Astronomy Cast Episode 264 for Monday, May 7, 2012: The Hazards of Space Flight

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Fraser: 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. How are you doing, Fraser?

Fraser: Good, well I hate to sound like NPR or PBS for a second here, but we need to drum up some money for the production of Astronomy Cast, so we kind of need to ask for some donations.

Pamela and Fraser: Please!

Fraser: So as you know, Pamela and I don't make any money, we do this on a purely volunteer basis, but we do pay for transcripts, we pay for editing of the show, we have the hosting of the show, and other cool educational outreach programs that we're trying to do as well, so your donations make all of this in any way possible, so if you can see it in your heart to kick us a couple of bucks, that will help us pay for all these expenses. Now, where can people go if they want to donate?

Pamela: So if you want to donate, the easiest thing that you can do is go to Astronomy Cast.com or .org – they both work, and there's a "support the show" button, and a "donate" button both right there. Look at the page, they're just waiting for you to click, and donations go through SIU-E, so they're all tax deductible. Now, you can also donate through Astrosphere New Media. That will then go to support the general things. There' s a friendly guy named Joe who does our day-to-day management of things, so go through either one. They're both tax deductible here in the United States, and we just need your help making ends meet. So every time you hear us in these live recordings, apologize to Preston…well, we need to feed Preston, so please help us feed Preston. We like Preston.

Fraser: Perfect. And once again, we're recording this episode of Astronomy Cast as a Google Plus hang-out, so if you ever want to join us and watch us record the show live, we do this every Monday at noon (although we're a little late today, but Mondays at noon) on Google Plus. And so if you circle me, circle Pamela, you can see when we're recording the show, and that is on Google Plus, and you're…we stick around, we answer questions from the fans, and it's a lot of fun, so if you ever want to take your love of Astronomy Cast to the next notch, come watch us record live – totally free. Alright, cool! Let's get on with the show, then.

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Fraser: So we hold all these romantic notions about humans exploring the Solar System and turning humanity into a true space-faring race, but the cold hard reality is that space, really the entire Universe, is trying to kill you. Any humans venturing out into space will face all kinds of hazards. Only death will be certain.

Pamela: Yes.

Fraser: So this is this constant argument that people always have: Should we send humans? Should we send robots? The robot camp has some really persuasive arguments about the fact that robots should go.

Pamela: Yeah, robots… you don't need to feed them, you don't need to water them, you don't have to oxygenate them…you have to keep them kind of warm, but really, they're OK with being somewhat frozen now and then.

Fraser: So let's take a look at if we take a human being, we try to put him out in space, how will they die? And then, what are the ways that we could…

Pamela: [laughing] Oh, that's such a broad question! So, I mean, just the entire process is possibility of death after possibility of death. So you start off with you're on the launch pad, you're getting ready to take off, and your rocket can explode. Now, that could also do bad things to a robot, but that's the first hazard that you have to deal with is just getting off the ground.

Fraser: And this isn't a theoretical problem; I mean, rockets explode all the time.

Pamela: Yeah, this happens. This is a reality.

Fraser: In fact, every new space program is mostly just, you know, exploding rocket after exploding rocket.

Pamela: Well SpaceX did kind of better than the rest.

Fraser: They didn't blow any rockets up?

Pamela: They had an engine malfunction while they were testing an engine, but so far they're doing pretty good. They're not in the whole collapsing multi stages onto the launch pad…

Fraser: Did you see the one where the rocket takes off for a second, and then just kind of collapses, and it's just like a tube filled with liquid that explodes?

Pamela: The early rocket days were not good. So the first issue is you have to get off the launch pad. Once you make it off the launch pad then you have to survive the…every different type of rocket has stages that are combined in different ways. With the space shuttle you had to survive the separation of the SRBs, the separation of the external tank, now you have to worry about the different stages coming off. You get through all of that, now you're in space where there's no air, where it's either way too cold or way too hot, pick how you want to die – fire or ice are both available depending on which side of the planet you're on. So once you make it into space, you're dealing with the fire and ice reality of which side of the planet are you on. Are you in shadow, where it's way too cold? Are you on the sunny side where it's way too hot? So you now need thermal protection, you need oxygen, you need something to scrub the carbon dioxide out of the air that you're exhaling...

