Blueshift - Episode Two

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Maggie: Welcome to the May 2007 episode of Blueshift, produced by the Astrophysics Science Division at the NASA Goddard Space Flight Center in Greenbelt, Maryland. I'm Maggie Masetti.

Steve: And I'm Steve Fantasia. We're bringing the Universe closer to you each episode with new stories about the Universe we live in, and interviews with the people who study it. You can find us on the web at: astrophysics.gsfc.nasa.gov/podcast

Maggie: This month, we're talking about matters of life and death.

Steve: Ooh, that sounds really serious...

Maggie: Well, you know, the Universe is very dramatic - explosions, dying stars, colliding galaxies, and those mysterious black holes, pulling in matter and warping the space around them.

Steve: There are also new objects being born, like stars and planets.

Maggie: Did you know that lots of planets have been detected outside of our Solar System, orbiting other stars?

Steve: Actually, I did.

Maggie: Oh. Well, in fact, hundreds of planets have been found with new ones being discovered daily. Maybe some of these planets are just like ours! We'll be talking with a scientist who is very interested in discovering and understanding these planets.

Steve: But first, Louis Barbier will start things off with this month's brain teaser.

Louis: Hi there, everyone! We're talking this episode about all of the planets out there in the Universe. And here's your question, so pay close attention.

How many Earth-like planets have been discovered orbiting other stars in the Universe? Is the answer:

A. Nada, none, zero
B. A big 10
C. 100
D. 1000 (that would be B times C, for you math whizzes)

Think you know the answer? I'll be back at the end of the show to fill you in and see if you've earned a gold star this episode.

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Anita: The first planet orbiting a normal star outside our Solar System was discovered not all that long ago, in 1995. Since then, astronomers have gone on to discover more than 200 planets, and the count is going up almost daily. The search for these other worlds and studying their properties is a very exciting area of research in astrophysics today, and we have an active group working in this field here at Goddard. This is Anita Krishnamurthi, and joining me today is Dr. Jennifer Wiseman, head of the Lab for Exoplanet and Stellar Astrophysics in the Astrophysics Science Division at NASA Goddard Space Flight Center. Hi Jennifer, I'm glad you could join us today.

Jennifer: I'm glad to be here.

Anita: This study of exoplanets has just exploded in the past decade, hasn't it?

Jennifer: It's a very exciting time for astronomy right now, because we are finding planets around other stars and this is a question that humans have had for centuries - is whether or not there are planets similar to our own around other stars, and now we know the answer is, "Yes."

Anita: Can you start us off by setting the stage a little bit on exactly what it takes to find these planets?

Jennifer: Planets are very difficult to see. They are dim, they don't emit their own visible light - they only reflect the light from their parent star, so that makes them hard to see, in that sense. They're also small, so if you add together those two properties of planets around other stars, it means they're hard to find. So astronomers have to be somewhat like detectives, and use mostly kind of indirect techniques to find planets around other stars.

Anita: Sounds really hard! So why are we finding so many, now? I mean, why 200, now, as opposed to ten years ago?

Jennifer: Well, the technology that we have now is much better than even in just recent decades. So we now have the sensitivity, and much of this is done from ground-based telescopes, to find very small changes in the frequency of light from these stars, and that shift in frequency is what we call Doppler shift. It tells us that the star is moving back and forth a little bit, that tells us that the planet is tugging on the star. And we also have had some time to survey many, many stars to see exactly how many of them have this kind of cyclic pattern of motion, so that's given us the time to detect some of these planets, especially the ones with shorter orbits. Those are the two main things that have helped us recently.

Anita: So this is clearly a very active area of research today. Where is this field going next?

