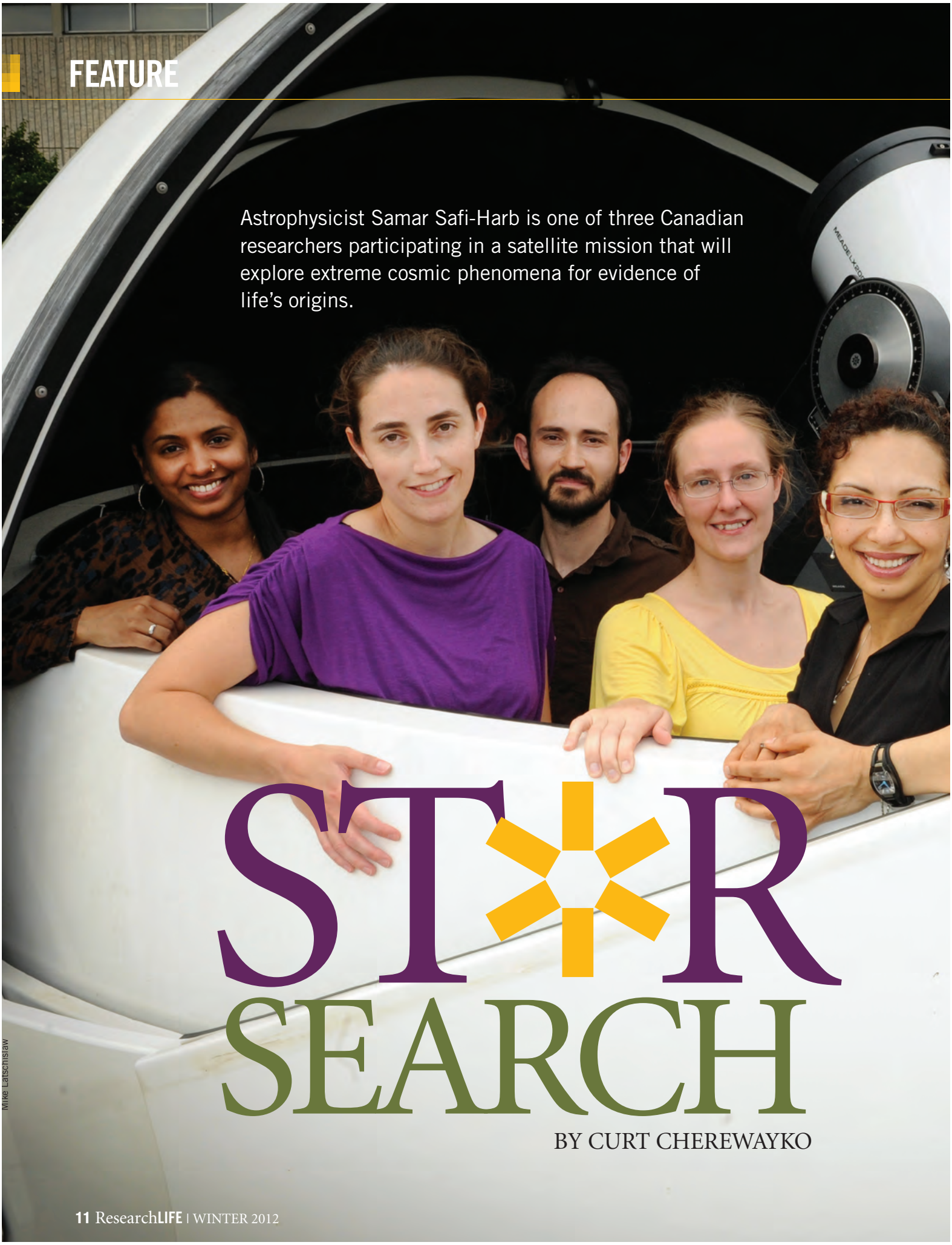


Astrophysicist Samar Safi-Harb is one of three Canadian researchers participating in a satellite mission that will explore extreme cosmic phenomena for evidence of life's origins.

STAR SEARCH

BY CURT CHEREWAYKO

Mike Latschislaw

Inside the Ewan remote telescope (l-r): Harsha Kumar, Heather Matheson, Gilles Ferrand, Jennifer West, Samar Safi-Harb, Paul Edmon, Erica Franzmann, Adam Rogers.