Fraser: So let's deal with those. I think you also, as it relates to the launch risks, you've also got the landing risks with more physical things that could kill you. And as we've seen…we've seen one space shuttle detonate on launch, and we've seen one space shuttle come apart on landing.

Pamela: And there's been a number of capsules over the years that have been lost at various stages. Nowadays, we actually have a new hazard of what if your parachutes don't deploy. So every skydivers worst nightmare now becomes every space capsule flying astronaut's worst nightmare as well. The Russians tend to land on land; we, at least, tend to land on water, which allows you the chance to simply become a dead, smushed bug bouncing around inside of your capsule. It's…either way, if you hit water at a high enough velocity, you're still…the sudden deceleration is going to do really bad things to you.

Fraser: Well, let's start with temperature, then. You mentioned a bunch of things, so lets start with temperature. How cold is space?

Pamela: It depends on…so if you're in shadow, it can get down to just a handful, single-digits of degrees Kelvin, so you're starting to hit temperatures where volatiles, oxygen, carbon dioxide all become ice. Vacuum space means they tend to become sublimated as well, so it's none-the-less, it's a bad place to be, so if you expose human flesh to this, it's going to freeze. That's bad. Now, at the same time, it will be many hundred degrees on the sun side, so you're going from frozen to boiling water just by changing what side of the planet you're on.

Fraser: And so, it's not just having to give yourself the level of insulation that's required that you can keep yourself warm enough in the frigid temperatures of space. You've got to be able to oscillate between those two temperatures: first super cold, then super hot, back again… So how do they deal with that?

Pamela: Well, the best way to deal with it is you simply make it a giant, perfect, insulated container because if you have a very well-insulated container, it's going to keep the contents of the container at a constant temperature. So here, you simply do the multiple layers of vacuum so that you don't end up with temperature transferring in between. For spacecraft that works; for astronauts' spacesuits, you simply do multiple layers that will either reflect off the heat or simply not transfer the cold through, and then human beings are pretty good at heating up the inside of their spacesuit, so we actually have to cool off human beings inside of spacesuits, and warm up human beings inside of spacecraft.

Fraser: Right, but even if you're in the cold, do you still need to be warmed up? Or do you need to be cooled off?

Pamela: If it's a really well-insulated spacesuit, the heat that you're generating is going to get trapped inside the spacesuit and not radiated out into space, so it's generally enough to do all of the insulation to protect the outside temperatures from migrating in, and then cool off the astronaut on the inside.

Fraser: Right. OK, so we've got…definitely your rocket's going to blow up. If your rocket doesn't blow up, then you're going to freeze solid in the vacuum…or the cold of space, and I just about said the next one, which is the vacuum, right, the fact that there's no air there.

Pamela: Right. Right, so yeah, lack of air is a serious problem as well. Human beings kind of like to respirate; we require oxygen in order to keep our systems functioning, and if you expose a human being to the vacuum of space, the first thing that's going to happen is they're going to get all bruised up, the blood vessels in the eyes are going to rupture over time…yeah, it's just a bad thing, and then at the same time, you're not getting oxygen into your lungs.

Fraser: Well, let's deal with those separately, though, because I mean, I think we as, I guess, like fish at the same time, fish don't think about the water that they're swimming in. We don't really think about the air that we're swimming in, but we evolved to deal with one atmosphere's worth of pressure pushing on our bodies at all times, and without that pressure, as you say, you just discover a bunch of nasty things.

