Astronomy Cast Episode 176
Mysteries of the Milky Way, Part 1

Fraser: Astronomy Cast Episode 176 for Monday February 8, 2010, Mysteries of the Milky Way, Part 1. 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're you doing?
Pamela: I'm doing well. It's a sunny day! I didn't know that we still had a local star anymore.
Fraser: Sometimes the clouds are on fire... I'm not sure what that is. Yeah... we don't get a lot of sun here. So, thanks to everybody who has been sending in their postcards.
Pamela: Yes!
Fraser: We've been getting a bunch of virtual postcards, which... I'm not sure we know what to do with those... I guess we can cut them all out and post them to the wall, but we love the paper! Kill more trees...
Pamela: Yes, please. I'm aiming to have an entire wall covered so that I can take a glorious photo and list out where all of your postage stamps came from.
Fraser: And we will include it on the podcast, in the show notes, and we will all be amazed by it and... yeah, that will be awesome. So, if you haven't already... send a postcard from your hometown to...
Pamela: P.O. Box 804, Edwardsville, IL 62025, and you can address it to either Astronomy Cast or Astrosphere New Media.
Fraser: Perfect. So, we've wrapped up our solar system mysteries, and now we move on to the Milky Way mysteries and some of the general mysteries of galaxies from blue stragglers to Eta Carina... what's going on? So, yeah, so this week we will expand our field of view and talk about some of the mysteries of our own Milky Way and then some of the kind of common mysteries that go on in galaxies. So, let's start with blue stragglers. What's a blue straggler?
Pamela: Well, when you look out at globular clusters--little blobs of stars that live on the edges of the Milky Way galaxy, you see that the majority of the stars are nice and old... the majority of the stars are red. According to stellar evolution theory, there should be this nice point at which all of stars have turned off what's called the main sequence. They've stopped burning hydrogen in their cores, they've moved on to do more interesting things based on how much mass they have.
Fraser: Right, so the globular cluster is thought to be a big ball of stars that all formed at the exact same time many billion years ago, in fact, shortly after the big bang... shortly after the formation of the Milky Way, they should have all formed at the same time and so..
Pamela: The highest mass stars have all moved on to do other things, the lower mass stars are still petering their way through their hydrogen, and there should be a clear turning point where stars have either evolved off the main sequence or are doing their slow little "I'm a red dwarf" thing.

Fraser: I think we've used this analogy... it's like when you see the... we have Remembrance Day here in Canada and every year at Remembrance Day you see the people from WWI and you see the people from WWII and every year that goes by you're seeing less and less of them because the wars happened so long ago and people are passing away. So you would expect to see the equivalent of that... you would expect to see stars of a certain age and no greater in these globular clusters... and yet....
Pamela: And yet, we've got these blue annoyances that are sitting there on the main sequence where they don't belong at too high of a mass.
Fraser: Is it a baby star?
Pamela: Well, we don't know. We just know they're blue and they're big.
Fraser: But blue and big is a very massive star that should only survive a couple of million years and then go kapoo, and that will be that.
Pamela: Or maybe not that big and blue, but still big enough that they shouldn't be there.
Fraser: Right... they shouldn't last more than a few hundred million years at best...
Pamela: Yeah, and so we've got these blue stars that are kinda large, and they're sitting there where they have no right to be. People have been trying to figure out how they got there, and some of the explanations are... "Well, maybe they just formed late," but that sort of botches up our whole theory of globular clusters and these wonderful stellar laboratories where everything formed at the same time out of the same stuff and thus the only thing differentiating one star from another is its mass. So, we don't like that idea. The other ideas, though, are kinda neat. Most of these blue stragglers are found deep in the heart of these clusters, and maybe the reason you have these stars is because two other stars, two normal stars collided. And suddenly you had something new and big that wasn't there before.
Fraser: Right, so you've got such a dense place inside the globular cluster and all these stars are buzzing around the center of gravity of this cluster that collisions could be inevitable.
Pamela: Right.
Fraser: Two bang into each other and suddenly you've now got... before you had two stars with the mass of the sun, or whatever, and now you've got one star with twice the mass of the sun.
Pamela: And then there's also just the simpler idea of well, maybe one star stole mass from the other, or maybe two binary stars merged. So it wasn't necessarily two things running rampant from one side of the cluster to the other and colliding as they crossed in the center. Maybe it's two objects that started out in a close binary and merged. And different scientists have worked to figure out the statistics of all these different possibilities, and statistically it's kinda looking like most of these blue stragglers probably came from stellar collisions but we don't have that final bit of proof... we've never seen anything collide. We don't have that final bit of proof that says yes... this is the reason we have blue stragglers. So the people who are supporting binary stars, the people who are supporting mass transfer, all of these different things... the door isn't shut on those ideas yet. And that's kinda sad.
Fraser: What would a stellar collision look like from our perspective?
Pamela: Well, that's where it gets kind of interesting. You have to be able to look at earlier images. The stellar collision would probably give off a mass of gamma rays... you'd get a flash of light, you'd get gravitational waves... not necessarily detectible from