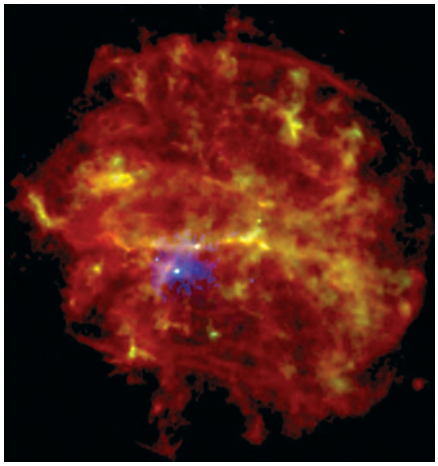
Samar Safi-Harb has to make one particular compromise for her fascination with the remote and exotic: she will never be able to get up close and personal with her research subjects. The associate professor in the Department of Physics and Astronomy (University of Manitoba) will only ever be able to study her subjects remotely via satellites. They are supernova remnants, neutron stars and cosmic rays —parts of the universe that are governed by the most extreme laws of physics. And Safi-Harb continues to explore further into the unknown corners of the cosmos.

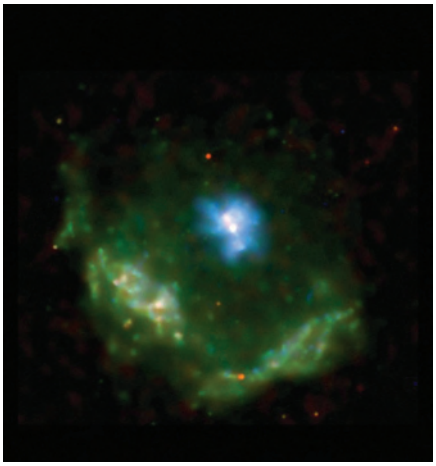
Last August, she was named a researcher for the ASTRO-H x-ray satellite being developed by the Japan Aerospace Exploration Agency (JAXA) and slated for launch in 2014. There are only a handful of x-ray satellites in orbit right now, and ASTRO-H is the first x-ray mission in which the Canadian Space Agency (CSA) has an integral role with prime observation time on the telescope.

JAXA approached the CSA to build an instrument that can measure distortions and wobbles in the satellite's six-metre mast and consequently enhance the performance of the hard x-ray telescope and the accuracy of high-energy data collected from space. For equipping the satellite with the multimillion dollar instrument—built by an Ottawa engineering firm (Neptec)—the CSA receives prime observation time in the first phase of the mission.

"It's a very important mission," said Denis Laurin, a senior program scientist at the CSA. "It's one in which we are contributing a small instrument, but getting a lot out of."

Safi-Harb and two other Canadian researchers were selected as the Canadian science working group members on the Astro-H team through a competitive application process at the CSA. Researchers from Japan, USA, and Europe also receive prime observation time on the satellite for their respective country's contributions to the project. As well, following the initial phase of the





(l-r) X-ray images of two young supernova remnants taken with NASA's Chandra satellite. Source: (left image) NASA/CXC/UofM/M. Gonzalez and S. Safi-Harb; (right image) NASA/CXC/UofM/H. Kumar and S. Safi-Harb.

mission (approximately nine months), the wider scientific community will be able to compete for access to the satellite's unique set of eyes.

For many astrophysicists, submitting proposals to access observation time on space telescopes is a regular task. Much of Safi-Harb's recent research, and of the students she supervises, involves data collected from two existing x-ray satellites operated by National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA).

The ASTRO-H satellite, however, is equipped with newer technology that can collect cosmic x-ray data on a broad part of the electromagnetic spectrum, including imaging data in extreme parts of the x-ray spectrum that have remained undetectable by the existing missions.

"[It will] help us understand the physics of the extreme—extreme temperatures, extreme gravity and extreme magnetic fields," said Safi-Harb, who holds the Canada Research Chair in Supernova Astrophysics. "Studying high-energy phenomena with this new mission will equip us with a unique lab to experiment in and use to understand physics that we could never probe here on earth."

It's also significant that Canadian scientists will be among the first researchers to access celestial data from ASTRO-H.

"This will be when key discoveries are made," said Safi-Harb with an infectious excitement that her students and post-doctoral fellows are familiar with.

Born in Lebanon, Safi-Harb first became interested in high-energy physics at the American University of Beirut (AUB) during a course about the fundamental, elementary particles that make up our world.

"Of course this was all on an extremely small scale, and now I find myself studying things on extremely large scales," she says, adding "instead of studying high-energy physics, I am now studying high-energy astrophysics".

After completing her undergraduate degree in physics at AUB, she arrived in the U.S. to continue her studies at the University of Wisconsin (UW) on a fellowship from the Lebanese-based Hariri Foundation that sponsored qualified Lebanese students. It was there that she first applied her physics knowledge to astronomy research.

