Astronomy Cast Episode 172

William Herschel

Fraser: Hey Pamela, how're you doing?
Pamela: I'm doing well, how are you doing Fraser?
Fraser: Good, good. It's cold and wet, but that's Canada in the winter.
Pamela: We're cold, sunny.
Fraser: My wife is down in Cancun right now. So, yeah, I get the call every now and then telling me how much fun she's having... but she's back tomorrow. So, she get's to join us in the winter again. Right, so ancient astronomers knew of 5 planets--Mercury, Venus, Mars, Jupiter and Saturn. Six if you count Earth. And then in 1781, William Herschel discovered an entirely new planet.... Uranus... boosting the number of planets to 7. Now, let's learn about Herschel, his equipment, his discoveries, and his sister Caroline, an accomplished astronomer all on her own. Alright, so Pamela, we've talked a bit about Uranus and the discovery, but so why don't we just start talking a bit about William Herschel. Who was Herschel?
Pamela: Well, he was a classically trained musician, actually. He was someone who'd gone through life following in his father's footsteps, thinking that as a musician he could really make something of himself. He was a violinist, he played the oboe, he conducted, he even wrote a symphony, but like so many people he got introduced to astronomy by a friend, by a book, by both actually...
Fraser: By a podcast...
Pamela: Well, not quite back then, but back in 1773 he got introduced to astronomy and by a year later he was already starting to build telescopes. We all occasionally if we're lucky meet in our local astronomy club someone like this, just bit by the bug, dives in head-first, but the thing that made William Herschel special is he didn't just dive in head-first into observing the sky and documenting what he saw but he shared and he communicated and he just started innovating. In 1781, as you mentioned, he discovered Uranus. He was touring around the sky, he saw what he thought was a comet, he followed it up, he realized... oh, no, this is a planet.
Fraser: So, was he looking for planets?
Pamela: No, he was looking for comets.
Fraser: He was looking for comets... and here's the thing with Uranus, right, is that you can look into the night sky with your perfect eagle vision in a perfectly dark sky and you can make it out at the very limits of human eyesight. So, it's entirely possible that Uranus could've been discovered, known for thousands of years, but...
Pamela: But they didn't have catalogs, that's the amazing thing. When Herschel was doing his work, the sky was still this uncharted land where you could go oh, there's something... I can see it with my eye but wow, it's a whole lot brighter through the telescope. And Uranus is one of those edge-of-your-vision objects, it's moving relative to the stars very slowly, but when you look at it through a telescope, you can start to see it's more than just a point of light.
Fraser: It's a little fuzzy bit.
Pamela: Yeah, and so he noticed a little fuzzy bit... a little blue fuzzy bit. And he watched it, and he watched it move. And he realized... planet. I have a planet.