Pamela: Right. Right, so here in the surface of the Earth, we constantly have this pressure bearing down on our skin. We call it "one atmosphere." It's the equivalent of 10,000 newtons per square meter -- sorry, 100,000 newtons per square meter of force. So a newton is the amount of force required to lift a kilogram rock, so if you think about the force needed to lift that kilogram rock, there's 10,000 times that pushing on every square meter of your skin. Now, a square meter is a whole lot, but still that's a whole lot of force that's holding our large pocket of water that is our body together. Now, our body is pushing back, so there's this equilibrium where we're pushing out the same way it's pushing in like a balloon in equilibrium. You remove the air that's pushing on us, and our blood starts trying to get out of our body, our fluids start trying to get out of our body, the vessels in your eye start trying to get outside of your eyeball…it's all kind of gross, and reminds me why I am a physical scientist and not a biological scientist.

Fraser: But it's strange to think about that the fact that we actually have this outward force pushing out from our bodies at all times that is counteracting this force of the atmosphere. You don't, as you move around in the atmosphere, and as you, you know, run around, or ride your bicycle, or you know, you see dancers, and you don't think about the fact that their bodies are forcing against this enormous pressure of the atmosphere at all times.

Pamela: Well, if you ever go SCUBA diving and you get to serious depths, you do feel that added pressure on your body. You feel it's harder to expand your lungs, and the limitations on SCUBA diving in flexible suits are partially there simply because, at a certain point, you can't expand your lungs, and you need to be inside of a submarine or a hard-bodied something. Yeah, we're limited by our ability to expand our lungs, and at the same time, we have to be able to push out to prevent the atmosphere from crushing us like an empty balloon.

Fraser: So we need the gas to breathe, and we need to gas to keep us from leaking.

Pamela: Exploding.

Fraser: But we're not going to explode.

Pamela: No, it's more like a slow leak. It's kind of just gross.

Fraser: So just to be clear, there was that "Outland"…I'm trying to remember…there was a movie a few years ago where someone gets...

Pamela: "Battlestar Galactica" got it right. We don't need to know who got it wrong.

Fraser: Yeah, you said "Battlestar Galactica," but when people get it wrong, right, when they throw you out of the airlock, and you detonate in space…

Pamela: You don't.

Fraser: No, that's not going to happen -- you just kind of flash freeze and then you leak.

Pamela: Bruise…

Fraser: And bruise and leak, and…yeah.

Pamela: Yeah.

Fraser: OK, so we've got…so there's the need of our atmosphere, and our need for both keeping us to not leak, and for our…so awful! I do not want to go to space. So we've got our…the leaking, and then we've got the need for oxygen, so let's…fine, so fine. We've got a spacecraft, it's keeping us warm from the cold temperatures of space, it's providing us the atmosphere, it's giving us something to breathe, but we're still not going to survive very long. So what else is out there?

Pamela: And we've only hit orbit of the Earth at this point. The hazards get worse as we get further from the planet.

Fraser: So what else then is another risk, another hazard of space flight?

Pamela: Well, you also have to worry about radiation. So if you're in sufficiently low Earth orbit, you're still mostly getting protected by the Earth's magnetosphere. Still have to worry about x-rays and things like that that won't get stopped by the atmosphere, but that magnetic field does a fair job dealing with day-to-day radiation hazards.

Fraser: Right, you're looking at, I mean, it's the same thing when people fly in airplanes a lot of the year, then they have an increased risk of getting cancer from the cosmic radiation that makes it through the atmosphere. And if you're up in the space station, then you're looking at even more cosmic radiation, but you're not looking at the nasty, nasty, kill-you-in-a-couple-of-days. You're more looking at, like, if you're just an astronaut, you're going to increase your chances of cancer later on in life.

Pamela: Yeah, they haven't so far needed to evacuate the space station because of a solar flare, for instance.

Fraser: And nor would they really ever need to.