A physics professor of hers researching neutron stars invited students to work with him during the out-of-school summer months, and Safi-Harb approached him about her fascination with pulsars and the unique way in which such neutron stars emit pulsating x-ray light. She was particularly fascinated by those objects that energize their surroundings and interact with the remnants of the supernova explosions that created them.

"He gave me x-ray data on a pulsar and went to Turkey for the summer," she said "having sensed my excitement about the subject and being up for the challenge". "I started working on that data having no clue—it was my very first exposure to an astronomy project. I have been hooked ever since."

Safi-Harb's chief inspiration among her peers, both past and present, is Jocelyn Bell Burnell who, as a young astrophysicist, discovered radio pulsars—only to see her supervisor famously receive the Nobel for her discovery. Interestingly, Safi-Harb's current four PhD students are women. Safi-Harb has pondered whether that is significant or not, but can't really explain it. She noted that the ratio between men and women in sciences is lopsided, but less so these days particularly in astrophysics.

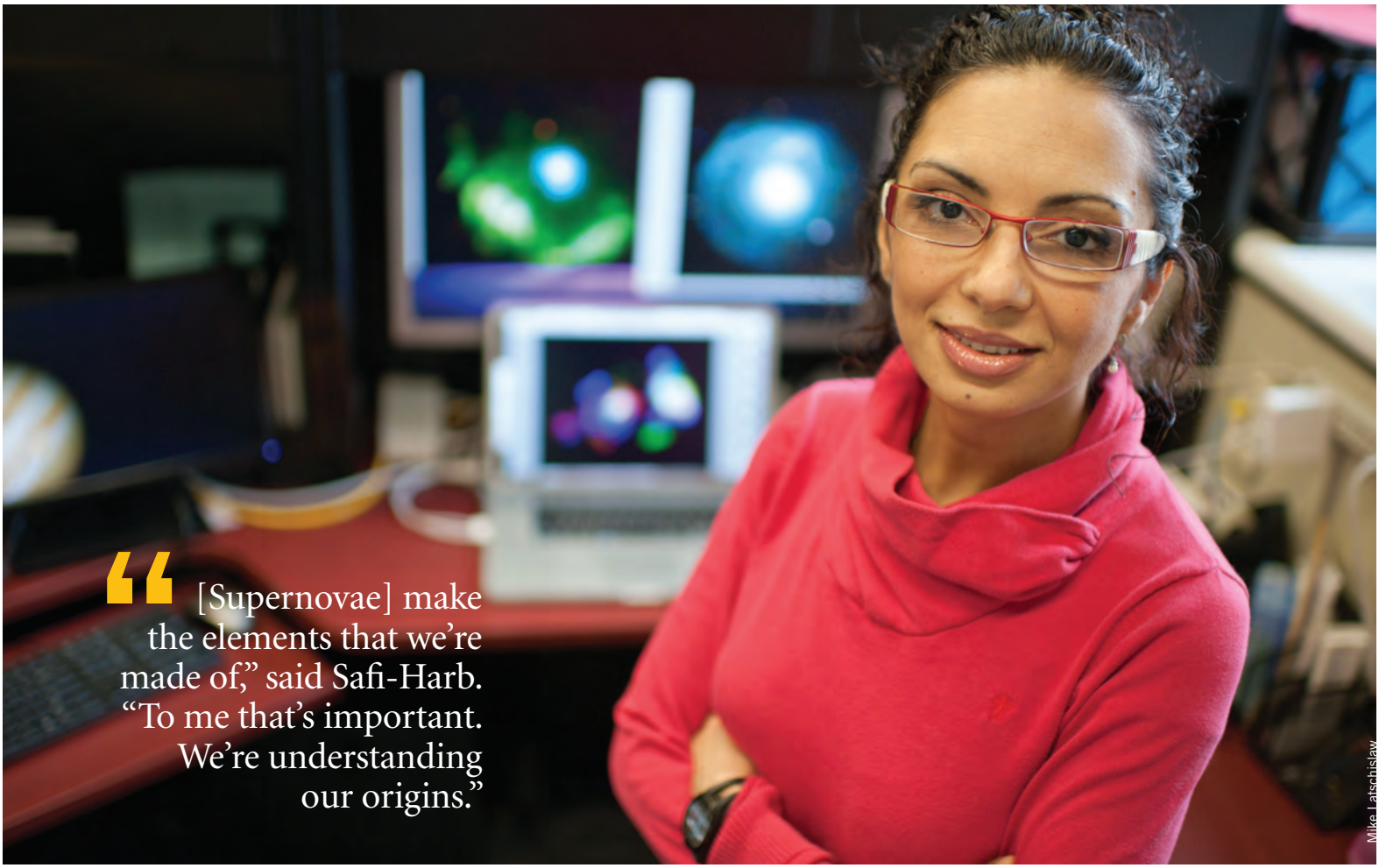
"I like to inspire [my students] with the fact that the discoverer of pulsars was a woman," said Safi-Harb.

