Blueshift - Episode Three

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Sara: Welcome to the June 2007 episode of Blueshift, produced by the Astrophysics Division at NASA Goddard in Greenbelt, Maryland. I'm Sara Mitchell.

Mike: And I'm Mike Arida.

Sara: Okay, Mike, I have to ask... what are those ridiculous glasses?

Mike: These are my X-ray specs! I heard we were learning about X-rays today, and I just had to get them to be prepared.

Sara: Well, Mike, we use satellites to study X-rays around here, not cheesy glasses.

Mike: Oh, that's probably why I got them for such a low price.

Sara: Well, the kind of X-rays we're talking about today aren't the kind you get at the doctor or the dentist, where they're shooting X-rays from a machine and looking at shadow of your bones or your teeth. We're actually talking about catching the X-rays coming from objects deep in space.

Mike: That's right! There are a lot of NASA scientists that study X-rays coming from space. They study black holes, supernovae, active galaxies - in fact, there are several satellites up in space right now, looking at these X-rays and trying learn more about these objects.

Sara: That's right! Well, since we study this right here at Goddard, we actually sent a microphone out into the field - up and down the hallways, bugging the scientists to hear about what they're studying.

Mike: They love that.

Sara: They do love that. So, Koji Mukai and Maggie Masetti will report back on what they had to say.

Mike: And Louis Barbier spoke with Curtis Odell, and we'll hear about how some of our X-ray satellites are designed and put together.

Sara: And finally, we'll get a behind-the-scenes tour of the Astronomy Picture of the Day website, which brings new images and information to millions of viewers around the world each day.

Mike: Let's start things off with a brain teaser - and here's Louis Barbier.

Louis: Since this episode is all about X-rays, this question is about one of the satellites up in space that we use for studying X-rays.

In 2005, a new X-ray satellite was launched. This satellite was built by the United States and Japan, and we called it Astro-E2 for years. But after it was launched, it got a new name -- Suzaku. So here's your question:

Why was the Astro-E2 satellite given a new name?

The choices you have to choose from are:

A. The newly-elected Japanese government exercised its right to name all spacecraft

B. The Hitachi Corporation was outbid by Suzaku, Inc. for naming rights

C. It's a Japanese tradition to rename spacecraft after they are launched

D. The name Astro-E2 was already being used by a British heavy metal band

Stay tuned, and I'll give you the answer.

[music]

Sara: Now here's Koji Mukai and Maggie Masetti, with a bit more about X-rays and what we can find out about them.

Koji: Hi, I'm Koji. Maggie and I are here to tell you a little bit about X-ray astronomy today. X-rays are emitted by some of the most extreme objects in the universe, like black holes.

Maggie: But what exactly are X-rays?

Koji: X-rays are actually a form of light that is higher in energy than visible light. Our eyes can't see X-rays, but we can build detectors that can! Since our atmosphere absorbs X-rays...

Maggie: ...and it's a very good thing for us that it does...

Koji: ...to study objects that emit X-rays, we have to put our instruments on board satellites.

Maggie: And that's one thing we specialize in here at the ASD.

Koji: We just celebrated the 11th anniversary of an X-ray satellite called the Rossi X-ray Timing Explorer...

Maggie: ...which is quite a long name, so we call it RXTE for short.

Koji: 11 years is quite a long time for a satellite, but RXTE is still going strong.

Maggie: RXTE's strength is actually its ability to detect very fast changes in the intensity of X-rays coming from things like black holes, and neutron stars, all of which, due to their natures, are variable sources of X-rays.

Koji: Meaning their X-ray brightness isn't constant.

Maggie: That's right! We might see pulses of X-rays from a rotating neutron star! Or some objects might give off bursts of X-rays.

Koji: Exactly. Like, when matter spirals into a black hole and heats up!

Maggie: We can even actually translate X-ray data into audio signals, so that we could listen to a black hole.

Koji: That's what Ed Morgan of MIT did. He took data from a black hole called GRS 1915+105...

Maggie: ...that is quite a name...

Koji: ...and made this sound file that we'll play for you. Maggie's going to tell you what to listen for.

Maggie: What you're going to hear is roaring noise, which is turbulence in the disk of matter that circles the black hole (and we call this disk the accretion disk). The thumping noise is instabilities in the accretion disk. And te whistling noise is the accretion disk vibrating.

