Episode 20: **Neutron Roundup**

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

Pamela: Every week or so we will bring you a summary of a recent news event from the world of astronomy. And during slow news weeks, we'll capture unsuspecting theorists and force them to use telescopes so they can observe how the other-half lives.

Travis: But this week, instead of torturing theorists, we're simply going to talk about all the data observationalists are dumping on them.

Pamela: You may recall that back in February we told you about the neutron star SGR 1806-20. This very special little neutron star belongs to a popular clique called the "Magnetars". Stars in this group have extremely powerful magnetic fields, spin very rapidly, and emit powerful X-rays and gamma rays.

Travis: And occasionally, like so many Big Name stars, they throw temper tantrums that get their names in the news.

Pamela: People may have been shocked when Russell Crowe threw a phone, but his telephone tossing tendencies are nothing compared to the violent behavior of SGR 1806-20. This city-sized star is located roughly 50,000 light years away and even being that small and that far away, it managed to nail the Earth with a powerful enough blast of energy that it stunned several satellites.

Travis: Now any of you out there who have had the misfortune of having to throw a punch know the adrenaline rush can leave you a bit shaky. Well, SGR 1806-20 didn't exactly get an adrenaline rush from the knockout blow it threw at our communications satellites, but it still got a case of the shakes.

Pamela: SGR 1806-20's Earth blasting burst of energy was created when the magnetic fields passing through the little magnetars surface rearranged themselves. This not only sent energy radiating in all directions, but it created tremendous star quakes.

Travis: While the US Geological Survey didn't have any seismometers on the surface of SGR 1806-20 to measure the size of the quakes, astronomers were able to measure the frequency of the quakes using the Rossi X-ray Timing Explorer.

Pamela: Just as hitting a bell causes it to ring and give off soundwaves, hitting a neutron star causes it to ring and it gives off X-Ray fluctuations.

Travis: The X-ray light from SGR 1806-20 was observed to fluctuate in a way that indicates the star was ringing at 94.5 Hz, or roughly the same frequency as a low F sharp, the F sharp that is hanging off the bottom of the G Clef.

<Insert Tone Here>

Travis: So, SGR 1806-20 temporarily provided the universe with a tuning fork. While interesting that alone isn't newsworthy.

Pamela: What is news worthy is the potential information we can get out of this ringing.

Travis: Here on Earth geologists use Earthquakes to study the density structure of the Earth. As the shockwaves from Earthquakes pass through the Earth's core, mantle and crust, they change speeds and frequencies and sometimes just stop propagating. Every time an Earthquake occurs in a new place, the network of seismometers scattered across the Earth's surface gets a new image of what lurks inside the planet.

Pamela: While the Earth's guts are lumpy and bumpy, with continents crashing together in some places and pulling apart in others, the insides of neutron stars should be symmetric, and we should be able to learn a lot about the insides of these stars from our one view of the one magnetar 1806-20 and how it rings.

Travis: "Should" being the keyword in that last statement.

Pamela: And this is why we have theorists. At this time, no one really knows what it's like inside a neutron star. These ultra-dense objects form when a large star collapses under its own weight after running out of fuel.

Travis: Young and even middle-aged stars support themselves by fusing atoms in their core and sometimes even in shells around their core. Thus fusion produces radiation.

Pamela: While we aren't used to thinking about it, light produces pressure. If I hit Travis with a large enough laser beam, the pressure from all that light hitting him would knock him off the sofa, and the energy from all the photons would turn him into a crispy critter.

Travis: Note to self, keep lasers away from Pamela.

Pamela: In much the same way, all the light coming from the fusion burning regions in a star creates enough radiation pressure to support the outer parts of the star, even though gravity is trying to drop the stars atmosphere on its core.

Travis: When the radiation pressure goes away when the star runs out of stuff to fuse, there is nothing to stop gravity from collapsing the star.

Pamela: In really big stars, this collapse will cause the outer layers of the star to crash together with so much violence that they explode into a supernova, and the inner parts of the star is crushed to the point atoms can't exist, and electrons and protons squeeze together to form neutrons.

Travis: Now, since we can't actually see inside a supernova explosion or probe the depths of neutron stars, all of this is just theory that is very well tested, and seems to accurately predict what we see when stars explode. Unfortunately, while our big picture understanding of supernovae and neutron stars seems pretty good, it's still missing a few details.

Pamela: Specifically, we don't fully understand the structure of neutron stars. Some people think they are made almost entirely of neutrons, with a very thin skin of normal atoms floating on the surface. Others think that neutron stars may have a core made exotic particles, like quarks.

Travis: But now, hopefully, the theorists can fill in these details.

Pamela: The observers have done their part: they identified the giant explosion that rocked our ionosphere in December as a magnetar, they followed up on the star in a bunch of wavelengths, and they carefully measured everything they had they ability to measure. The only data theorists can ask for and not find is data that we don't yet have the technology to measure.

Travis: So all you theorists out there listening, you no longer have any excuses, it's time to tell us just what is inside a neutron star. We're waiting theorists. The world wants to know if neutron stars are truly all neutrons, or if they have any quark-like secret ingredients hiding in their cores.

Pamela: And on days like this, I am glad to be a simple observational astronomer.

