Astronomy Cast Episode 173

The Herschel Space Observatory

Fraser: Astronomy Cast Episode 173 for Monday January 18, ~~2009~~ *2010 [ed.]*, the Herschel Space Observatory. Welcome to Astronomy Cast, our weekly facts-based journey through the cosmos, where we help you understand not only what we know, but how we know what we know. My name is Fraser Cain, I'm the publisher of Universe Today, and with me is Dr. Pamela Gay, a professor at Southern Illinois University Edwardsville. Hey Pamela, how're you doing?
Pamela: I'm doing well, how are you doing Fraser?
Fraser: I'm doing great. Now I understand that you have a task you wish to get some help with from the listeners.
Pamela: I do. I have a homework assignment for all of you. Now when we look at our Google stats, it gives us a vague idea of where people coming to our site are coming from, but it doesn't give us personality, it doesn't help us explain to other people who our audience is. So I'm going to ask you to do something that I hope is simple. Go get a postcard of where you live, and just send it to us. No matter where on the planet you are. We have a P.O. box... you can reach us at Astronomy Cast, P.O. Box 804, Edwardsville, IL, 62025, and we can post that address on our website. So all I want is a postcard, just a postcard, simple postcard... say Hey! Hi!
Fraser: Having fun... wish you were here... Here's a picture of the Acropolis...
Pamela: And give us a face to who you are.
Fraser: That would be cool. Last week we talked about Herschels--the people... William Herschel, his sister Caroline, and his son John. This week we're going to look at the Herschel Space Observatory... Herschel the robot! A mission launched in 2009 to reveal the coldest and dustiest regions in the universe. Alright, so lets talk a little bit about the Herschel telescope, then. So, what is it?
Pamela: It's a telescope.
Fraser: Thank you for that.... but what is it?
Pamela: It's an infrared observatory that was launched May 14, 2009, that is the biggest and the most infrared observing of the infrared observatories that have been launched into space so far.
Fraser: So we're going to compare this to Spitzer, then, right?
Pamela: It's actually something entirely new. It has a mirror that is about four times bigger than what has been seen before, and it goes further into the infrared than we've been able to go before.
Fraser: Alright, so infrared is on the electromagnetic spectrum on the more red side... beyond red... we've done a whole show on infrared. Herschel starts where and ends where?
Pamela: The Herschel mission goes roughly from about 55 microns out to about 670 microns. So this is way, way smaller wavelengths once you start getting down to the 50 micron than anything that can get through our atmosphere. So, what we run into when we start dealing with infrared, is our atmosphere in particular... the water in it, in many cases, removes infrared light and it never reaches the surface so we have to launch telescopes into space if we want to start studying things like molecular transitions, things like

galaxies forming at the edge of the universe. And infrared has this neat feature where it lets us look through dust, which is always a good thing.
Fraser: Right, so this is a region of the electromagnetic spectrum... in the infrared, but it's the part of the infrared, the longer wavelengths, that are blocked by the earth's atmosphere.
Pamela: Yes.
Fraser: And if I can kind of remember from our previous show on infrared, this is stuff... sort of enshrouded by dust, that the light would normally be blocked, but infrared can see through that. We're seeing like protoplanetary systems, into nebulae, into the heart of the Milky Way, and then we're also seeing out to the very distant edges of the universe where the light has been red-shifted.
Pamela: Exactly. So we're essentially studying the birth of stars all throughout the history of the universe, in a lot of ways. Because nearby it allows us to look at star forming regions and look INTO the star forming regions.
Fraser: And see these stars as they're just getting going, they're not bright hot stars, they're just getting going... they're warmer than the background.
Pamela: Exactly. And we're able to see the detailed temperature flows, in some ways... how is the material flowing through these nests of star formation. But then as we look out to the beginning moments of the universe, we're seeing star formation that the stars already emerging from their gas and dust and giving off violent amounts of ultraviolet radiation, but by the time that ultraviolet has been stretched and stretched and stretched and stretched on its journey from the first moments of the universe to today, it's all back out into the infrared.
Fraser: So then Herschel... it's got the detectors to see this infrared... you say it's got a mirror that's four times larger than any telescope that's looking in this spectrum?
Pamela: It has a 3 1/2 meter mirror, and it also has high-resolution spectrometers, so it's able to start saying, aha... right there I see carbon monoxide, right there I see water. And so we're able to start tearing apart what are all of the different molecules found, what are all the individual elements that are starting to turn up in all of these different gas clouds.
Fraser: And this is part of the situation where different molecules will release electrons... or photons--sorry--at a very specific wavelength, right, and then you can see them and then you know that those photons coming at me are evidence of alcohol, or...
Pamela: Formaldehyde...
Fraser: Or formaldehyde, or... yeah... exactly. So you can see those individual molecules.
Pamela: There's all sorts of amazing stuff out there, and the key to seeing it is to first get above the atmosphere, and then to get yourself good and cold and keep yourself that way. And this is one of the things that makes getting Herschel where it is something of... not a challenge, but a waiting process for scientists. They had to take Herschel and stick it out on the other side of the sun-earth system... so you go sun... earth... and then you go out past that to L2, and it's out in the L2 gravitational point where you're constantly living in Earth's shadow that they decided to stick this little mission.
Fraser: Is there anything else out in L2?
Pamela: Well, we're working on slowly filling it up. It's where James Webb is going to go live, I believe it's where WMAP lives... it's a good place to stick things you want to keep cold.