Jennifer: Well, the big questions are being answered step by step, so I think what we would like to know first of all is how many stars have planets orbiting them, and what kinds of planets. Do most stars have big Jupiter-like planets? Do most of them have smaller Earth-like planets? The near-term future for that question looks bright because we have a NASA mission launching next year that's called Kepler, that's designed to survey many, many stars in a distant starfield toward the center of our Galaxy, looking for transits - looking for systems where the planet is orbiting and eclipsing between the star and us (as the observer). And through this mission, we'll be able to do some statistical studies on how many stars have planets and what those planets are like. That'll tell us how common it is for us to have Earth-like planets in solar systems. Then we want to know how many of these sort of terrestrial planets have atmospheres and compositions that are similar to our own. So our future goal is to develop missions that can both take pictures of these planets and take spectra of them, that is, to decompose the light into the different frequencies emitted by different elements like oxygen, or molecules like water. And that can tell us whether or not these planets can support life. That's something that we have as an ultimate goal.

Anita: A lot going on! So, is your lab involved in developing any of these missions that you mentioned?

Jennifer: Our scientists are involved in just about every aspect of this question of extrasolar planets. We have some scientists that are involved in developing missions that would be able to actually block out the starlight, so that you could see the very faint material around the star, including planets and the material from which planets form. That mission that we're looking toward is called the Terrestrial Planet Finder mission, and we have different techniques in development to consider for that mission. We have scientists, both in our lab and in other NASA laboratories, that are interested in looking more precisely at the stellar motions - that wobble I mentioned to you - using astrometry, such as will be used in the Space Interferometry Mission, and also using very precise techniques for looking at the line-of-sight wobble or even transits, as I mentioned to you, for different types of stars. We're also interested, in our lab, in the upcoming James Webb Space Telescope that's set to launch in about 2013. That telescope will be a large infrared facility, and will be able to both characterize the regions around stars where planets are forming, and maybe even characterize some of the planets themselves. So that's another future excitement that we have, just around the corner.

Anita: Thank you very much for joining us today, Jennifer. It's been great talking to you and hearing about all the work in this field and what your lab does.

Jennifer: My pleasure.

Anita: For Blueshift, this is Anita Krishnamurthi.

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Maggie: Thanks, Anita. That was really interesting.

Steve: Now we're going to talk about another fascinating discovery - gamma ray bursts, mysterious flashes outside of our Solar System.

Maggie: Here's Ilana, with a look inside the world of gamma ray bursts.

[beeper sound]

Neil: That beep is part of an alert system we have that monitors the Universe day in and day out.

Ilana: Dr. Gehrels is an astronomer at the NASA Goddard Space Flight Center in Maryland.

Neil: Whenever a gamma ray burst goes off, telescopes around the world are alerted and follow the progress of that burst. We can see almost immediately whether it is an interesting one or if it's not.

Ilana: What are gamma ray bursts?

Neil: Well, that's actually a very interesting story. About 30 years ago, the US built satellites to monitor the Nuclear Test Ban Treaty that JFK had signed with the Russians. They launched satellites with gamma ray detectors and they discovered flashes of gamma rays. Luckily for us, they weren't nuclear tests at all. They weren't even coming from anywhere near Earth, they were coming from space. They've been a puzzle ever since then. Nobody could really figure out what was producing these very bright flashes of gamma rays. In fact, in the 1990s there were more theories about what produces gamma ray bursts than there were gamma ray bursts themselves.

Ilana: It is difficult to study gamma ray bursts, because they can disappear very quickly. A satellite would detect one burst, and estimate its approximate position on the sky. This was very inaccurate. Astronomers on-call would contact people in mission control for other satellites in orbit, and they would point their satellites to that approximate position. This could take many hours, if not days. By the time they were looking at the given location, there would be nothing unusual to look at. No mark of what had happened, absolutely nothing would be left. Then, about ten years ago, faint light coming after the burst was discovered. That was enough for scientists to be sure that the bursts were coming from faraway galaxies. But, other than that, very little was known about how everything worked. To solve this puzzle, Dr. Gehrels and his colleagues proposed to build a satellite that could scan the sky in gamma ray and quickly rotate to pinpoint the spot when a gamma ray burst occurred. This satellite was called Swift.

