Episode 50: **Sterile Neutrinos, Enough Said**

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Travis: Welcome to Slacker Astronomy; a podcast about astronomy and just about anything else that floats over our heads.

Pamela: Every week or so we bring you a news event from the world of astronomy, and when there is nothing new to report, we will be forced to sit in the corner taking a mandatory time out.

Travis: What?!?

Pamela: Zip-it. It's non-interaction time for you, Slacker Boy.

Travis: But what did I…???

Pamela: Zip it! Today we are going to do our best possible imitation of neutrinos. This means we can only interact very weekly via the electro-weak force.

Travis: But, but, but . . . I don't want to be forced to interact with cleaning fluid! Isn't that what neutrinos interact with? I, mean, I don't even like to touching cleaning fluid. <pause> In fact – I refuse to interact with cleaning fluid.

Pamela: No electro-weak interactions at all?

Travis: Not at all. The electron neutrinos can go play in chlorine at the Homestake Mine Observatory all they want. And, in fact, I'm not going to play with scintillator fluid, heavy water or mineral water either. I'm just going to stay right here, and do the world's best imitation of a neutrino refusing to interact.

Pamela: Are you, by any chance, right-handed?

Travis: Ah, yeah.

Pamela: Then you must sterile.

Travis: <shrinking a bit> WHAT?!?!?

Pamela: Well, right-handed neutrinos don't interact. These little, refusing to interact boogers, are quite sterile. If you are right handed and won't interact, than you are quite sterile.

Travis: <Manly voice> I assure you, I am most definitely **not** sterile.

Pamela: Well, I guess doing the world's best imitation of a non-interacting neutrino is just not the right role for you.

Travis: Okay – How about I play the part of the comet that brought life to Earth?

Pamela: Um, no one knows if that really happened. It's just a wild speculation without any evidence.

Travis: I don't care – Just call me the father of all life on Earth, and watch me spread my seed everywhere that is fertile!

Pamela: Um, Travis, Flora might have something to say about that.

Travis: Just call her Eve. We're in this one together.

Pamela: Yeah, well, I think I prefer to think about sterile neutrinos. It's a less painful image.

Travis: Painful? My visage is a sight of beauty that all who glance upon my face pause to marvel at. Plus - What do those neutrinos have on a mythical life-spawning comet? If they don't interact, what can they possibly do that has any consequences?

Pamela: Well, according a recent press-release…

Travis: Press release, schmish-release…

Pamela: ACCORDING to a recent press release, new theories involving sterile neutrinos could explain everything from the lack of anti-matter to the high velocities of pulsars.

Travis: But, I'm talking **life**.

Pamela: So are they. If our universe hadn't had some weird thing happen at the beginning of time that caused matter to dominate anti-matter, well, let's just say our atoms might have had a more explosive and less life nurturing history.

Travis: <curious, question> So, these little leptons formed in the Big Bang and could have biased the universe into forming more matter like protons than anti-matter just by existing?

Pamela: And, when they popped into existence, with their right hand spins balancing out the left hand spins of the detectable electron, tau and muon neutrinos, these critters formed in high enough numbers that they could be the missing dark matter everyone is constantly looking for.

Travis: Theory says that particles form in balanced pairs: left-handed and right-handed spin being one of the things that has to get conserved. If the universe is going to form left handed neutrinos with masses that we can detect, it follows that there should be right handed neutrinos that we haven't yet detected.

Pamela: So, all because these anti-social particles haven't been directly seen, doesn't mean they don't do observable things. If they have mass, which theories predict they do, then they pull on things via gravity – acting the way a good dark matter candidate should act.

Travis: If they all have the same spin, and Supernovae produce sterile neutrinos at the same time as the more normal left handed neutrinos, then theory also says that sterile neutrinos could also give pulsars formed in supernovae the kick they need to escape supernovae at the observed velocities.

Pamela: <Think Home Shopping Network> So far so good. We have three mysteries

possibly solved by one theoretical particle. The sterile neutrinos push, they gravitate, they make matter dominate. All this in just one bit of mass – what an intellectual bargain.