Fraser: Or comet... I think I see a comet. So, when did he figure out then that he really was looking at a planet?
Pamela: That isn't something that I've managed to find documented. But the standard is he discovered it and announced it in 1781 which was just about 10 years after he started observing. He was an experienced observer but he wasn't one of those long-time people who'd been doing this his entire life. It was a pretty amazing discovery. And just a year later he was able to leave his job as a musician entirely because King George III of England named him his court astronomer because of what he had done.
Fraser: And so what impact did this have on the search for planets? I mean this must have just blown everybody's minds. You can imagine that suddenly, it's wide open... if there's one planet there's gotta be more.
Pamela: Well, this was a point where the entire sky was still something that people were discovering, and for Herschel it wasn't so much the search for new planets that was opened up, because... oh, new planet, ok that's kinda cool... move along. He was much more into actually looking for nebulae. He realized, looking at Messier's catalogs, looking at the catalogs of fuzzy bits on the sky that other people had documented, that there's a whole lot of really cool stuff out there that no one had taken the time to note, no one had taken the time to write down and document. So, rather than going out and looking for more planets, he went out and he started looking for the fuzzy bits that today we know are globular clusters, are emission nebulae, are other galaxies. He spent most of his life not looking for other planets, although he did find 2 more moons of Uranus, he found in 1787 Titania and Oberon, and he found 2 moons of Saturn--Enceladus and Mimas. But he spent most of his life documenting stars, documenting nebulae, just cataloging what was out there so that the next person to find a fuzzy bit, could look up in a catalog is the fuzzy bit going to move or not.
Fraser: Right, as a way to know which are comets and which are just galaxies or nebulae.
Pamela: Right.
Fraser: So, where did his research go from there? I mean was that just how he spent the rest of his time, just building up these catalogs? What state are these catalogs in?
Pamela: He ended up building progressively larger and larger telescopes, and he ended up making progressively more and more lists of objects on the sky. By the time he died, he'd created so many thousands of detailed observations that it was his and his sister's catalogs that went on to become basically the base material for Dryer's New Galactic Catalog that came out in the 1870s.
Fraser: These are the NGC numbers.
Pamela: Right. So, he literally cataloged thousands and thousands and thousands of objects. The original catalog that Dryer put out contained 7840 objects. Dryer put all the pieces together and he used the original objects that were put together by William Herschel, Caroline Herschel, and William's son John, who helped both William and Caroline in the work. They had a lot of observations. Everything was meticulously laid out.
Fraser: And so you've mentioned a bit his sister Caroline was an accomplished astronomer as well. How did that come about?
Pamela: Caroline's one of these unfortunate individuals who, given the time that she grew up in, even though she was brilliant, she was sort of set aside because, well... her

family decided that she wasn't suitable for marriage. She'd been ill as a child, she never grew very tall, all records are that she wasn't a particularly good-looking woman and had a personality to match. After William moved out and moved to England, after his father died, Caroline was pretty much stuck becoming, well... a maid in her own household, and that really wasn't a good way to live. So, William invited his sister to come out. She was an accomplished musician as well. Apparently, she was a very good soprano singer, and so she came out, joined him, they worked together as musicians, she was often he soprano soloist. But, when he got into astronomy, he sort of said... here, take a telescope, go keep yourself busy. So in 1783, when he'd done his discovery of Uranus, when he'd left music to become the court astronomer, he basically said, here... be busy... and gave her a 6 inch diameter 7 foot long Newtonian telescope that has the eyepiece up near the front of the telescope. It's the same type that modern-day Dobsonians are made. It became how she kept herself busy. Originally, according to many stories, she wasn't so much into this, but she was going to show her brother that she was a completely accomplished person in her own right. But then she got hooked, and between 1786 and 1797 she discovered a record number of comets that held for a long, long time. She actually in 1787 was awarded her own income of 50 pounds per month from King George III for her work to assist her brother. She ended up being one of the first two women inducted to the Royal Astronomical Society. It was her along with Mary Sommerfield and the two of them would be the only women to be inducted until Vera Rubin, who's still alive.

Fraser: There's a... just on a completely side note... there's a really fascinating series... documentaries on a British BBC radio documentary called "In Our Time." They do 4 episodes on the Royal Society and talked about the politics and the people involved and Newton and all that... It's quite interesting.

Pamela: For me, it's just amazing the politics of how you can go from in 1835 you have Mary Sommerville and you have Caroline Herschel, and then you have no other women until the modern era.

Fraser: Yeah, absolutely... I mean it was a... it just sounds like an amazing time where they would sit around in these smoky rooms and someone would perform an experiment for the week. Someone would, like, dissect a dolphin in front of everybody...

Pamela: Well, this was the Royal Astronomical Society so there were fewer dolphins being dissected...

Fraser: Of course... yeah... but they'd bring a telescope out onto the lawn and show people this comet and that moon. It would've been a pretty amazing time, a lot more really touching and feeling the astronomy and the science. It would've been great to be a part of that. Now Herschel then... two weeks ago we did Fermi, and Fermi was a theoretical physicist who came up with the big ideas and then let the little people go out and do the research and find the particles, and so on... Herschel was the opposite, right? Herschel was an observational astronomer.

Pamela: Yes.

Fraser: Did he do any theoretical work?

