Astronomy Cast Episode 66:
How Amateurs Can Contribute to Astronomy

Fraser Cain: This is one of the shows we've had a lot of people ask us about, so I'm really glad to be able to do this one.

Astronomy is one of the few sciences where amateurs can make a meaningful contribution to the advancement of science. Many professional researchers work hand in hand with teams of amateurs to make discoveries that wouldn't be possible without this kind of collaboration.

We've got a special guest here today – Pamela, you do this kind of collaboration. Why don't you regale use with a tale of your research?

Dr. Pamela Gay: I'm a variable star researcher. I study these little stars called RR Lyrae stars that are perhaps most famous for all pretty much being the exact same luminosity. This means these lights are all their own little moral equivalent of 100W light bulbs. When we look at them, we measure how bright they appear and we can figure out where in the universe they're located by knowing the luminosity. I've used this example a million times, but it's the same way we're able to figure out how far away cars are at night by looking at how bright the headlights appear.

Fraser: How do amateurs come into your work?

Pamela: Well, RR Lyraes are most famous as standard candles. That's not why they're most interesting. These little pulsating variable stars, over the course of human lifetimes, can actually be seen to evolve and change. If you watch them night after night, year after year, you can see their periods change, you can see them occasionally pick up, you can see them go through these weird multi-period effects where it's like 2 windshield wiper blades that aren't quite in sync. Sometimes they're both moving to the left, and sometimes one is going to the left and the other is going to the right.

When you get these periods beating against each other, you get the same sorts of beats and increases and decreases in how the star's behaving. These really weird stars are the ones that interest me.

But it takes lots and lots of nights of telescope time to understand what's going on. Telescope time at national observatories and university facilities is extremely hard to get. By working with amateurs, who are generally happy to look at the same star night after night, month after month, I'm able to get enough data to de-couple all these different weirdnesses that are going on.

Fraser: What kind of setup would one of your contributors have?

Pamela: A lot of the people I work with have your normal, off-the-shelf Meade or Celestron telescope. Something eight inches in diameter or bigger is good for getting into the harder science – 12 inches is just about perfect.

Attached to this is a special type of digital camera called a CCD. They're generally made for amateur use by SBIG Corporation (Santa-Barbara Instruments Group) and by a company called Apogy. These special digital cameras are used with filters that only let certain colours of light get to the detector. This allows people to take data all over the world and then combine the data together to get one great combined data set.

Fraser: Okay, so let's say you're interested in astronomy and you want to contribute. What kind of a budget would you be looking to lay out for that?

Pamela: You're probably looking to spend about 5 thousand dollars, as an initial buy-in, to start doing good, hard science.

Fraser: But you're going to be able to use this telescope for…

Pamela: Everything.

Fraser: …pretty astro-photos and showing your friends Saturn, as well as doing hard science.

Pamela: This is a telescope you can use for everything.

Fraser: Right. Okay.

Pamela: So you're doing the digital imaging. You're doing filtered scientific imaging. You're looking at pretty objects with your eyes by pulling the CCD off and putting the eyepiece that came with the telescope in. It's a very versatile, flexible system.

Fraser: Maybe in the show notes, we'll describe what we think the perfect setup for that. This is not going out with binoculars and your eyes and learning your constellations. This is the next level of stuff, but at the same time what are the rewards? I mean, beyond contributing to the knowledge of humanity… you can get your name in journals, even speak. I've seen some pretty neat things happen in these kinds of collaborations.

Pamela: I'm actually in the process of putting together two different research papers where other than me, all of the authors are going to be amateur astronomers that I have collaborated with on two different projects. In one case, the first author on the paper is one of the people that I've worked with through Swinburn Astronomy Online, who's an amateur astronomer who's been taking some online classes to work to get an advanced degree in this thing he does as a hobby.

You can see your name in the peer-reviewed literature, but I think the most cool thing that comes out of particularly studying variable stars is you can, over the course of a single night, see a star change. You can watch it get brighter, get fainter and its behaviour from night to night isn't always identical with the RR Lyrae stars I study in particular.

There are other types of stars that are misbehaved out there as well. You can just watch their strange variations and get involved in why it is. Not everyone is sure. We don't really have solid reasons for some of these misbehaviours that are going on. The data that normal people in their backyards are taking is the data that is someday going to help us solve these mysteries.

Fraser: I think as well there's a certain amount of innovation that's going on with some of the people with the smaller telescopes. They're having to learn some tricks, having to learn some image processing techniques. There's actually something they have to teach the professionals again. It really is a true collaboration.

This is going to sound like a total laundry list, and I apologise in advance. We kind of brainstormed all the areas we could think of and I can't really think of a way to string it all into some kind of logical narrative.