Fraser: Because the earth acts as a sun shade?
Pamela: And it's also constant temperature. If you think about it, something that's going in and out of the earth's shadow all the time is going to have all sorts of temperature fluctuations. And an instrument that is sensitive to... well, the color of temperature is one way to think of it. Having all those temperature fluctuations is going to make any sort of accuracy very difficult. One of the problems of infrared telescopes is they can see themselves if they get warm. If the tube of your telescope gets hot, it's going to be the brightest thing in your field of view, and that's just a really bad idea. So, they keep these telescopes in the shade... they keep these telescopes where they can be completely thermally controlled by not having to constantly go in and out of the sun's light.
Fraser: I think it's kind of amazing, when you think about it, we already know that space is incredibly cold... you know, just a few degrees above absolute zero. And then, they cool them further because that's not cold enough!
Pamela: It's also a matter of they have to cool off the detectors because... well, electronics get warm. Anyone who's sat on the sofa with their Apple laptop on their lap... you might want to grab a pillow before you burn yourself... electronics get warm. Telescopes get warm. And so you do have to use cryogenics to cool them off. You do have to launch them with a reserve of cooling liquids and in some ways that is a curse because it limits how long these missions can last. Hubble--we can keep using Hubble as long as the little gyroscopes are happy to keep spinning, as long as the detectors are able to send us back data. Some of the instruments on Hubble do get cooled, but not all of them. Once you start looking at the universe in the infrared, well now you're limited by how much cryogenics you can carry up with you and so Herschel, we have planned to be able to use for 3 1/2 years, and if we're lucky we'll be able to get it all the way out to 4 1/2 years. We think that the cryogenics were built well enough that they'll be able to keep going and last a whole lot longer. But if the cryostat evaporates faster than that, as happened with one of Hubble's instruments, it will have a shortened mission and a shortened amount of science that it's able to do.
Fraser: Right, right... and this isn't one of those situations like with Spirit and Opportunity where they just keep going and going and going... yeah, they've got a very set lifespan. This is more like the Phoenix lander, where it lasts one winter and then it's a goner. But, then even when it runs out of the cryonics, it's still a useful telescope... it's still going to be able to see... just not the really cold stuff anymore.
Pamela: Well, unfortunately, the way it's been calibrated, it actually has a set life... it's not like Spitzer that has a warm mission plan.
Fraser: That's what I thought... ok, ok, so it's done...
Pamela: Right. So Spitzer, they have a warm mission for Spitzer, and there's actually a really fabulous video podcast... the IR-relevant, IRrelevant video series has a great one on Spitzer's warm mission, but with Herschel, it's limited to 3 1/2 to hopefully 4 1/2 years...
Fraser: I predict they'll figure out something to do with it... something... who knows what it could be, but I'm sure they'll figure out something. They'll be bouncing lasers off of it to calculate the distance to L2 or something... I don't know...
Pamela: I think this is one of those times where they may just figure out how to recalibrate the instruments, but probably not. They'll probably move the dollars on to the next big cool mission that gets launched.