Pamela: No. He was what some people might disparagingly say, he was strictly a leaf collector. He was someone who went out and he just documented what he saw. He was the type of person though that went out and looked and looked and looked and looked, and he looked at so much that he was able to start putting pieces together, start

understanding what was going on as he looked out at the universe around him. One of the neatest discoveries was as he watched the sky year after year after year that he was able to note in 1783 the direction that the sun is moving relative to the stars. That's a pretty amazing discovery. He was able to discover what's called the solar apex. So here you have someone who is a college educated musician determining our motion through the galaxy just by looking.
Fraser: How would you do that?
Pamela: Well, you're able to see very slight changes in the positions of the stars over time. And he was able to notice those very slight changes, the proper motions, and document the proper motions.
Fraser: And that requires observing the same star year after year after year to see it moving slightly against the background.
Pamela: Yes, and so he was one of the very first to look out at the structure of the Milky Way and conclude that we live in something that's disk-shaped and to see that we're moving through this disk of material.
Fraser: Well, didn't he take a crack at trying to map out the shape of the Milky Way?
Pamela: He did, but one of the things that he and many other early astronomers suffered from is not realizing that we're limited in what we can see by dust. As we look out, the universe is fairly opaque. You might be at the very edge of a fog bank, anywhere say along coastal California, and as you look around, as near as you can tell, the fog is the same density in all directions. You can tell nothing about how deep it is just because you can only see 5 feet, you can only see 10 feet. In our galaxy, we can't tell that we're not in the center because we can't tell what is the depth of this density of stars and gas that is blocking our way to look across the disk.
Fraser: Right, but Herschel essentially tried to figure out how big the universe is.
Pamela: Yes.
Fraser: And tried to then calculate the distances to all the stars and then map out the stars in a sphere around the earth and then that would really help get a sense of scale of how big the galaxy was. But, he didn't realize that huge portions of the sky are obscured by gas and dust and that we're actually on one side of the Milky Way. He didn't realize that the Milky Way is just one galaxy in this enormous universe of galaxies and so it was completely off, but still it was a very careful and complicated piece of research that he had to do to even get to that point.
Pamela: Right, and so he basically was hampered by a lot of just underpinnings that we didn't get until modern times. These nebulae that he was so carefully documenting, he didn't realize that a lot of them are galaxies well outside of our own Milky Way, that the disk that we're looking through... we can't see out to the edge. So, this caused him to have an accurate representation of what the sky looked like, but not have an accurate representation of what the galaxy looks like. But it was a start. And it changed how people think. He's responsible for changing the language of astronomy in a lot of different ways. He is one of the people who coined the term "asteroid," although it wasn't until the 1850s that people started actively looking at it. He was one of the people that worked on trying to figure out if there was a link between our sun's behavior, between solar activity and terrestrial climate. Some of his ideas were rather insane. I've seen some references that say that he thought there was life everywhere in the solar system, including on the surface of the sun. But, everyone occasionally has a crazy idea, and there