[the sounds of black hole GRS 1915+105 - roaring, thumping, and whistling]

Koji: We spoke with Craig Markwardt to learn a little bit more about what happens when matter spirals into a black hole.

Craig: People often think of a black hole as a vacuum cleaner that sucks up everything in its surroundings. In reality, matter usually approaches a black hole in a very ordered, disk-like structure. Although we can't see into a black hole, because it is black, we can use RXTE to listen to the vibrations of that disk, like vibrations of a drum head. RXTE hears higher pitched vibrations than any other satellite, which means that it can listen to the sounds of the matter right before it plunges into the black hole.

Maggie: 11 years into its mission, RXTE is still discovering new X-ray sources, like the black hole we just talked about.

Koji: Some scientists use the instruments of another X-ray satellite, called Suzaku, to look at the spectra of these sources.

Maggie: Can't one satellite do it all?

Koji: No, actually, it can't! Different instruments are designed for different purposes, and use different technologies.

Maggie: Suzaku, a newer satellite, has been designed for spectroscopy, and it can get much better resolution with its new technology.

Koji: So what do we mean when we talk about the spectra of these X-ray sources?

Maggie: Well, spectroscopy is simply the science of measuring and graphing the intensity of light at different energies. X-ray light contains a range of energies within it, just like visible light ranges from reds to blues.

Koji: And by studying the intensity and the energy of the X-rays, we can learn a lot about the source that emitted them. For example, iron atoms emit X-rays of a particular wavelength. But around a black hole, that iron atom may be moving fast - close to the speed of light, in fact. That creates a huge Doppler shift.

Maggie: And I know you all know what Doppler shifts are - that's like when a police cars siren sounds higher or lower, depending on whether it's coming towards you or away from you.

[siren sound]

Koji: Preferably away!

Maggie: Most definitely! So, matter circling a black hole might be moving towards us or away from us as well, and we can tell this from the black hole's spectra.

Koji: That's right! Blobs of matter moving towards us will emit X-rays that are blueshifted. And, that's a nice tie-in to the name of our podcast!

Maggie: Which is entirely coincidental, I'm sure.

Koji: Ahem. Anyway, we spoke to Jean Cottam, who is a scientist in our lab who has used data from Suzaku to study black holes and neutron stars.

Jean: We study the light emitted from hot spots of matter that spiral into a black hole. These generate broad emission lines in the spectrum. The details of the line shape tell us a lot about the nature of the black hole, and the conditions in the matter surrounding it.

Koji: Thanks, Jean. X-ray astronomy really is a great way to learn about black holes.

Maggie: That's very true, and hopefully now you know a little more about them than you did before.

Koji: Okay, that's it for now! Thanks for listening! I'm Koji...

Maggie: And I'm Maggie.

[music]

Sara: Thanks, guys. I can't say I'd ever heard a black hole before. Mike, had you?

Mike: Uh, nothing like that!

Sara: It's probably not going to be a chart-topper this year.

Mike: Well, we've heard about the ways that we're studying X-rays and what we're looking at. But now we wanted to talk a little bit about the satellites themselves.

Sara: Well, one of the things that happens here at Goddard is the development of new satellites - many satellites have actually been built right here! And sometimes, we build parts of satellites that are put together other places in the world. So, Louis Barbier sat down with Curtis Odell to talk about the X-ray satellites that have been worked on here at Goddard.

Louis: I'm here this afternoon to interview Mr. Curtis Odell, who's the instrument manager for Astro-E2 X-Ray Telescope. Astro-E2 is now known as Suzaku, as you all know. And Curtis has been here at Goddard for 18 years, and he's an expert in the art of making X-ray mirrors and X-ray telescopes. So Curtis, thanks for being here.

Curtis: You're welcome.

Louis: When I was in high school, I made my own telescope. I got a piece of glass, and ground it down by hand for many, many, many months, and got a little lens from my father, and put it all together and made myself a refracting telescope. Why can't I do that for X-rays?

Curtis: Well, Louis, the X-ray photons won't be bent by that lens that you made.

Louis: If I wanted to make an X-ray telescope, can you give us a big picture of what we'd have to do to go about that?

Curtis: Well, you'd have to do something that would cause a reflection of the photon onto a detector. And even a reflector telescope that you might think of for optical telescopes would not work either, because the photon would simply strike the surface and be absorbed. It would not reflect. However, if you took that reflecting surface, a reflector telescope, and turned it up on its edge, so that it was almost edge-on to the source of the X-ray photons, then the photon would reflect at that shallow angle we call a grazing incidence angle.