Fraser: And one of the things that we haven't really mentioned is this is not from NASA...
Pamela: No, this is the European Space Agency. This is a program that as you explore data on it, yeah a couple of the instruments were built by NASA in part, but I love all the press releases are from Cardiff because I'm a Dr. Who fan, and who doesn't love Torchwood... that has absolutely nothing to do with the mission but I just get a giggle every time I read press releases where all of the scientists are from Cardiff. So, you have a strong UK contingent, you have the European Space Agency that launched it. They launched it from French New Guinea, and the launch images are fabulous and there are these giant birds that are flying all around in the video, and it looks like it's being swarmed by pterodactyls if you use your imagination.
Fraser: Which I choose to... so it's launched on an Ariane rocket...
Pamela: And it co-launched with Planck. This was one of those great missions where we got two satellites for the cost of one rocket.
Fraser: We haven't even talked about Planck yet... we'll talk about Planck. And then it made the long slow journey out to L2.
Pamela: 60 days...
Fraser: 60 days, yeah... so we've done an episode on the Lagrange points, L2 is, as you said, on the opposite side of the earth. This is a point where the gravitational forces are perfectly in balance and it requires a minimum amount of fuel to keep it in that position. But it's not... it's fairly stable... it's sort of like perching a car at the top of a mountain, you know, as long as you keep the car at the top of the mountain it's not going to go anywhere. But if it gets a little one way or the other, maybe a big gust of wind and it starts to roll off the mountain, then it's off and away. So, when a spacecraft is in the L2 point, it needs to keep firing its thrusters to remain in that position, right?
Pamela: And more than that, it's not sitting exactly in the center of L2, it's actually in... forgive me, I'm going to mispronounce this... a Lissajous orbit that is centered on the L2 Lagrange point. So it's orbiting around the L2 point which is more like you can imagine yourself attached to a piece of string, bouncing around the top of the Matterhorn... well, a really big rope bouncing around the top of the Matterhorn.
Fraser: Right. Don't let go!
Pamela: Exactly. So it's out there, it's orbiting, but it has to have control thrusters anyways to be able to maintain its mission. It uses gyroscopes to do its pointing, but still... It has to be able to get where it needs to go and stay there.
Fraser: So it launched May 2009...
Pamela: Yes.
Fraser: And here we are, as we're recording this in early 2010, so what have they found so far?
Pamela: The first thing they did, of course, was take pretty pictures... because that's what you do when you have a brand new telescope is you take pretty pictures. And what's amazing is by looking at nearby big bright pretty stuff, they're already doing amazing science. They looked at a star-forming region in the constellation Aquila, and they were able to see through the dark, optically opaque gas and dust and make out the most amazing filament structures around the new-forming stars... where they can see knots that are significantly hotter and individual points where stars are just starting to collapse and heat up. Looking at these images, you can start to see how things are fragmenting, how

materials are flowing in the texture of this image. It's really quite amazing. Then they turned it outward, looking at the Virgo cluster. They have this really fabulous pair of images--one stolen ruthlessly from the Sloan Digital Sky Survey and then a comparison image that was taken in the infrared with Herschel--and what they're able to show very well is that as you look out from these giant elliptical galaxies that are so bright in optical light... they go away almost entirely in the infrared... they just don't have that much gas and dust. Whereas small spiral galaxies, rich in star formation, pop out as these bright sources of infrared light. Suddenly we're able to say Aha! You! You have gas and dust... and you--you are dead... you shall star-form no more... just by looking at things in a completely different color of light.
Fraser: Right, this is where these galaxies have already used up all of their gas and dust and so they're just going to age and die and just turn redder and redder, while others still have a little bit of dust left over. Herschel lets them see these stockpiles of dust.
Pamela: And it also lets us see the dust that we might not have noticed otherwise. In galaxy clusters there's a lot of galaxy-on-galaxy violence that takes place. There's what we call galaxy harassment, ram-pressure stripping, all of these horribly violent words get used, and what it boils down to is through varieties of different types of interactions between galaxies and the galaxies and the stuff between galaxies, you end up knocking gas and dust out of systems. In this Herschel image of the Virgo cluster, you can see extended emission from a long dust trail streaming out behind another galaxy, and so we're able to see where the dust is that's been removed from the optically luminous galaxies.
Fraser: We'll link to some of the pictures in the Show Notes, but the pictures coming out of Herschel are just beautiful. They're sort of in that same class as the Hubble... all the really beautiful nebulae... the Eagle Nebula, the Pillars of Creation... Some of the pictures are just amazing. No, it's all fake, right? It's all fake colors, right?
Pamela: We ignore that part.
Fraser: We ignore the fact that these aren't the real colors that you're seeing with infrared eyes, but these pictures are just great. The picture of the nebula in Aquila, there's a picture of the Southern Cross... the nebula in the Southern Cross, and one of M51... these were all released in December for some of the first science that came out from Herschel, and they're just beautiful pictures. And that's what really.... that's why that telescope was launched... was for me to be able to display beautiful pictures on Universe Today.... I believe is the reason... we should check into that, though.
Pamela: But beyond just doing the pretty pictures, there's also the occasional... you look at it and go "that's a lot of dots," those are nicely colored dots, but that's a lot of dots. One of the things that Herschel is participating in is the Great Observatory Origins Deep Survey--GOODS. This is a project that's taking many of the best observatories around the planet and around on the planet and peering at this one small area on the sky, roughly the size of the moon, that has nothing nearby in it. There's no Milky Way-based stars, there's no nearby large galaxies. This is an otherwise completely empty area on the sky. At the time of this release, they'd used Herschel for about 14 hours on this one section of the sky, which is nowhere near as much observing as they're going to do by the time they're done. In just that small 14-hour window, they were able to make out what looks like... looking at Christmas lights in a snowstorm is the best way I know how to explain it. It's just dots and dots and dots and dots and dots of all the shades between blue and red,