are other brilliant people who occasionally articulate crazy ideas, but along with all the astronomical observing work he did, he's also the person who discovered infrared radiation and I think that's one of the things that gets ignored a lot but that makes sense if you look at, oh... the Herschel Space Telescope... optimized for infrared, the William Herschel Telescope in Tenarife, optimized for the infrared.
Fraser: How did he discover infrared?
Pamela: This is one of the coolest accidental discoveries, I think. He was passing sunlight through a prism, making a rainbow and he'd been using a thermometer to measure the temperatures of the colors. As a control, he took the thermometer, put it beside the visible rainbow to get a room temperature reading, and realized that the reading he was getting was well above ambient air temperature.
Fraser: Oh, I see... so he was putting the thermometer off to the side of his rainbow to try and get a temperature reading and it was still higher, so it was still being hit by something.
Pamela: Right. So what he did was he just moved his thermometer out of the visible red and straight into the invisible infrared. The thermometer... it didn't care if the human eye could see the color or not... it intercepted the energy from the infrared light and got hot. And by noticing my thermometer is reading a temperature that does not match what this room actually is...
Fraser: Well, it was higher than the visible light, right?
Pamela: It was higher than the visible.
Fraser: Wow... so it's like a spike of temperature off to the side of the rainbow that's higher than the color of the rainbow.
Pamela: And this is because infrared is basically what conducts heat.
Fraser: Right. That is pretty amazing.
Pamela: Yeah, and it would have been so easy to simply decide you've done something stupid, but instead he investigated what's going on, what's this strange reading, and it was in those investigations that he figure out oh, there's colors we can't see.
Fraser: And you can imagine that that is just the kind of thing that changes your whole paradigm about this because you look at that rainbow and then you figure, ok there's something on the... beyond the red end, so who knows how far that goes. And then, you would go I betcha there's something above it as well... beyond purple.
Pamela: And he didn't, at least in what I've read so far, go so far as to start making those claims. He didn't think theoretically.
Fraser: No, but I could imagine other people just kinda taking that ball and running with it, right?
Pamela: Right. He opened the door. He was very much the what do I see, let me document what I see, let me try and understand what I see type of person. And in many ways he was also kind of your ultimate amateur astronomer even with all of the fame he got, even with the appointment he got to the royal court, he was still the person out there grinding his own mirrors, building ever-larger telescopes. The largest telescope he built he actually didn't use that much because it was kind of awkward. He always had his favorite, slightly smaller scope that he used for most of his observations. This actually is probably the reason that it was Lord Rosse that discovered spiral galaxies rather than Herschel, Herschel just didn't like his big 40-foot long telescope, he preferred to use his 20-foot long telescope.

Fraser: Right... it's faster... quicker...
Pamela: And he got his sister involved... "Hey, you, you're not doing anything, come out here, help me." He got her involved at the level of he accidentally used her as a counterweight one night. The two of them were out working in the dark, and these were giant telescopes they were using back then. They were still learning how to make mirrors well and they didn't have short focal length telescopes at that point. So his telescopes were 20 feet, 40 feet in length, had massive counterweight systems and his sister got tangled up in one of these counterweight systems, got lifted up off of the ground by one of the hooks one night and ended up leaving behind a chunk of flesh dedicated to astronomy.
Fraser: Ouch.
Pamela: Yeah... ouch... but she kept going.
Fraser: She kept going! That's quite the sacrifice for astronomy. Are you willing to make that sacrifice, Pamela?
Pamela: I have actually been instructed that if you trip carrying this part of the telescope, hold it to your body and give up on the rest of your body, and I was willing to accept that instruction.
Fraser: Right, right... put out your back in order to save this piece of glass.
Pamela: Exactly. Yes. And beyond his getting his sister involved and beyond his building his own telescopes, beyond the recordkeeping, he also got his son out there... he got John involved. And this was in some ways the way he put his family back together. After he got married... he and his sister had been living together, but when he got married, his sister ended up having to go find someplace else to live... it was too many women in one household, and there was distance between the two of them. But, after he had his son John, John and Caroline became close, Caroline was the doting aunt, it was Caroline and John that continued his work that finished his catalogs. And his son went on to be another noted person in the astronomy community.
Fraser: And so how long did he live?
Pamela: He died when he was 84. He had a good long life. Now, he stopped making his major discoveries well before then. It was in 1800 that he discovered IR and he didn't make any discoveries after that. He coined the term asteroid in '02, but that was still a good long life spent working in astronomy.
Fraser: And Caroline lasted, as you said, quite a while after her brother.
Pamela: Right. And together, the two of them are responsible for pretty much changing our paradigm of how we look at the sky.
Fraser: Well, that's a great story. And next week, sort of following this little bit of a tradition we've started, we're going to talk about the Herschel Space Telescope which is named after him and, as you said, is an infrared telescope designed to peer into that side of the spectrum... so we'll talk about what Herschel has found...
Pamela: The telescope named after two people...
Fraser: Three!
Pamela: Well, three... well, in the notes they say it's named after William and Caroline.
Fraser: Alright. So that sounds good. We'll talk to you next week, Pamela.
Pamela: Sounds good, Fraser. I'll talk to you later.