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## Pioneers of the dark

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Dark matter is a funny thing to have discovered. Not only has no one ever really seen it, but it is impossible to see, at least in the traditional sense. Even the woman who found it thinks it might not exist. And she did not really find it, she just proved it is there. Or seems to be.

Vera Rubin's discovery, in the late 1960s, was that most of the universe is missing. There is five times more gravity out there than there is detectable matter to exert it. She learned this by judging the speed of stars orbiting in a galaxy, and seeing that they orbit at a constant speed no matter how far they are from the galaxy's centre. This directly contradicted the predictions of classical physics, and implied there was some other stuff out there in the cosmos, unseen but massive, whose gravity was powering the stars through space.

That insight alone would have been enough to place Dr. Rubin, 81, in the pantheon of great American physicists. The fact that she made it in an overwhelmingly male field that sometimes explicitly banned women makes her a unique sort of icon, with a rare perspective on the barriers to women in science, which she says have "improved enormously but not at a rapid rate."

At a cosmology conference in her honour this week at Queen's University, she described the convoluted schedule she had to develop with her husband, a mathematical physicist, so that she could take graduate studies at Georgetown University, despite having two children (now four, all with scientific PhDs). She recalled the decision to return to high-level science after starting a family, and how she broke down while reading a paper on galaxy rotation on a playground bench, weeping "because people were doing science and I wasn't."

"I married the right man," she said over lunch the day before, on a patio at Kingston's Chien Noir bistro.

It seemed a strangely old-fashioned emphasis for someone who is praised as a feminist pioneer. But the sentiment is shared by her former student and scientific protege, Sandra Faber, also a leading cosmologist, whose work at the University of California, Santa Cruz, has helped explain the evolution of galaxies, and the hidden structure of the universe, in which dark matter plays the central role.

A generation younger than Dr. Rubin, Dr. Faber sees a modern scientific establishment that has solved

the small problems of gender equality, but not the big ones. A mother of two herself, Dr. Faber often sees women "diverted" from science by children in part because they have this culturally honourable "out."

"If men did, they'd be doing the same thing," she said. "Men can sing only one song. Women can sing two."

Dr. Faber said one factor in her own success was that, academically, she was four years ahead of her husband, and so he became "the trailing spouse" whose career was adapted for hers, in a reversal of the more common scenario.

Dr. Faber thinks women lack some of the personality traits that the modern scientific world values, in part because it was created by men. One effect in cosmology has been to skew the proportion of observers versus theorists. Women tend to be observers, good scientific listeners like her and Dr. Rubin, whereas theorists are almost invariably men, who "stand up and pontificate. They are in the spotlight."

In a lecture on Tuesday night, at which the spotlight was turned on her, Dr. Faber described dark matter as "a backbone, a structure, a trigger" for the formation of galaxies. Ordinary matter (the kind we can see, of which some 95% in the universe is either hydrogen or helium, the two lightest elements) is kind of a leftover "trace" that gets pulled by gravity into the structure created by dark matter as it exploded outwards after the Big Bang.

Over billions of years, stars burned up and died, or exploded as supernovae, and as they did, they fused hydrogen and helium into the other elements. This stardust formed into little "sticky" droplets, that eventually coalesced into asteroids, and over time, into planets in orbit around stars.

Afterwards, a boy called Jack, 11, visiting Kingston from Beijing with his parents for a year, bravely approached her with some informed questions on astrophysics, such as the possibility of wormholes, theoretical connections between black holes that could allow time-travel.

Dr. Faber deftly adjusted his question and agreed that, yes, wormholes are possible, but only like balancing a pencil on its point is possible; it is just too unstable to last in reality.

It was a rhetorical tactic she also used at lunch the next day. Over a meal of pickerel (at which Dr. Faber learned for the first time about the mysterious kind of matter known as cheese curds, and their starring role in poutine), the women revealed different temperaments with poorly phrased questions.

Dr. Rubin tended to slap down questions that she found silly, or possibly rude. For instance,

she is Jewish by family and tradition and occasionally participates in a synagogue, but does she believe in the traditional God?

"I don't think I even know what that question means. I mean, do I believe there is a man up there? I think the answer would have to be no."

Dr. Faber was more conciliatory (and also atheist). She took questions and rephrased them into something far more clever, then answered herself. It made for a smooth interview, if somewhat passive. She even started asking Dr. Rubin questions, such as "Do you think miracles ever occur, where a miracle is defined as an event that is either impossible or extraordinarily rare according to scientific law." (Answer: "I would say extraordinarily rare things happen.")

To a question about how long it will be before science understands dark matter, Dr. Rubin said she has little time for predictions. "Ten years from now, if they haven't found it, it's unlikely they'll give up," she said.

But Dr. Faber played along.

"You could have asked the question, 'Are there any believable efforts that are currently underway that have a ghost of a chance of discovering dark matter within the foreseeable future?'"

The answer, she said, is yes. There are three.

One is the upcoming experiments at CERN, the huge particle accelerator in Switzerland, which could "fill in a few of the details" by possibly discovering a particle called the Lowest Super-Symmetric Partner, one candidate for dark matter.

Another are the projects to detect dark matter by putting massive, super-chilled crystals in abandoned mines. A third is based on the notion that dark matter particles should collide with each other occasionally in the clouds of dark matter in space, and those collisions can perhaps be detected by a new gamma-ray satellite called Fermi.

At this point Dr. Rubin interrupted with two more, slightly pessimistic possibilities. Number four is that there is no dark matter at all, and we have to change our physics, a theory known called Modified Newtonian Dynamics. The fifth, and the "absolute worst" possibility, Dr. Rubin said, is a little bit of everything; there is no real clear answer, just more tantalizing hints and unexpected discoveries.

The talk of gender equality reminded Dr. Faber of the day she got her PhD, and booked a table at a fancy fish restaurant in Sausalito in the name of "Dr. Faber." She laughed as she recalled the obsequious maitre d' who fawned all night over her father-in-law, who eventually corrected him.

Dr. Rubin told a similar anecdote about being mistaken for a "wife" at a formal occasion, but it went over so well that she got nervous, and after a few moments of reflection, she begged and pleaded until the National Post reluctantly agreed not to repeat it.

This is a shame, because it was a charming story, involving mistaken identity, awkward ceremony and men in funny costumes. But she felt she had violated the privacy of a special moment.

"I really think it would do me harm," she said. "I think they'd kick me out. There's no way I can survive. They're tough guys."

As she offered a warm hand and a relieved smile at the agreement to secrecy, it seemed strange that the woman who discovered 85% of the universe was so worried about a petty scandal of manners. It was also frustrating to realize that even the sister has a sense for the brotherhood.

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