except for green because there's nothing green in the sky... at least not that the human eye perceives. These dots are galaxies all the way back to the first moments of the universe in the process of forming stars and sitting there glowing and evolving through time. So we're now able to--in a single image--look back, hopefully to the beginning. We need to start sorting out what are the nearby red galaxies, and what are the galaxies that appear red because they're at the very limits of what we're able to see. But, this is the first time that we're able to start resolving this color of light in the background of the sky.
Fraser: Are they able to see right to the background radiation? Or not quite...
Pamela: This we still have to sort out. To be able to say I have definitively seen back to the first moments of the universe you need to look at something... and these are just little fuzzy blobs on the sky. But, you need to look at the little fuzzy blob on the sky and find some way to figure out how far back in time it is, how far away it is in distance. They have spectrometers... we have other methods as well to get at that. The press releases are coming... they're not here yet... I'm sure over the next 3 1/2 to 4 1/2 years we're going to be seeing "and Herschel has confirmed..." galaxy at red shift "large number" looking back further and further into time.
Fraser: Right, and so what we're doing at this point is we are just shy of a year into this mission, and I think with Herschel, not a lot of really official news has come out yet just because these things take time. The scientists have to schedule their time, Herschel takes their readings, they take it back, they work on their journal articles, and then they start to publish. We're in that in-between time while they're still crunching the numbers and waiting to publish, so...
Pamela: Well, and it's still very much a baby mission. It launched May 14, and then it took it 60 days to get to the Lagrange point, and then once it was there it had to calibrate all of the instruments. So, we're still.... in terms of when they were able to start doing science, the science images only started coming out late June. So, we're just 6 months into the mission, and they're already starting to say this is what we can see.
Fraser: That sounds great.
Pamela: There's a lot of good things to come.
Fraser: Yeah, absolutely. We've got another 2 1/2 years of life in the spacecraft, and the news is just getting rolling. This is the time that I would recommend that you subscribe to Universe Today, and we'll be releasing all of the news as it comes out. Well, thanks a lot Pamela! I think this is great! It's really exciting that we can kind of get in at the ground floor and give people some perspective so that when they see news that comes out about Herschel, they can go oh yeah, right, that's that infrared telescope and it's only got a couple of years left, and really put that news into perspective and know what they're looking at. And like I said, the first pictures that have come out are amazing, they're beautiful... they're the kinds of things that you would frame up and put on your wall. They're just these beautiful colors of gradations of colors... it's quite amazing...
Pamela: And the thing that many of us are waiting for on the science side is all of the really ugly spectra...
Fraser: And numbers, and graphs.... I don't like to put that in the site...
Pamela: But those are the things that are going to tell us what molecules are in space and that's cool.
Fraser: Just one last thing... what would you say is like the biggest question that could be answered by Herschel?

Pamela: Herschel has the potential to look at the atmospheres of exoplanets and say I see the components that are created only through life.
Fraser: It has the potential...
Pamela: It has the potential... we need to find the right planet--it needs to be a planet that transits its star, and if those conditions are met, then we have the chance to be able to pull out molecules in that planet's atmosphere. And that would be very cool.
Fraser: That would be amazing. There's a bunch of missions that are zeroing in on that, and hopefully when James Webb finally shows up, we'll really have the tools at our disposal to find life.
Pamela: And in general, this is a chemistry mission. We talk about the pretty pictures, but this mission does chemistry.
Fraser: Yeah, but chemistry can tell you so much.
Pamela: Yes.
Fraser: Cool. Well thanks a lot Pamela! We'll talk to you next week.
Pamela: OK, bye-bye.