Astronomy Cast Episode 208

The Spitzer Space Telescope

Fraser: Astronomy Cast Episode 208 for Monday November 22, 2010, The Spitzer Space Telescope. 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. Hi, Pamela, how are you doing?
Pamela: I'm doing well, Fraser. How are you doing?
Fraser: Great. So just another plug... 'cause we're in this plugging mood... to clear out Pamela's spare bedroom. You can buy cool Astronomy Cast gear at astrogear.org, so check that out and support the show and impress your friends with your ?? t-shirt.
Pamela: And if you're in TAM Australia this week, which I know is very, very few of you because it's a very, very small event, we will have—and by we I mean I—will have some Astronomy Cast shirts there that the skeptic's booth has been friendly enough to allow me to sell there.
Fraser: Yeah, you're going to be... last minute, right... you're going to be doing part of The Amazing Meeting. You're going to be doing a talk there?
Pamela: Yeah, I have to admit I don't know what day I'm talking on yet. I'm going to be giving a talk on basically using curiosity and the scientific method to inspire curiosity and awe.
Fraser: Cool. And this was just last minute... I know that you... a month ago...
Pamela: Totally last minute...
Fraser: Yeah, you didn't even know that you were going to be there. Sorry we didn't announce it better. We really had no idea this was going to happen.
Pamela: There's nothing like a last-minute trip 180 degrees around the planet.
Fraser: Gee... whatever... travel—you're used to it. I just assume you're in a constant state of travel, unless told otherwise. Ok, well let's get on with the show. So last week we talked about Lyman Spitzer, and this week we'll take a look at the orbiting observatory that bears his name; the Spitzer Space Telescope. Designed to see into the infrared spectrum, Spitzer has returned images of objects that were previously hidden to astronomers by thick shrouds of gas and dust. Now I think you had kind of given a sneak peek of this week with last week about Spitzer, formerly known as SIRTF... which doesn't roll off the tongue as nicely.
Pamela: But it's kinda cool.
Fraser: What did SIRTF stand for?
Pamela: It was the Space InfraRed Telescope Facility. I think SIRTF sounded kind of cool... it sounds like a surf shop, but that's ok. You can laugh at me here... insert laughter...
Fraser: No, no, it's genuine! So... Space InfraRed Telescope Facility... so this was a from the ground up an infrared observatory but designed to be a space observatory. But I know that infrared is one of those wavelengths that do get through the atmosphere, so you don't necessarily need to go to space to see infrared.