We talked a bit about variable stars. Why don't we start with that? What are the kinds of variable stars that amateurs can help out with?

Pamela: The best way to get involved is to check out the website of the American Association of Variable Star Observers (AAVSO). They have a lot of different ways that you, as a normal person with a telescope, can go out and get involved in doing real science.

There's variable stars that intrinsically vary – RR Lyraes, Cepheid stars…. These are individual stars that are changing in brightness. You could also study binary stars. These are stars that appear to vary, but it's really two stars with one that's passing in front of the other. We can use data to figure out the masses of these stars, the distance to the stars, how their orbits are evolving over time.

There's one type of variable stars called cataclysmic variables where one of the two stars is sucking material off of the other star. Occasionally these flare up as nova events.

There's recently been a set of Hubble Space Telescope images that were taken for Paula Scodi, a researcher out in Washington. She got ground-based data from amateur astronomers to support this data. If this particular cataclysmic variable she was observing had gone into a nova event while Hubble was looking at it, it would have been too bright for Hubble's instruments. She needed to work with the amateurs to make sure her star stayed nice and non-nova for the duration of the Hubble observations.

There's also the biggest boys of all, the supernova. There are still amateur astronomers out there who search the sky by eye and by digital camera night after night, imaging in some cases hundreds of galaxies looking for that one elusive supernova that might crop up out of all these galaxies.

Fraser: With the supernovas, that's really important. A lot of astronomers need to study those, right?

Pamela: Supernova get used for a bunch of reasons. There's the whole standard candle thing that we've all heard so much about. But you and I are made out of supernova material. So by understanding the nearby supernova that are close enough we can get good images, we can get good spectra, and we can measure how much of all the different elements is getting produced in this supernova event. By looking at these nearby supernova events getting discovered by amateur astronomers in many cases, we can better understand where the stuff that made you and I originated.

Fraser: From what I understand, the techniques for finding supernova is a little different. With a variable star, you just point your telescope at the object and report over a long period of time and send in your observations. With supernova, you don't know where you're looking. You're just scanning the skies based on your knowledge of how bright a galaxy should be, looking for a strange star in one of them.

Pamela: The supernova discoverers are some of the most amazing observers in some respects. I got a chance to know one out at McDonald Observatory, Bill Ren. He'd take his telescope out and every night he'd scan through over a hundred galaxies with his eyes, jumping from one galaxy to the next, to the next to the next. He'd memorized what all of these galaxies looked like. As he jumped from them, he'd be looking for changes where any change he saw just might be that next great, cool, supernova that everyone turns to look to.

Fraser: So that's where the training and where the amateurs have something to tech the pros.

Pamela: Yeah, we can't find anything on our own.

Fraser: What about finding planets? I know the search for planets sometimes involves dimming the light of the star, making it a variable. Are amateurs involved in that?

Pamela: This is another place where amateurs are out there keeping up with the big boys with the big telescopes. There's an organization called transitsearch.org, and they go out and study the stars that have planets transiting them. They've gotten together pockets of amateur astronomers to help out in this.

There are a number of planets we know of that cross directly between us and the nearby bright star they orbit. We can see at sometimes just the 1% level (or even less than that – the 0.1% level), the light of the star dimming as the planet passes in front of it.

Even though this is such a small change in the brightness of the star, if you have a four-inch telescope, just a little one, and you calibrate it really well, it's possible to go out and observe planets in your backyard from a dark enough location. That's really cool.

Again, these are things amateurs have already done.

Fraser: I guess the problem with observing extrasolar planets is that you don't know where to look. If you find the right star, with the planet moving in front of it on a regular basis, you could have that dimming of the light by 1% on a periodic basis, but the problem is there are millions and millions of stars to look at.

This is one of those situations where many eyes makes light work. Many different astronomers can be looking at many different stars and recording. You've also got to record over a long period of time. You can't just look one night and go "no planet". You've got to watch one star for night after night after night after night, watching for that dimming, right?

Pamela: Transit searching for amateurs can fall in a couple of different ways. It can be just as simple as someone with a big telescope doing spectroscopy and looking at Doppler shifting, finding the star has a planet and seeing if we can go out and see it as a transient.

Or it can be what you just said. You go out and observe a chunk of the sky, say an open cluster of stars – a large busy section filled with lots of stars. You look at this field night after night after night. You find the RR Lyraes in it, you find Cepheids in it, you find the binary stars in it. You also find those occasional stars with those tenth of a percent changes in magnitude that are varying because they have planets.