the planet Earth... it would depend on the size of the collision. But, you'd have to then go back and look at prior images to figure out... is this a binary system? Is this a system where you have two stars coming at each other from opposite directions that aren't orbiting one another? It's in going back and finding early images early... perhaps glass plate images from a hundred years ago... that would let us start to figure out what is it we just saw?
Fraser: That's pretty cool. Alright, well lets move on to our next mystery... and that's where are all the supernovae? Are we missing some supernovae?
Pamela: We're missing quite a few, it's kind of disturbing. Our galaxy is far less interesting than we'd like it to be.
Fraser: How interesting do we want it to be?
Pamela: Well, as long as they're not happening too nearby, we have reason to believe that there should be two or three supernovae every century here in the Milky Way galaxy. That means that every 100 year old grandparent should have seen 2 or 3 supernovae in their life, or at least heard about them happening.
Fraser: Right. And we should have seen one in our lives...
Pamela: Yeah, we're in our 30s, there should have been one.
Fraser: And the only one that we can point to was the one that happened relatively near by...
Pamela: In 1680.
Fraser: No, sure, and then there is the one in 1987, right, in the Magellanic Cloud, but that's far away... that's like 200,000 light years away.
Pamela: Yeah, that doesn't count.
Fraser: That's not close. So the closest most recent one was... what was it?
Pamela: 1680.
Fraser: 1680... that was the one seen by...
Pamela: Flamsteeds.
Fraser: Flamsteeds supernovae, that was seen by the astronomer, and I know that earlier in the 1600s there was one seen by Kepler, but... that's right, so we're missing like 12 supernovae since then...
Pamela: Yeah, it's kind of disturbing.
Fraser: Yeah, we've been ripped off...
Pamela: So the question is... where are the missing supernovae? And we have some hints that there were supernovae in some of the dusty regions of the Milky Way... ones that were just hidden so we're not quite able to see it. In 2007, Chandra took some images and was able to identify some expanding dust clouds that look like maybe they're remnants of supernovae. So, here we have the remains of a young supernova that we're calling G 1.9 + 0.3 because really we shouldn't be allowed to name things. But that's only one of the missing supernovae. So...
Fraser: So... let me see if I understand this correctly, then... if we look out at other galaxies and just keep track of them... and it's like pop, pop, pop, pop, pop! and if we see supernovae all around, and then we figure out for the size of the galaxy and for the distance we can measure, then we say ok, we have a spiral galaxy, about the same size as the Milky Way, should be having three a century. We're missing ten.
Pamela: We're missing ten supernovae, statistically. I want my supernovae! They're exciting, they're beautiful, they expand into amazing-looking things.