<applause>

Travis: <Still thinking Home Shopping Network> But that's not all you get with the sterile neutrino, Pamela. This little particle species also helps explain star formation in the early universe. Observations show that stars formed when the universe was just 400 million years old. That's several hundred million years earlier than expected. BUT, with the sterile neutrino, gas is able to encourage the formation of molecular hydrogen, causing gas clouds to contract and form stars on a theoretical schedule that matches observations. So, they push, gravitate, make matter dominate AND they trigger early star formation. Now THAT is an intellectual bargain.

<Whooting!>

Pamela: Now hold on Travis, according to the press release, they do even more than that.

<gasps>

The sterile neutrino theories also have testable predictions! If they are correct, the dark matter forming, pulsar pushing, star formation triggering sterile neutrinos will exist in huge numbers in galaxy clusters and will decay in ways that can be detected in X-Ray spectra. Now that's an intellectual bargain!

<mad cheering!>

Travis: Seriously, though folks, the press release we're looking at, which we have linked into our show notes along with some related articles, indicates that sterile neutrinos just might be a way to solve some serious astronomical mysteries. Still, what we are looking at are just theories.

Pamela: And while the theories predict X-Ray emissions, detecting those emissions is something so hard, that it may not be possible to get unambiguous positive or negative results.

Travis: But, if the right-handed, sterile neutrinos exist, they are going to come in a variety of sizes and qualities, the same way the left-handed neutrinos come in tau, electron, and muon varieties. While the ones that seem capable of answering many of life's mysteries would need to be about 100,000 times larger than normal left-handed neutrinos, there might be some sibling sterile neutrinos with smaller masses.

Pamela: In the world of particle physics, small things are much easier to detect than large things.

Travis: And if the large sterile neutrino is really the invisible elephant sitting in the room, we may never be able to see it.

Pamela: But, little things, the dust motes floating around our invisible elephant, are just shouting for the scientists to see them.

Travis: This means that small particles are easy to wrestle out of accelerated electron beams, and if there are lighter weight sterile siblings, directly detecting them at a particle accelerator just might be possible.

Pamela: And it is something scientists just might have already done. Several years ago, scientists working at Los Alamos National Lab found a low mass mystery object that looks like it could have been a sterile neutrino.

Travis: Today, scientists at Fermilab are running an experiment called MiniBooNE to try and repeat the results in a way that confirms that a low mass sterile neutrino does exist.

Pamela: And theorists are working to refine their theories, looking for ways to test their results against the observable universe.

Travis: And the sterile neutrinos are smiling back, saying "Neener Neener you can't see me" as they refuse to interact.

Pamela: Still think you'd rather be a life infested comet that crashes on the primordial Earth?

Travis: Look, I'm a guy. Given the choice of being a sterile neutrino or a comet that gets to cause life AND destruction as it dies in a blaze of glory…. I'm just not a sterile neutrino kind of guy, and I challenge you to find a guy who is!

Pamela: <pause> I don't even know where to go from that comment. Let's face it, men are men, women are women, and no theorist can explain our genders' interactions.

Travis: But maybe NASA can. If men are from Mars and women are from venus, than the new Mars Reconnaissance Orbiter, and Venus express should be able to answer all life's questions.

Pamela: <Pause> Again, you leave me speechless. BUT… That does make for a good transition. This week the world of astronomy news had just to many good things to talk about, and we passed over cool releases about both Mars Reconnaissance Orbiter and Venus Express because, well, how could we not discuss sterile neutrinos.

Travis: When these happily working new space missions start spewing out science, we'll bring you the results. For now, we have linked cool images into our show notes.

Pamela: To learn more about all of today's topics, check out slackerastronomy.org. Also, don't forget about our bonus feed where we host interviews with professionals, talks we give around the nation, and other bonus material.

Travis: Clear skies and clear bandwidth. This is Travis Searle on behalf of Pamela and Aaron.

Pamela: This has been Slacker Astronomy, a three-person collaboration for you, for fun, for the voices in our heads.