Neil: Since its launch in November of 2004, Swift has revolutionized our understanding of gamma ray bursts. It carries three different instruments on board. One is a gamma ray burst imager, and then we have two others. One observes the sky in the optical and ultraviolet band, and the other in the X-ray band. When a burst occurs, it takes between 10 and 30 seconds for the computer on board to calculate its rough position and to start rotating to point all the telescopes on board to observe that point. Swift is actually not an acronym. It's named for the rapid rotation of the spacecraft. In the first year of Swift operation, we established that gamma ray bursts are most probably the signature of the birth of stellar-mass black holes in the Universe. Some people call it the birth cries of black holes. We found that there are two very different ways that black holes can be produced. One is in the collapse of the core of a massive star. The other is in orbiting compact stars in a binary system that eventually coalesce in a fiery explosion and produce a black hole. We've detected more than 200 bursts, each of them providing a small piece of the puzzle to understand this.

Ilana: What they found in the process was that there was more than one puzzle.

Neil: There was a single, very important and interesting burst, a very well observed burst, that occurred on July 29, 2006. With Swift, we saw the afterglow in the X-rays and in the optical lasting for many months. Usually it dies away in just a few days. It was really unusual. People had thought for a long time that only black holes would be the origin of gamma ray bursts. But because of this burst, scientists are now thinking of other possibilities. Since a black hole has such strong gravity, the processes taking place near it happen quickly. It's hard to explain how you could have a gamma ray burst with extended emission for many months produced by a black hole. This is where the magnetar comes in.

Ilana: Could you explain what's a magnetar?

Neil: Well, it's a rapidly spinning, compact star - a neutron star that has a very high magnetic field.

Ilana: How fast does it rotate?

Neil: You can think in terms of a kitchen blender, which rotates a few hundred times per minute. Well, of course, it's a very small object. This whole star is rotating that fast. And, you see, the important thing about this, thinking about gamma ray bursts, is that this rotating magnetar in the center of the collapsed star would make energy for a long time. There's so many bursts of all different types. You never can prove a theory with one burst. It was really going to take at least another burst, and probably several more, to convince us that magnetars are powering them.

[beeper sound]

Neil: There was another interesting burst on January 10th of this year. It was quite similar that it had optical light that continued on for a long period of time. It also had X-ray afterglow that faded quickly, not at all consistent with the kind of fireball explosion that you'd expect with a black hole being born.

Ilana: And this also points to a magnetar?

Neil: It's supporting that theory. But the future will tell. Swift will be observing gamma ray bursts for many years, maybe as many as ten, and will see lots of gamma ray bursts. If there are magnetars at the core of some of these, we'll have many bursts that have that signature. It'll take years, though.

Ilana: Thank you, Dr. Gehrels. I wish you luck with Swift for many years to come.

Neil: My pleasure.

Ilana: From Blueshift, this is Ilana.

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Maggie: So there you have it, life and death in the Universe. New planets, black holes... there's always something happening out there.

Steve: You can learn more about these stories on exoplanets and gamma ray bursts, at our website. Visit us at astrophysics.gsfc.nasa.gov/podcast for more information.

Maggie: You know, speaking of our website, joining us now are Jim Lochner and Beth Barbier, here to answer your questions from the mailbag.

Jim: And here's our first mailbag question: What kind of rays are cosmic rays?

Beth: That's a good question, Jim, because the name is confusing.

Jim: Right, Beth. You might think that cosmic rays are a form of light, and part of the electromagnetic spectrum. You know, radio, optical, ultra violet, X-rays, gamma rays...

Beth: ...and cosmic rays come next? Well, no. Cosmic rays aren't rays at all. They are atoms and pieces of atoms. The name "cosmic rays" comes from a time long ago when scientists believed that they were rays - and now they're stuck.

Jim: It happens.

Beth: It sure does! So, cosmic ray particles bombard the Earth from anywhere outside our atmosphere. They have energies similar to X-rays and gamma rays (and even higher), but that's not the way scientists normally think of them.