Pamela: Well, actually you do. There's only very narrow bands in the infrared that get down to the surface of the earth. So if you're lucky enough to see what you want to see in these very narrow bands and at very high altitudes and on very dry days, and enough of these very-difficult-to-align characteristics all come into reality at the same time, then yes, you can get ground-based images. But the majority of the infrared wavelengths are best observed from outer space. There's also the problem that infrared is thermal energy, so from the surface of the planet, we're essentially looking through a brightly-glowing atmosphere. So even in the dead of night on the coldest of nights on the planet Earth, that sky is giving off its own infrared radiation. It's kind of like trying to observe the stars' invisible light at noon... sure, you could try but you're only going to be able to see the very brightest stars and you're never going to see them well because the sunlight is drowning you out. In the infrared, the atmosphere's thermal heat is drowning you out.
Fraser: Right. So for the perfect environment, you really need not only a cold telescope but a cooled telescope that's even colder than the background of space. That's when you can see those really subtle differences. Ok, so where did the concept of an infrared telescope space observatory come from?
Pamela: In the 70s and 80s NASA started developing the idea to have a set of Great Observatories. This began to become a reality in the 90s. The plan was to have the Hubble Space Telescope, an X-ray observatory, a gamma ray observatory, an infrared facility, and today those four great plans have become the Compton Gamma Ray Observatory, Chandra, which observes in the X-ray, Hubble, which is still going strong, and Spitzer which is now on the warm part of its mission. It does require an essentially expendable fuel in the form of helium. This one mission has gone through an amazing redesign from its conception to its launch. When they were designing these four missions, the plan was we were going to do everything all the time with the US Space Shuttle. It was going to be the wonderful device that went to space on a weekly basis, able to stay up there 30 days at a time, able to carry things up, carry them down, it was going to be a reliable pick-up truck that could haul anything. And it wasn't.
Fraser: A shuttle to space.
Pamela: Yes.
Fraser: Yeah. As opposed to a very complicated and delicate powerful vehicle that it turned out to be.
Pamela: Right. It's kinda like borrowing Grandpa's farm truck. You're pretty sure it's going to get you to the mall and back, but you're never completely convinced.
Fraser: Right... right... and so Spitzer... Hubble was carried on the shuttle, and Spitzer was designed to be carried on the shuttle, but that's not how it turned out.
Pamela: They actually had to redesign it. The original plan for this mission is, in retrospect, absolutely ludicrous. The idea was they were going to carry it up into space inside the space shuttle, use it attached to the space shuttle, bring it back on the space shuttle and just tote it to and fro so they could refurbish the liquid helium needed to cool it off on a regular basis. The problem with these missions is that even when you put them in space, they're still getting heated up by the planet Earth. So if you have an infrared facility that's orbiting the planet, it's going to blow straight through all of its coolant trying to protect the spacecraft not just from the heat of the sun but the reradiated heat of the earth. It was a great idea up until, unfortunately, we had the Challenger explosion. Challenger forced a lot of things to change. One of the things that happened was not only

did they say, ok no more carrying stuff back down from space, but they also said some of the chemicals you're planning to launch with SIRTF, you can't launch anymore. So they had to take this wonderfully strangely-planned yo-yo of an infrared telescope and redesign it to launch on a smaller Delta rocket and the smaller Delta rocket and the not bringing it back down to the planet on a regular basis meant that the coolant couldn't get regularly recharged. Not only that, but due to weight considerations, they couldn't carry as much coolant. And this set of complications led to an actually really revolutionary design. Some concepts of which are getting stolen for the James Webb Space Telescope.
Fraser: Can you give me some examples?
Pamela: The biggest example is the sun shade that it has. If you look at images of the Spitzer Telescope, there's the standard telescope tube in the center, but then the spacecraft components are on basically supports with a gap between the electronic parts of the spacecraft and the tube and optical assembly of the space telescope. Then inside all of this is this weird "why is that there" basically fin of material, or section of a tube of material, and that random extra bit that sticks off the side—that's providing the spacecraft with shade... protecting it from getting heated up by the sun's light.
Fraser: So it's like it's carrying around its own umbrella to protect the spacecraft from just even a slight amount of heating from the sun. That allows its coolant to last longer.
Pamela: A pre-installed parasol, you might say.
Fraser: Yeah, and if you see the models... you're exactly right. If you see the model of the James Webb, they've taken that to the next level. There's this huge sun shade being used to keep the spacecraft cool.
Pamela: And the other neat thing that they're doing with Spitzer that's different than what they're doing with James Webb is with both spacecraft you want to protect them from Earthshine to allow their coolant to last absolutely as long as possible. With James Webb they're sticking it out basically in the shadow of the moon. With Spitzer what they're doing instead, instead of having it orbit the planet Earth, they're having it orbit the sun. So when it got launched, it got launched with an escape velocity that put it in a trailing orbit where every year it lags a little bit further and further behind the earth. Right now if you look at maps showing from a top-down perspective on our solar system where Spitzer and the planet Earth happen to be located, if the solar system were a clock, they're about an hour and a half to two hours apart on that clock.
Fraser: That's crazy that you would want to keep the telescope away from the earth so that it wouldn't be heated up by the reflected sunlight bouncing off the earth... but they're serious about keeping this spacecraft cold!
Pamela: This mission was all about insane things to get good IR data. So if you're not going to treat it like a yo-yo on the space shuttle, then stick it in a screwy but completely successful orbit.
Fraser: And this is great... with Hubble, they wanted to keep it close and they wanted to be able to upgrade it, and that's one whole philosophy. And it's worked quite well... they've gone back up to Hubble and they've repaired it. In some ways they've repaired it in ways that no one had ever expected they'd have to repair it. But you take this other philosophy and you say let's put it in the most useful place it could be to get the best science but let's build it right the first time and not or not even... let's make due with what we've built and not think of ways to upgrade it later. Both philosophies make a lot