Pamela: You know, I don't say that there isn't a coronal mass ejection that won't someday cause them to evacuate, but so far they haven't had to, but we do have to worry once we leave the Earth's magnetosphere and just go as far away as the Moon. There you now have to start worrying about solar flares. Once you start hitting the middle parts between the planets, the inter-planetary space, suddenly you're ready to take on the full brutal force of the Sun's radiation. You're dealing with high-energy particles from the rest of the Universe. It's all passing through your spacecraft unless you're somehow inside of a hollowed-out asteroid, which is a completely feasible way to travel, or unless we've figured out how to create low-energy magnetic fields to artificially protect ourselves, so…

Fraser: So let's break down those risks specifically. So we've got the dangers of the Sun, and we'll sort of deal with that radiation. So what exactly is coming at us from the Sun?

Pamela: Well, we have a variety of both photons that are at x-ray and gamma ray, and ultraviolet if you decide to hang out without glass between you and outer space. So those are just regular, everyday, high-energy photons headed toward us. We also have to worry about cosmic rays, which are higher-energy particles. They're not just photons of light, but they're actual atoms heading towards us, or electrons coming towards us.

Fraser: And these are coming from the Sun as well?

Pamela: These are coming from the Sun as well, and when you have a solar storm, when you have a coronal mass ejection, you can get waves of high-energy electrons heading our way, and when these things hit and slow down, all of that kinetic energy from their travel gets imparted on you, and that can be deadly, so we try and avoid getting our human selves in the way of a coronal mass ejection.

Fraser: And this is one of those situations…I mean, we're not talking about "let's increase your risks of cancer when you're 80," we're talking about "kill you…"

Pamela: "…now, please." Yes.

Fraser: Now -- kill you right away. And this is one of those situations where there's dangers of dealing with radiation places like Chernobyl, and places like that; I mean, yeah, everybody involved in the surrounding area had an increased risk of cancer from the radiation damage, but at the same time, you just get burned by the radiation and by the particles, and you take a lethal dose and you're done.

Pamela: Yeah.

Fraser: And the Sun could generate this level of activity, and astronauts are going to get hit by it and just be all killed.

Pamela: Fried. So getting your human self in the way of a coronal mass ejection is a quick way to die, so not recommended unless you have proper protection, which again, figuring out how to generate heavy-duty magnetic fields -- we're not there yet.

Fraser: Or being able to put a lot of material between you and radiation, like your hollowed-out asteroid, or like a great big shield that you hide inside…

Pamela: Right. Then it becomes a matter of how do you get a spacecraft that heavy moving. Hollowing out an asteroid seems to be the best idea we've come up with so far, simply because launching all those resources from the surface of the planet is hard.

Fraser: But right now, the way the astronauts deal with it, or the way…how did the Apollo astronauts deal with it? They didn't, right?

Pamela: They got lucky!

Fraser: That's it?

Pamela: The Apollo astronauts simply got lucky. They managed to be on the Moon between solar flares. There were a couple of the Apollo landings that had they simply been there a few days earlier or a few days later, they could have taken significant radiation doses. It's unclear if it would have been enough to kill them, but it definitely wouldn't have been good for them.

Fraser: But if people are going to be there longer, they can't count on that.

They're going to have to…

Pamela: …underground.

Fraser: …set up shelters and be ready, and when something's detected, they're going to have to get underground and wait it out.

Pamela: Yeah, and this is where lava tubes are so important.

Fraser: Yeah…but I mean, fortunately, we can detect these, right?

Pamela: We do have an early warning system. The light from the coronal mass ejection luckily travels far faster than the electrons do. Sometimes it's only a few hours of warning, sometimes it's a couple of days of warning -- it all depends on the energies involved, but any warning at all is a chance to get underground as needed.

Fraser: Right. And that's the radiation just coming from the Sun, but then there's radiation coming from just the rest of the Universe.

Pamela: Right.

Fraser: You live once in on the "let's kill people" action, right?