Travis: Simple? You must be doing something wrong. Our next story involves using three satellites to observationally figure out what one object might be!

Pamela: Okay, so to me observational astronomy is simpler. I'll take a telescope over theoretical modeling any day. Given the choice of three datasets, or three-dimensional hydrodynamical relativistic models, well… Heck, I can't even spell hydrodynamical without a spell check!

Travis: You can't spell most words without a spell check.

Pamela: True, but you guys still let me edit this show.

Travis: Only because you're the only one willing to format our transcripts.

Pamela: Um, so back to those three datasets we were taking about.

Travis: According to a European Space Agency press release, which we have linked in our show notes, observational astronomers recently pooled the abilities of three different spacecraft to identify one shy little star.

Pamela: This neutron star lurks inside a bunch of dust, embedded inside both a murky binary star system, and the dusty Norma arm of our Milky Way Galaxy.

Travis: Our galaxy has an arm named Norma?

Pamela: Yes. For reasons I will not try to explain, our galaxies arms are named Orion, Perseus, Saguttarius, Scutum, Crux, and, well, Norma. We have a link to a map of these arms in our show notes.

Travis: Norma.

Pamela: So off in the heart of the Norma Arm, astronomers using the Integral wide-field gamma ray camera noted a little something giving off gamma rays off in the region of the Norma Arm.

Travis: The cameras on Integral weren't good enough to clearly make out what this little ball of gamma rays might be, so astronomers working on Integral asked the folks over at NASA's Swift satellite to use their Gamma Ray and X-ray detectors to better determine their mystery objects position. With a good location in hand, astronomers then turned to the folks at NASA's Rossi X-Ray Explorer, which is a highly sensitive instrument, and asked them to take a look and see if they could identify the object.

Pamela: Good science requires a mixture of luck and sweat. These scientists put themselves through an intellectual work out as they worked through the data from so many satellites, but the workout wouldn't have been as worthwhile without a bit of timing luck.

Travis: In April of 2005, with Swift watching, their object underwent an outburst.

Pamela: Their object turned out to be a neutron star. When neutron stars are in binary systems, matter will sometimes fall from the companion star onto the neutron star, creating an outburst as the material explodes at the neutron stars surface. These outbursts can last weeks at a time.

Travis: And Swift was lucky enough to watching during the right week!

Pamela: Rossi jumped on the observational bandwagon and watched as the light from the outburst faded away.

Travis: The neutron star, dubbed IGR J16283-4838, is one of only 7 neutron stars found embedded in dusty star systems.

Pamela: While it may seem odd that astronomers exerted so much effort to identify one little neutron star embedded in so much dust, it is actually very useful for scientists to know the location of every possible neutron star.

Travis: Here in Boston we can identify the population density of an area from the density of Dunkin Donuts stores. The more Dunkin Donuts, the more people you'll find guzzeling coffee and wolfing down donuts.

Pamela: Mmmmm Latte

Travis: Neutron stars trace out the densities of star formation in our galaxies much the same way.

Pamela: Neutron stars form when some of the fastest burning and shortest lived giant stars in a star forming region die and go supernova. The stellar embers are then left behind as eternal beacons, marking the locations where star formation occurred. By mapping out where neutron stars lurk in our galaxy, we are also mapping out our galaxies star formation.

Travis: The high-energy nature of neutron stars allows them to show up in X-ray and gamma ray images in areas that are so dusty and gas filled that we could never see them optically. While it would be nice to simply scan the skies with Hubble and map out star forming regions, we can't do that – the light from young stars just can't get through the gas and dust — but the combined high energy efforts of Integral, Swift and Rossi allow us to map out a cosmic view that our own eyes and Hubble will never see.

Pamela: And, thanks to the efforts of theorists who determine how many sun like stars are likely to form for every neutron star, we can combine theory and data to better understand the overall structure of distant and badly named arms like Norma.

Travis: Here’s to you Norma. <clink of glasses>

Pamela: And here’s to our twentieth episode of Slacker Astronomy. As we grow into a more mature, if still very silly, podcast, we are working to bring you a more bang for your buck.

Travis: Um, Pamela, this is a volunteer effort. They get this for free.

Pamela: Oh yeah. Um, we work to bring you more bang for your megabytes. We launched our new site a week ago, and we’re working to shake out all the bugs, and we want to know what you think. Check us out at www.slackerastronomy.org

Travis: And if you like what you see and hear, don’t just tell us, tell all your friends and as well. Our goal is to spread astronomy to the unwashed masses. It is our goal to have 10,000 listeners by September 1, and that can only happen with your help.

Pamela: So throw a girl a bone, and coerce at least one of your friends to subscribe to us via iTunes or the aggregator of their choice. If each of you finds us just one more listener, that’s one more person who will be able to enter the secret club of those who know what a magnetar may be.

Travis: So play us at home, play us in the office, play us at school, and spread the slacker cause. Let us know what we’re doing right. Let us know what we are doing wrong. And let us know you’re listening. On behalf of Pamela and Aaron, this is Travis Searle.

Pamela: Clear Skies and Clear Bandwidth, this has been Slacker Astronomy, a three person collaboration for fun, for you, for the voices in our heads.