of sense... Spitzer is that second philosophy which is that it's going to become unreachable and so it had to be done right the first time.
Pamela: And part of that difference that you're seeing is the difference in when they were built. Hubble was the first of the great observatories to be assembled, and Spitzer was the last. Hubble was already complete when the Challenger had its accident. Because of that it basically was done. They weren't going to retrofit it in any way to rescue it from the changes that were forced upon it by all of the new regulations. It was designed to come back down to Earth, it didn't get to do that. Instead, we redesigned how we handled it. With Spitzer, it wasn't assembled yet, so they had the chance to go through and rethink their design and re-engineer what was getting done to meet the mission's goals in a new and very creative way.
Fraser: So it was launched, as you said, launched in 2003... August 25, 2003, on a Delta-2 rocket into a solar orbit trailing the earth... and then what happened?
Pamela: Then it started changing our perspective on the universe. It's really made a series of amazing discoveries over the course of its life. For the first several years... in fact up until May of 2009... it was cooled with liquid helium down to a temperature of about 4 Kelvin. This allowed it to not just peer into the interstellar medium but peer through the interstellar medium to see what was on the other side of all the clouds of gas, all the clouds of dust that blocked our view of the center of the galaxy. It allowed us to see in detail the star formation going on in neighboring galaxies and to basically see fragments of stellar remnants, details of planetary nebula that we never quite imagined.
Fraser: This is really significant. You can imagine as an analogy you look around your town and there are patches of fog that you could just never see into. You had no idea... you had an idea that there were probably buildings in there.... but you have no idea what's in them. For the first time this observatory could actually pierce through the stuff and reveal. If you see them.... so many of the images that you're going to see on Universe Today and others, are these Spitzer images. It's become such a valuable instrument for peering through this stuff. We're seeing pictures that nobody had any way of seeing before Spitzer.
Pamela: And some of the most fascinating ones are the images of the Bok globules. In visible light, these are giant clouds of nothing... it's the Neverending Story eating the galaxy. But then you look at these nothings with Spitzer, and suddenly you're seeing starlight from the other side.
Fraser: And so what's the process that's going on here? Why are we not able to see this stuff, and then we're able to see it with Spitzer?
Pamela: Well, what happens is as light in all the different colors of the electromagnetic spectrum passes through the different media, gas... dust... various materials, it gets absorbed. The colors of the light that get absorbed depend on two different things. One, the shorter wavelengths in the visible light are the first to go. This is in many cases just simple Rayleigh scattering. The blue light passing through gets absorbed and then re-emitted in all sorts of random directions. This diminishes the amount of blue light that goes straight through the cloud. This is where certain nebula if you view them face on with a bright star behind the nebula and you look through the nebula at that bright star, you see it as red. Whereas if you see the light reflected off to the side where the star is to the left and the cloud is straight in front of you, then the nebula will appear blue because you're not seeing the direct light from the star, you're only seeing the reflected blue light