Pamela: Yeah, so the entire Universe is giving off high-energy particles here and there. You have particles coming from supernova remnants, you have particles coming from cataclysmic variable stars, you have high-energy particles coming a little bit from here and there.

Fraser: Yeah, there are particles coming from things that astronomers haven't been able to figure out where they're coming from yet. The have so much energy they are theoretically impossible, and yet they're coming.

Pamela: So we keep detecting these high-energy cosmic rays, not always sure where they originated, and all of them represent a possibility of blasting apart your DNA.

Fraser: But this is back to the increased risk of cancer when you're 80, not kill you. Could there be a storm of particles coming from something…some supernova? Some event?

Pamela: As far as we know, all of the supernova that we need to worry about either would point in other directions, or they're just not near enough that we need to worry. There's always the concern that there's a nearby neutron star that we haven't detected, that there's a nearby white dwarf that we haven't detected that's calmly eating material, but this is such a low risk; this simply falls into the category of possible what-ifs.

Fraser: Right, so there isn't a range of objects out there that could generate enough radiation to per se kill astronauts when they're outside of the Earth's magnetic field, apart from the Sun, of course, but that wouldn't…

Pamela: Instantaneous death.

Fraser: Yeah, so there's nothing out there that's going to do that. OK.

Pamela: It's much more of a Marie Curie-playing-with-radioactive-particles kind of death, where you're guaranteeing yourself a bad end.

Fraser: OK. Let's see, we've got launch risks, we've got atmosphere problems, we've got temperature problems, we've got radiation…

Pamela: Oxygen and carbon monoxide …

Fraser: So we've got gases of the wrong type building up.

Pamela: Yes, so you have to be able to scrub all of the carbon monoxide out of the air; you need to be able to keep oxygen coming into the air…

Fraser: So how do we deal with that? How do you deal with these gases that are building up?

Pamela: Well, currently we just scrub them out using various types of charcoal filters. It's kind of like dealing with your fish tank. Human beings, fish -- it's really the same when you put them in a closed environment. So they use a variety of different filters to get all of the carbon dioxide scrubbed out of the air, but I mean, long-term, the idea of having a central garden that is converting the carbon dioxide into oxygen and plant stuffs – that's a completely reasonable idea.

Fraser: Now, can you go on scrubbing carbon dioxide forever? Like if the astronaut just kept breathing, would you be able to just keep absorbing the carbon dioxide, or are you going to run out of whatever material you need?

Pamela: I think you run out of filters eventually, but plants don't have that problem so much because they just grow.

Fraser: They just grow, and you eat them. OK, so you're building up…so I guess, more specifically, I guess, you're getting waste building up.

Pamela: Yeah, that luckily you can sort of fling out the airlock, but you still need to be able to eat now and then, so probably you want to recycle it. I know the International Space Station actually recycles liquids as well. I'm not going to go into details that one…

Fraser: But they're not throwing everything out the window on the space station. They're gathering up everything, Soyuz capsules, and the dragon, and then taking the trash out.

Pamela: Well, Soyuz …they were just burning up in the atmosphere, so really they weren't returning it home.

Fraser: It's like you're lighting your garbage on fire outside your house.

Pamela: They were just using the atmosphere, and the entire planet Earth was their house.

Fraser: But I guess there was no real problem with the…burning it very efficiently.

Pamela: But, ideally, in the future, you want a completely closed system where all of your liquids are getting recycled, where all your solids are going into fertilizer, food -- depending on what stage your in, and suddenly it becomes a careful, you-can-only-consume-so-much, and what-goes-in-has-to-come-out…

Fraser: So now the biggest problem is going to be for long-duration space flight is really the gravity.

Pamela: Right, so there you run into problems with the human beings. We need gravity in order to deal with minerals in a proper way. Our bones will actually weaken over time -- decalcification of the bones basically.

Fraser: Our muscles atrophy…

Pamela: Yeah, and so this is where you start looking at spinning spacecraft, you start looking at spinning beds, so that you have people experiencing gravity just while they're asleep. You need to do this in multiple directions to prevent the angular momentum from doing bad things to the spacecraft. You have to add all the pieces up just right, and you have to exercise, exercise, exercise.