Louis: Could you explain exactly what you mean by grazing incidence?

Curtis: You're driving down the highway, and you're kind of drifting off a little bit, and you go off the shoulder of the road and you bounce off the guardrail and right back onto the highway. That's a grazing incidence angle. You didn't hit it head-on, you just sort of touched it and came off.

Louis: So that's what you call a grazing incidence. To come back to my telescope I made in high school, the lens was about 3 or 4 inches across. How many inches, so to speak, are your X-ray mirrors?

Curtis: The diameter of the ones that we produce for Astro-E are 16 inches - 40 centimeters. But that doesn't tell us the same information that your refractor told us.

Louis: And why not? Can you explain why?

Curtis: Well, now, remember we turned our reflector up on its edge. And so now that we've got it up on edge, we have a lot of room in our 40 centimeter diameter telescope to nest a whole bunch of concentric reflectors around from the outside inwards.

Louis: Okay, so if I were to look at this thing from the top, looking down, I would basically see a series of nested cylinders, is that a good analogy?

Curtis: Right. Nested thin-walled cylinders. That's correct. Actually, 175 to be exact.

Louis: Okay, well that sounds great! Well, Curtis, I want to thank you very much for coming into the studio today. This is Louis Barbier, for Blueshift.

[music]

Mike: Thank you, Louis! To see video clips about the Suzaku telescope, visit our website at universe.nasa.gov/blueshift. We also have more about X-rays and the missions you've heard about today.

Sara: NASA has satellites out there studying all sorts of objects... stars, galaxies, black holes, planets... and there are even some that look back at Earth. These satellites send back all different types of data. Some are really pretty pictures, and some are pictures that only scientists find pretty.

Mike: I'm sure you've seen some of these images - fields of stars, swirling galaxies, up-close views of objects that look like tiny dots when you look up at the night sky.

Sara: Well, for the past decade, the Astronomy Picture of the Day website has been showing off pictures from all sorts of telescopes. Every day of the year, they put up an image with lots of information about what you're seeing.

Mike: And one of those astronomers, Jerry Bonnell, works right here at Goddard. So Steve Fantasia paid him a visit to find out more about the Astronomy Picture of the Day and all of those pretty pictures.

Steve: For over a decade, the Astronomy Picture of the Day Website, apod.nasa.gov, commonly known as APOD, has been delighting viewers with pictures from all over the Universe. It gets somewhere around a million visitors every day, has over 20 mirror websites around the world, and has been translated to more than 10 foreign languages. I'm Steve Fantasia, and it is my great pleasure to have with me today Dr. Jerry Bonnell, one of the curators of the APOD website. Hi Jerry, welcome to Blueshift.

Jerry: Hi, Steve.

Steve: So, just how did APOD get started?

Jerry: The short answer to that question would just be over lunch. My good friend and colleague and former officemate, Bob Nemiroff, and I were discussing over lunch one day what the World Wide Web might actually be and how we could explore it. And of the many projects that we came up with, to sort of play around with the World Wide Web, Astronomy Picture of the Day was one of them that the two of us thought we could have a good time with.

Steve: So, you're talking about the start of the web. So how long has it been going, then?

Jerry: That would have been in 1995. The first Astronomy Picture of the Day was actually on June 16, 1995.

Steve: So for two people, for twelve years, that's quite a commitment! Why do you guys do this?

Jerry: Well, believe it or not, after twelve years, it's still fun. I guess that's the reason that I really still do it. As an astronomer, in my research, I tend to concentrate on just very tiny little specific areas. But doing the Astronomy Picture of the Day really forces you to step back, at least occasionally, and, you know, look at the bigger picture. See what all is going on. And I really like that.

Steve: Do you have any idea what the favorite image of all time might be?

Jerry: I know if you just judge by hits to the website, it was an image of planet Earth at night. It was a composite of satellite photographs, which were mapped out into the whole Earth showing the distribution of lights. That was an extremely popular one a few years ago.

Steve: Alright, thank you Jerry for your time, and for APOD.

Jerry: Sure.

Steve: For Blueshift, I'm Steve Fantasia.

Sara: Thanks, Steve. You can learn more about these stories at our website. Visit us online at: universe.nasa.gov/blueshift

Mike: Well, you had questions... and we have answers. Joining us now are Jim and Beth, to answer a question for the mailbag.