from the star. As more and more of the blue and the yellows, as all of these visible wavelengths get scattered in random directions, that only leaves the infrared to make it through the gas and clouds and dust. So that's where we have to go to see through the dust is we have to look in the wavelengths that can traverse that distance of material.
Fraser: And with Hubble... Spitzer has turned up discoveries that I don't think the astronomers ever suspected that they were going to be finding. It's been used to look for extrasolar planets, to look at newly-forming stars, it's been looking at the core of galaxies, it's looking out to the limits of the universe... So what are the big highlights to come out of Spitzer?
Pamela: Well, I think my favorite result to come out of it was the astronomers Alexander Kashlinski and John Mather they went back and looked at one of the original test images that was taken with Spitzer... one of the original pretty pictures they took to prove the telescope worked. When they looked at it they realized that once they accounted for all the known sources of light, all the things they knew were there from visible images, there was still numerous blobs left behind. They realized that this background light, this glow, was probably from stars that formed as early as 100 million years after the Big Bang. So quite by accident we captured the first starlight while making a pretty picture.
Fraser: And this is one of those situations where the telescope gives you this tantalizing glimpse at what might be these first stars, and this is where James Webb should come along and give us the real view. But still, the earliest stars is amazing. Spitzer was the first to directly observe an extrasolar planet.
Pamela: And that's part of its continued warm mission. Unfortunately, about a year ago... well, not even that... more than a year ago now... back in 2009, Spitzer ran out of helium. But some of its instruments were designed to keep working even once the telescope warmed up to its current temperature of tens of degrees Kelvin.
Fraser: Yeah, this is all part of the plan.
Pamela: And so they still have a working telescope, it's still within communications of the Earth... at some point it's going to pass behind the sun and we're going to lose our ability to talk to it for a while, but we can still talk to it, it's still functioning just fine, and as we find planets that transit in front of their parent star, Spitzer's able to catch the reflected sunlight. We're also discovering weird stuff with it. There have been planets found that don't pass directly in front of their parent star, they pass above and below it as they go round and round on a tilted orbit. We've noticed that there's hot spots on some of these planets, and the hot spots aren't at the noon position in the atmosphere. They're not directly on a line between the center of the planet and the star. Trying to understand how you get this weirdly-located hot spot is leading atmospheric planetary scientists to have to work all sorts of cool stuff with their models.
Fraser: But... I mean... that is mind-bending.
Pamela: Yeah...
Fraser: You know, that Spitzer is seeing the atmospheres of planets orbiting other stars with such a resolution that they can see where the hot spots in the atmosphere is and it doesn't match up with their expectations... so it's another puzzle. But, you know... atmosphere! Hot spots in atmospheres of other planets!
Pamela: And here it starts to just become a matter of combining excellent data with just really brilliant thinking. We can only see 50% of a planet at a time... that's one of the problems with only being able to see things that appear in the flat of the sky. By timing

when we see a planet brightening, we can figure out where east to west as it rotates a bright spot appears. So we don't know exactly where the hot spot is, but thanks to timing, we can figure out where along a band on a planet these hot spots are located. It's just amazing science that they're still pulling out of this. They're studying active galactic nuclei, they're finding Bucky Balls... carbon molecules shaped like soccer balls... and obscured supernovae. These are just all fabulous things that we just can't get at from the surface of the earth.

Fraser: The youngest star ever seen was found a couple of years ago. I think one of my absolute favorite images... I wasn't there for this, but I think you were there at the American Astronomical Society... where they had just spent hundreds of hours observing the Milky Way, the central core of the Milky Way and out into the arms, and they blew up these huge posters of these images and had them available at the meeting.

Pamela: Yeah, this was one of those times where in order to see what they had done at roughly full resolution—I don't think it was even at full resolution—they had to cover a convention center wall down much of the length of the wall with this printout of this survey. It was an infrared image of across the center of our Milky Way. That was just fabulous.

Fraser: And it completely changed our understanding of the structure of the center of the Milky Way. Once again, once you can see past this fog, you've just got all this additional information you can get. It's just astonishing. It's been going for 7 years... we can spend 2... 3 shows talking about all of the wonderful science that has come back from Spitzer. But, what would you say is the core science that is kind of leading astronomical thinking these days? I know a lot of this has sort of gone into the planning for the James Webb, right?