Fraser: So then, I mean, sure there's going to be a bunch that are going to be hidden by all the gas and dust, but that's still not enough.
Pamela: Well, it could be. It could be that we simply got unlucky. That's the problem with things that are randomly distributed... occasionally they clump up where we can't see them. So, it could be that they were on the other side of the galaxy... we got lucky for a while there in the 1600s... maybe we're making it up...
Fraser: Or they just didn't happen.
Pamela: Yeah.
Fraser: Is there some scientific explanation, that perhaps the Milky Way's kinda funny?
Pamela: More likely they're just hidden...
Fraser: So, there isn't like we don't have enough star-forming regions or we recently went through a period of using up all of our available dust or any of that?
Pamela: No...
Fraser: No? No?
Pamela: No. No.
Fraser: No? We're just as regular as everybody else? We ought to be having that number of supernovae?
Pamela: Yeah, so most likely it's a combination of... well, yeah, we're supposed to have 2 or 3 and maybe we only had one one of those centuries and it's perfectly reasonable that they were all annoyingly buried in dust and we just haven't detected them yet via other wavelengths of light.
Fraser: And we don't have good enough records for the ones that could have happened before then, and good enough instruments. So we've got a few of the ones that we can talk about... the 1680 ones and the 1604... the Crab Nebula, 1054... Ok, alright, so it's a mystery, we don't know... ok...
Pamela: I want my supernovae!
Fraser: Ok, well then the next question we've got is... we actually talked about them... the small and large Magellanic Clouds. These are these satellite galaxies of the Milky Way.
Pamela: We think they're satellites.
Fraser: Right, that's my question... are they? Well, are they?
Pamela: We don't know! The problem is this whole dark matter halo thing... you can't see dark matter... it makes it kinda hard to figure out its distribution. The large and small Magellanic clouds are currently plunging near the Milky Way galaxy. We pretty much know how fast they're going... we can measure using Doppler shifts their radial velocities, their velocity on a straight line between us and the center of them. We've been very carefully measuring their position relative to other stars for a number of years, so we know their proper motions, we know how fast they're moving across the surface of the sky. When we put these numbers together, we can figure out how fast they're moving compared to one another, we can figure out how fast they're moving relative to our own galaxy... and then we can do things like start calculating orbits and figuring out if they're attached. This is where unfortunately we have to start making assumptions because we don't know exactly how big the Milky Way is, we don't know exactly what the distribution of mass is for the dark halo... the distribution of dark matter that we can't see that's surrounding our own galaxy. Depending on what numbers you plug in, you either get--in the most bizarre case--that the SMC... the Small Magellanic Cloud and the Large

Magellanic Cloud are rushing past us, aren't gravitationally bound to us, and aren't even gravitationally bound to each other. And that's just bizarre, because that's a lot of coincidences all at once. But then in other cases, you get them politely bound to each other and politely orbiting in a rather self-destructive manner around and around our own Milky Way. And we just don't know.

Fraser: Right, and the one possibility is that we will eventually tear them apart and gobble up their stars and add them to our own and grow large with Magellanic clouds, and the other possibility is that it's just a complete coincidence that we've got two big beautiful dwarf galaxies zipping right past us. And I know that they're actually quite useful because they have in many cases much more active star-forming regions than we have in our own Milky Way. So, some of the biggest, best, hottest stars that we can see are in these clouds. There's an amazing image of the 30 Doradus--is that it? This incredible star-forming region that's just got thousands and thousands of stars blowing these bubbles--it's just amazing pictures to see. So yeah... thanks for coming close and giving us a shot at this. It's been very useful.

Pamela: But it's just neat looking at the numbers, because to escape from the planet Earth you have to be going a little under 12 kilometers per second. But to escape from the Milky Way galaxy, you have to be flying--if you're 50 kiloparsecs away--you have to be flying past at 380 kilometers per second, and that's what we're observing in that tangential velocity for the Large Magellanic Cloud, so that small galaxy that we're looking at is moving 380 kilometers each second!

Fraser: And to those of you who live in the southern hemisphere and can actually see these with your own eyeballs, I envy you.

Pamela: Yes. Total envy.

Fraser: Yeah, but we got the North Star so ha! Alright, so the next question is the closest star to the Sun is Proxima Centauri, a member of the Alpha Centauri system... or is it??

Pamela: Yeah, we don't know that one either.

Fraser: Again, we don't know--is our closest star a member of the system, or buzzing past?

Pamela: Right. Yeah... we don't know. The problem is, there's this whole cluster of stars that include Proxima Centauri and Alpha and Beta Centauri and a few others that are all moving through the sky at about the same velocity. As they chew on through, this separation between Proxima Centauri and Alpha and Beta Centauri is--or Alpha Centauri A & B, rather--is so small, just 0.21 light years, that it seems like statistically it shouldn't just be a matter of coincidence. The problem is anytime an astronomer sees two things that are just too close together to explain except as a coincidence, we're like no, can't have a coincidence... but maybe it is? The problem is that the compositions of the stars don't match as exactly as you would want if they all formed at the same time. So, Alpha Centauri A & B have very similar compositions, Proximal Centauri... not so much.

Fraser: So, it's a red dwarf... quite far away.

Pamela: Yeah, and so we want... just because it's a nice pretty picture... you can blame Proxima Centauri in some small ways for the cloud of material around the Alpha Centauri system. It seems like maybe... there are people who try to say that Proxima Centauri was captured, but we're just not sure. And if it is orbiting, it's currently at it's furthest place in its orbit from Alpha Centauri A & B stars.