Fraser: And the exercise only offsets it a little bit; the deterioration just goes on. When you see these astronauts that are running on their treadmills and such, they're just putting off the damage that is actually happening to their bodies, and you stay up there for a year, and you come back weak as a kitten.

Pamela: Yeah. Yeah.

Fraser: And if you stay up there longer…and your bones just turn into jelly.

Pamela: Well, no one's had that happen, but yeah.

Fraser: What about living on places like the Moon and stuff, where you've got partial gravity?

Pamela: it's still going to be decalcification.

Fraser: But will it hit some point, or is it just going to go on forever?

Pamela: I don't know if we have a way of knowing yet.

Fraser: Yeah, we don't know yet. Someone's going to have to be willing to go live in partial gravity for five years.

Pamela: And some of the things that we're still trying to figure out is how does it affect different ages. We know that there's major differences between men and women, where it affects women much worse, so there's lots of bio-medical issues still to be solved with human space flight.

Fraser: There are the psychological problems with flying in space: space madness…

Pamela: Space madness, the fact that you're trapped with the same "n" people, who you may discover you hate. There's always the concern that there are a lot of mental illnesses that don't emerge until people are in their 30s, there's a lot of dementias that don't emerge until people are in their 50s or 60s, and so a crew that starts out mentally sound may not stay mentally sound, and you have to figure out how to deal with all of these things on the go.

Fraser: Space aliens that want to get into your tummy and explode…

Pamela: Yeah, that one I'm not going to worry about.

Fraser: You're not going to worry about that one? Well, I do. I guess the other one, as well, to deal with is all the noxious chemicals and poisons and stuff that just goes into building the spacecraft, and fuel.

Pamela: Well, I…yeah, so if you've ever had a new mattress, you know it stinks kind of funny for a couple of days, new rugs have the worst smell – these are all things that, hopefully, you've dealt with before you've launched your spacecraft into outer space, and we clearly need to think about not launching things that are going to give off toxic gases.

Fraser: Open up a window. Let the air out.

Pamela: Yeah -- no, you can't do that, and unfortunately, you do have the methane coming out of the human beings, you do have the biological waste coming out of the human beings. Yeah.

Fraser: So we've got a couple more issues here. Fire is a deadly one.

Pamela: Yeah, about all you can do is prevent it. Everything that ever would affect a ship at sea, a submarine -- these are the exact same issues that you have to worry about with a spacecraft, so fire is a terrible danger, scurvy… So you have to worry about minerals, so you have to feed people, you have to scrub the air, you have to worry about getting the right vitamins, you have to not set them on fire, you have to not de-pressurize them, you have to not irradiate them…yeah. Humans are fragile – send the robots.

Fraser: Send the robots…no! You know what – no. I am a total advocate for human space exploration. Send the robots and the humans. Just be well aware of all the hazards of space flight, which we have filled an engineer's notebook with all kinds of ideas that I'm sure, at this point, they're going to be dealing with all these issues. Well that was great, Pamela. Thank you very much.

Pamela: And don't forget, listeners – please donate!

Fraser: Please donate.

Pamela: We need to feed Preston!

Fraser: Yeah…feed Preston. Have you told Preston that we're not going to feed him if we don't get donations? He needs to be aware of that.

Pamela: No, I haven't told him that. I simply looked at the bank account, and said, "Aaahhhh!"

Fraser: Aahhhh! OK. We need to feed…and Nancy, of course, who does all our show notes…

Pamela: And Romayne, who does all of our transcripts…

Fraser: Our transcripts, and all that…so, yeah, if you can provide some donations, that would be amazing. Thank you very much. Alright, well thanks, Pamela, that was great. I really appreciate it, and we'll talk to you next week.

Pamela: Sounds good.