Pamela: I would have to say that this is one of those times where NASA built an extremely versatile instrument that hasn't just taken one area of science and brought it leaps and bounds further along, but instead it has built an instrument that's allowed science ranging from the study of asteroids in our own solar system to studies of the chemistry of clouds in our Milky Way to studies of the accretion disks around black holes in other galaxies to studies of the very first stars turning on in the first hundred million years of our universe. All across all the different times of our universe and scales at which we study things, Spitzer has been able to have an impact. That really speaks to the power of building these great observatories.

Fraser: And so where we stand right now, as you said, we're a couple of years after the helium ran out. So what science can it no longer gather?

Pamela: It can't go into the longest wavelengths that it used to be able to study. So it's not going to be able to see the same sorts of things embedded in the interstellar media, it's not going to be able to do the same studies of newly-forming stars, and perhaps saddest of all, it no longer is able to use its fabulous spectrographs... so our ability to study the chemistry of many of these different things is completely gone until we get a new telescope. But it still has its imaging abilities in the shortest of its wavelengths so we're still doing the extra solar planets, we're still doing the asteroid studies, we're still looking at AGNs. So, we can't measure the chemistry any more, can't peer through the same levels of dust and gas, but there's still lots of fabulous stuff that it can do.

Fraser: And then what is the overlap between the capabilities of Spitzer and the James Webb? Because the James Webb... a lot of people say it's the successor to the Hubble

Space Telescope, but I think it's much more appropriate to say that it's the successor to Spitzer.
Pamela: I completely agree with that. Yeah, Hubble does infrared but it's not what it was designed for as its fundamental mission. Spitzer is definitely the intellectual parent to the James Webb. The way I think of it is the difference between a really cruddy kind of hard to focus old television stolen from Grandpa and a brand new high definition plasma screen... if that's the superior technology... I admit I'm not up on my TVs.
Fraser: Right, but the kinds of instruments are going to be very similar, it's just that you're going to have a much more sensitive telescope to see further and deeper.
Pamela: It's the double whammy of both being able to see much fainter objects because it's a much larger light-gathering area and it's a much more sensitive set of instruments, but not only are you going to be able to see the much, much fainter objects which gives you a greater contrast, but you're going to be able to see them at a much, much higher resolution. So it's this combination of more pixels and more sensitive pixels that are essentially going to allow us to see the beginnings of everything.
Fraser: Yeah. And so at some point we'll cover James Webb in more detail. We keep waiting... we keep waiting for it to launch. Then we're like... oh, should we talk about it before it launches and really go into it? Or wait until there's some science results?
Pamela: At some point we're going to give in because Webb just keeps getting pushed further into the future. But what's interesting is that we've now covered many of the named observatories: Kepler, Hubble, Spitzer, Chandra. All of these missions were named after they had successfully sent images back down to earth, although Hubble's images were a bit out of focus. Spitzer was in fact named by public opinion. It was one where they allowed the public to have a say in what it should be named. James Webb wasn't named after a scientist so much... and it was named pretty much as soon as it was funded, so this is a major break from tradition and there is this back of the heart oh no is that like wishing an actor good luck instead of break a leg. But hopefully we haven't cursed it with Congress or anything like that.
Fraser: Great... well, I think that's great. If you've got a little time, go to Google and type in Spitzer telescope, click on images and just look at some of the beautiful images because like Hubble the pictures from Spitzer are beautiful. They're meaningful for science and they're just gorgeous to look at. You would be happy to have them on your wall or as your screen saver.
Pamela: And if you have an account in Second Life, they've done this amazing fully walk-through exhibit of the large survey that Spitzer did. This is the GLIMPSE and MIPSGAL survey... Galactic Legacy Infrared Mid-Plane Survey Extraordinaire... the one that we were talking about from the conference wall. You can actually walk through that in the virtual reality of Second Life at the Astronomy 2009 Island... and that was put together by Adrienne Gautier.
Fraser: Cool! Well thanks, Pamela, and we'll talk to you next week.
Pamela: Sounds good. Talk to you later, Fraser.