Jim: We recently received a great question: Do we know what's happening this very second in the most distant parts of the Universe?

Beth: Well, let's think about it. How do we find out what's going on out there? To answer this, we just happen to have a good analogy, a comparison - and we love these!

Jim: Let's say you have a friend who lives far away. She writes you a letter and mails it on Monday, but you might not see it until Thursday or Friday, or next week, or even next month... depending on how far away she lives.

Beth: So by the time you receive it, any number of things could have changed. She may have cut her hair, or sold her car, or even started a new job. But by reading the letter, you only have information about her from the day she wrote it.

Jim: Now here's the analogy part: Light is like the letter. Light gives us information about objects in the Universe. In fact, it's almost the only information that we have.

Beth: And you probably know that there is a limit to the speed of light.

Jim: Right. In space, light travels at 300,000 kilometers per second. That's 186,000 miles per second. You know, I once had a Chevy Nova that went that far, but it took me 14 years to do it.

Beth: That's pretty impressive, Jim!

Jim: Which part? The fact that the Chevy Nova that went that far?

Beth: So anyway, this means that the light from an object 186,000 miles away reaches you one second after it leaves the object. So light from an object 100 times as far away will reach you in 100 seconds. And light from the Sun takes 8 minutes to get here.

Jim: I think I know where this is going! Light from the next nearest star takes about 4 years, and light from the most distant object astronomers have ever detected takes 13 billion years to reach us.

Beth: So all we can learn about those particular galaxies and stars is information from 13 billion years ago - from an object that may be 80 billion trillion miles away! So, no, we don't know what's happening right now in distant parts of the Universe, because the light takes so long to get here.

Jim: So the good news for astronomers is that this time lag allows us to study the Universe as it was 13 billion years ago. But how can we learn anything about those most distant objects as they are now?

Beth: Well, for some of them we have similar objects near us, and we can learn a lot by comparing them. But for objects like quasars and gamma-ray bursts, we don't have obvious cousins anywhere near us.

Jim: For these, we have to build computer models based on our knowledge of physics to better understand their evolution and fate. You could say that we are creating physical movies of their lives, as we learn more about them.

Beth: You do like the movies, don't you, Jim?

Jim: Oh, sure, I do!

Beth: So have you seen any crazy movies about this topic? "The Strange Case of the Cosmic Rays" was quite a hit last month.

Jim: No, no, nothing I can think of, oh but wait a minute! How about...

Beth: I'm sorry, but we are gosh darned outta time, Jim. We would love to answer more questions from our listeners, so send us yours.

Jim: This is Jim...

Beth: ...and Beth...

Jim: ...signing off.

Sara: Now it's time to get the answer to that brain teaser. Are you ready, Louis?

Louis: Why was the Astro-E2 satellite given a new name?

The answers you have to choose from were:

A. The newly-elected Japanese government exercised its right to name all spacecraft

B. The Hitachi Corporation was outbid by Suzaku, Inc. for naming rights

C. It's a Japanese tradition to rename spacecraft after launch

D. The name Astro-E2 was already being used by a British heavy metal band

The correct answer is C, it's a Japanese tradition to rename spacecraft after launch. Now, why Suzaku? Well, as you heard earlier in the episode, Suzaku is an X-ray mission to help us learn more about extremely energetic objects, like neutron stars, galaxies, black holes, and supernovae. All the hot stuff out there in the Universe! Before launch, we called it Astro-E2... the latest in a long line of satellites with very clever names like Astro-C, Astro-D, Astro-E... you see how that works?

Anyhow, the answer is C, it is a Japanese tradition to keep a satellite's final name a secret until after a successful launch. So after years of calling it Astro-E2 while it was being designed and built, it was launched into space in 2005 and given its new name -- Suzaku. Now for those of you out there up-to-date on your Chinese and Japanese mythology, and I'm sure that's most of you, will recognize Suzaku as the vermillion bird of the south and a symbol of renewal.

Well, this is Louis Barbier, and we'll be back next time with another brain teaser for you.

Sara: For Blueshift, I'm Sara Mitchell.

Mike: And I'm Mike Arida. That's it for this episode. Next month, we'll be talking with our favorite Nobel Prize winner, Dr. John Mather.

Sara: He actually works right here at Goddard! Don't forget to send us your comments and questions through our website at: universe.nasa.gov/blueshift

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