Jim: So, cosmic rays are electrons, protons, and the nuclei of atoms, accelerated to very high speeds. These atoms are the same as those on the periodic table, including hydrogen, helium, and very small amounts of the heavier elements.

Beth: Some of them come screaming toward us at nearly the speed of light - they come from the Sun, from the space between the stars, and from far across our Milky Way galaxy.

Jim: There's even evidence that cosmic rays coming from outside of our solar system get their start in supernova explosions. As they travel through space, they are accelerated further by shock waves and magnetic fields.

Beth: And the most amazing thing about cosmic rays is that scientists still can't explain how some of them even exist, because they travel at speeds so close to the speed of light. These particles may be coming from even more exotic sources than supernovas, like gamma ray bursts or dark matter - or there may be some brand new physics involved.

Jim: Wow! New physics! I like that idea.

Beth: Well, we don't know yet.

Jim: And cosmic rays don't take pretty pictures, which makes them more difficult to study than X-rays or gamma rays. "Why?" you might ask?

Beth: Yes, why, Jim?

Jim: Well it's because almost all cosmic rays have a charge, so they are affected by magnetic fields. By the time they reach us from these great distances, they've been spiraling and scattering through stray magnetic fields in the galaxy, including the Sun's magnetic field.

Beth: So here at Earth we see them arriving from all directions almost equally. Information about the original direction is totally lost.

Jim: Right. But measuring the speed, quantity, and types of these particles as they arrive at Earth helps us understand a lot about our galaxy - about its magnetic fields, the composition of stars, and the composition of the space between the stars.

Beth: It just boggles the mind that scientists know how to make sense of all this complex information.

Jim: Hey, speaking of cosmic rays, can we mention our favorite movie, “The Strange Case of the Cosmic Rays”?

Beth: Oh, Jim, the one with the marionettes, right?

Jim: Yep, that’s the one! The authors Dickens, Dostoyevsky, and Poe are played by marionettes, and a couple of live scientists try to convince them that the discovery of cosmic rays should be the Mystery Story of the Year.

Beth: Oh, it’s a classic.

Jim: It sure is. Well, you know, we could go on and on about that movie, but we probably shouldn’t.

Beth: I don’t think so. Well, for the Blueshift mailbag this is Beth...

Jim: ...and Jim...

Beth: ...signing off.

Steve: If you have any questions about what we discussed in this episode or on other topics in astronomy, send them in and maybe they’ll get answered on-air!

Maggie: Last month, we kicked off our first podcast with a story about the James Webb Space Telescope, a new satellite being built here at Goddard.

Steve: We talked with two scientists who told us about the innovative technology developed for the mission. We’re excited to announce that one of the two scientists we interviewed, Harvey Moseley, just won an award.

Maggie: Yes, that’s right. Dr. Moseley won the 2007 Joseph Weber award from the American Astronomical Society, which is an award given to a scientist for the design, invention, or improvement of instrumentation leading to advances in astronomy.

Steve: Congratulations to Harvey Moseley, and the entire JWST team, on this award!

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

Louis: At the beginning of this episode, I asked the question: How many Earth-like planets have been discovered orbiting other stars in the Universe? The answer isn’t 10, or 100, or even 1000. It’s zero. We just haven't found any. So far, we know of over 200 exoplanets. The smallest ones that have been discovered are only about five times the size of the Earth.

Now, it's easier to find the large planets, because they're big. Finding another Earth is tricky, however, because it's so small compared to the star that it orbits. We're working on new techniques and satellites that will be able to find those smaller planets. And perhaps, one day, we'll find one that looks like our own beautiful world.

This is Louis Barbier, and we'll be back next time with another brain teaser.

Maggie: For Blueshift, I'm Maggie Masetti.

Steve: And I'm Steve Fantasia. I hope you enjoyed this episode of Blueshift. We look forward to bringing the Universe closer to you each month with new stories and interviews.

Maggie: And don't forget to send us your comments and questions through our website at: astrophysics.gsfc.nasa.gov/podcast

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