After Safi-Harb completed her Masters and PhD in physics at UW, she received another fellowship from the U.S. National Academy of Sciences/National Research Council, this time to conduct research at NASA's Goddard Space Flight Center in Maryland.

By then, Safi-Harb was fully immersed in high-energy astrophysics research, with a particular focus, which continues to this day, on the fate of massive stars that are at the end of their life span. Consider the sun for a moment: it's a smaller star roughly halfway through its life span. The nuclear fusion of hydrogen that occurs in the sun creates the immense heat and light we are familiar with. The exotic stars that Safi-Harb studies result from the death of more massive stars that have exhausted their nuclear fuel. All of the hydrogen in their cores has fused to become helium, but due to their extremely hot core temperatures, nuclear fusion continues to burn helium in the interior to make carbon.

This ageing process continues, creating increasingly heavy elements, like oxygen, neon, magnesium, and silicon, until iron is formed. At this point, iron's stability puts a halt to fusion. Then, fusion's opposing force on a star—gravity—gets the upper hand, causing the star's collapse. As the star collapses, a massive explosion—a supernova—occurs. The explosion sends remnants of the star, including heavy elements that are necessary for life to occur, hurling into space.

"[Supernovae] make the elements that we're made of," said Safi-Harb. "To me that's important. We're understanding our origins."



The heat generated by a supernova is immense. Our sun’s surface temperature is in the thousands of degrees Kelvin range, while the temperature of a young stellar remnant is in the millions of degrees Kelvin. The hottest and most energized supernova remnants will be detectable by x-ray satellites such as ASTRO-H. What’s left of a massive star after it explodes is an x-ray emitting, immensely magnetic and dense sphere made of neutrons—a neutron star—about the size of a small city. The gravitational pull of a neutron star is not as strong as a black hole’s, but it’s nonetheless only comprehensible in terms of relativity. If you were to drop a penny on the surface of a neutron star it would accelerate to half the speed of light before hitting the surface.

Safi-Harb arrived at the University of Manitoba from NASA in 2000 on a university faculty award fellowship from the Natural Sciences and Engineering Research Council of Canada, becoming an associate professor four years later. Today, Safi-Harb lives in Winnipeg with her husband and two young children. Safi-Harb first met her husband at the university in Beirut. They lost touch only to reconnect some years later in North America, initially as colleagues.

Safi-Harb currently supervises four PhD candidates including Harsha Kumar who, like Safi-Harb’s other students be they past or present, notes the enthusiasm in which Safi-Harb approaches her teaching and research.

“Whenever I have a meeting with her, she speaks with so much excitement about the research that it gets me really motivated,” said Kumar, who is currently assisting Safi-Harb with preparatory research for ASTRO-H. “She gives me enough freedom to do my research. Some supervisors constantly keep watch on their students.”

Marjorie Gonzalez, who received her undergraduate and masters degrees in physics and astronomy under Safi-Harb, echoed Kumar’s assessment of Safi-Harb, noting that she is approachable and receptive but expects a fair level of independence.

“She will help you understand something and then let you go to try things out on your own,” said Gonzalez, who is a brain researcher at the University of British Columbia’s Positron Emission Tomography Group.

Gonzalez’ career trajectory is an exemplary defence against the argument that astrophysics, despite the research funding it receives, cannot be applied for any earthly benefit.

She draws a direct connection between her astrophysics education under Safi-Harb and the research she conducts now, which involves x-ray medical imaging of the brains of Parkinson’s sufferers. “It’s just that these images happen to be of people’s brains instead of stars in the sky,” said Gonzalez.

Safi-Harb expects her own research to increasingly focus on cosmic rays, which are mysterious energized particles found in many areas of the universe. One of the mysteries about cosmic rays is the source of their intense energy. Safi-Harb is researching with her postdoctoral fellow, Gilles Ferrand, their origin and the energy they can achieve as they veer into the path of high-speed, energized remnants of supernovae.

In its 2010 to 2020 vision, the Canadian Astronomical Society says high-energy astrophysics research is experiencing “explosive” growth in Canada.

“There are a lot of unanswered questions in this field that I’d really like to pursue,” said Safi-Harb. “We are lucky to have access to these powerful telescopes.”

To learn more about Safi-Harb’s research go to www.physics.umanitoba.ca/snr/