Fraser: So that's right, so when they do the velocity measurements of where it's going, the only way for it to even be in orbit around those two stars is if it's in this wildly elliptical orbit and it's at the very maximum point in its orbit and just about to break free. Right?
Pamela: Yeah, 330 times further away than Pluto's orbit from the sun.
Fraser: Right. So even if it was orbiting the sun, it would be hard to even spot it as a bright star in the sky.
Pamela: And because it is at its most distant point, if it's part of a bound system, the problem is that it's at its slowest point of that orbit as well, so it's not like we can just watch to see if it just moves in that orbit. All we can basically see right now is all these objects moving through the sky together.
Fraser: And they are kinda moving together, and that's a coincidence and astronomers don't like coincidences so...
Pamela: Yeah, so we ended up just sort of getting confused. We need more data.
Fraser: Yeah. You know what we should do... we should send a spaceship there.
Pamela: Hollow out an asteroid, put on some rockets, fill it with a few generations of humans... I'm all for that.
Fraser: Alright, let's move on to another mystery. Oh, I love this one... if anyone has ever heard of Eta Carinae, it is probably one of the most massive stars that we know of... 100+ times the mass of the sun, maybe 150, at the theoretical limits of what a star can be... formed in a massive star-forming region--the Carinae nebula...
Pamela: Surrounded by the Humunculus nebula, which is just one of the coolest-named objects...
Fraser: Due to detonate as a supernova... yesterday!
Pamela: Yeah.. it's...
Fraser: When's it going to blow up?
Pamela: I'm hoping soon!
Fraser: Yeah, I know... me too. So, what's the evidence that we know that it's going to blow soon?
Pamela: So, if you look at stellar names, the brightest star in a constellation is named "alpha," the second brightest star in a constellation is "beta," and you work your way through the Greek alphabet. At no point in the naming of constellations was the brightest star in a constellation ever named "eta," except the brightest star in the sky is kind of eta carina. This is because back in 1843, the star underwent what we call a supernova imposter event. It had this amazing brightening, it underwent basically a nova event and in the process poofed out a fairly significant chunk of material that is forming this Humunculus Nebula around it. Now when we look out across the galaxy, we see other stars that have rings of light radiating away from them, other stars that have undergone these false supernovae moments. And in at least a few cases, these flashes have occurred right before the star decided to go nova as a supernova. So here's to hoping that that 1843 event meant that in our lifetime we will get to see not just a supernova, but when Eta Car goes, it will probably go as a gamma ray burst except the points of the gamma ray burst--the jets that you have to worry about--are not pointed towards us. So we'll get to see a hypernova going off near us, and get to see how all it gets affected, we get to see what happens with the Humunculus Nebula getting blown apart, it's in a star-forming region, it's going to be a wonderful event when it goes off.

Fraser: Right, without the pesky mass extinction.
Pamela: Yeah, yeah. So the only problem is that "it could happen any day now" in astronomy means tomorrow or 10,000 years from now. So I'm hoping for tomorrow and those of you down in the southern hemisphere, you'll be able to see it day or night. So just let me know when you see it.
Fraser: Yeah, but I mean the longest that it could possibly go... like a million years? a hundred thousand years? It's not going to last longer than a hundred thousand? million?
Pamela: A million... I'll give you a million.
Fraser: Dead before a million years. Ok.
Pamela: And I'm willing to stick by my 10,000 years.
Fraser: 10,000 years.
Pamela: Yeah, that's my unprovable bet.
Fraser: Right, but you like that evidence of it puffing out that outer layer, having that brightening, and that being a precursor to it actually detonating.
Pamela: Yes.
Fraser: Is there any way that astronomers can get a better sense of when it's going to blow?
Pamela: No.
Fraser: There's no methods, there's no staring at the surface and watching for a certain kind of radiation coming off of it, or heat or temperature, fluctuations or solar flares, or gravitational anomalies, no? tachyon bursts?
Pamela: No, not so much! So if you just happen to be watching one of these things with an x-ray observatory--and this happened with Swift a few years ago--you can see a burst of x-rays coming off right before the thing blows. But, there you have to just get lucky... and that happens pretty much as the supernova is occurring, it's not like you're going to get months of warning, this is moments of warning, and once that x-ray burst goes off, the whole supernova--it has started. So, other than that, it's not like we can even see the surface of the system because it's surrounded by this rather awesome nebula. So, we just watch and wait.
Fraser: Come on, Eta Carinae... blow up for me... All right, well I think we've run out of time for mysteries for this week, but we've got some more mysteries... we'll warn you right now, for the Milky Way and galaxies for next week. So, we'll continue on and who knows how many more shows we'll do? Alright, thanks Pamela...
Pamela: Sounds great, Fraser... I'll be talking to you later.