Fraser: I wonder how long ago people could have found planets. I guess a big part of this is the technology. You've got these CCDs that can measure the light coming in from an object with such precision that you can know the light is decreasing by 1%. It would be hard to look through photographic plates and go "that object's 1% dimmer tonight"

Pamela: Just 10 years ago, people struggled to be able to do this. Once we started finding planets, it was a struggle to look for the transits. Now people are doing it with four-inch telescopes. The technology, the digital cameras have gotten much more precise, much lower noise, and it starts to make these sorts of detections possible.

Fraser: There's the micro-lensing too, right?

Pamela: Another way we can find planets around other stars is when a nearby star passes directly in line with a background star. The star's gravity can cause the light from the background star to appear to get brighter because some extra light beams that were originally headed off to a different part of the universe, get bent due to gravitational lensing to point directly to us.

Fraser: We did a whole show on this, so if you want to reference how the gravitational lensing works, you can listen to our show on it. But to recap…

Pamela: In a few cases you get: foreground star lenses background star, makes background star appear much bigger, and then as this alignment starts to change, you see the background star getting fainter and fainter and fainter. Occasionally you'll get this second spike. This second spike is caused by a planet going around that foreground star also passing in front of the background star and adding its own little bit of lensing to the game.

We've found some of the smallest planets we know about because of their gravity, not because of them transiting or causing Doppler shifts. These are planets that are out in the edges of the Milky Way in some cases, and we have no other way of finding them.

Fraser: This is one of those situations where astronomers detect the transit and then they make an announcement to a whole group of amateurs to point at it. The amateurs can watch the transit and confirm if there's a planet or not, and the details of the transit. So once again this is a great example because in many cases it's hard to get big telescope time at the drop of a hat. In many cases you can inform a large network of people and they can go out within the hour and see if they can confirm the transit or the micro-lensing.

Pamela: One of the things you can do with amateurs much easier than you can with professionals in some cases, is get a whole group of them together that are spread all over the globe, and get 24-hour coverage of an object. If you can find something near the celestial equator, you just bounce from nation to nation (and in some cases hemisphere to hemisphere), drawing together Canadian observers, New Zealand observers, Japanese observers, Turkish observers, bringing in people from all around the globe to look at one micro-lensing event, one supernova.

Gamma ray bursts are another place that amateurs get involved looking at the gamma ray burst afterglows. There are so many different ways that professionals just couldn't do the science they want to do without amateurs being out there willing to help out and willing to invest the money to have fun contributing to science.

Fraser: All right. We've talked about a bunch of stuff that's outside the solar system. Let's talk about stuff amateurs can help with inside the solar system.

Pamela: Yeah, we haven't escaped the solar system, have we?

[laughter]

Let's start with the Sun. One of the things we keep track of is how many Sunspots the Sun has at a given moment, where they're located on the Sun. this is how we tell we're coming out of solar minimum: when do we start getting spots on new parts of the Sun, when do the spots jump from the equator to the poles. So we have networks of amateur astronomers around the globe who count Sunspots.

We also have amateur astronomers who use radio equipment a lot of times home-built, to listen for bursts of the Sun's energy hitting our atmosphere and creating solar ionospheric disruptions (SIDS). These get recorded. This is again something you can work with the AAVSO to do. Our Sun is one target.

Another target, and in fact something that allows you to potentially permanently make your name part of the astronomical record, is looking for comets.

Nowadays, there's so many different automated telescopes that the majority of the comets are starting to get found by these automated systems, like LINEAR – we've all heard of different Comet LINEAR-this or Comet LINEAR-that. They're not all the same comet, but people like David Levy are still out there searching by eye for comets that are their own comet. You can go out and look for comets. If you find one, your name gets to go on it. People are still finding new asteroids pretty much everyday of the week.

There is a lot of junk out in our solar system, just waiting to be found by someone patient enough to look for it and then report it correctly. Harvard university has an entire minor planet association there where you can get checked out and contribute in three different ways. You can follow up on objects that are well-known and help refine the orbits.

Fraser: Hold on a second, can we talk about that for a second? That's pretty important. The stereotype when astronomers discover an asteroid is an astronomer looks through the telescope, spots the asteroid and goes, "oh my God!"

[laughter]

Pamela: That is so not true.

Fraser: "That's going to hit the Earth!"

But that's not what happens at all. It's a painstaking process where people watch it and watch it and watch it, and refine their orbit over time. So once again there's only so much telescope time the big observatories can dedicate to watching that random jumble of letters, 2007GR 906. But if an amateur has the time and equipment, they can watch it and determine its location and report in, a week later give another reading, and really help astronomers refine the location of these rocks.

Pamela: This is one of the more important things that you can be involved in. we occasionally misplace things because we don't know their orbits very well. We see them on one pass around the Sun, and on their next pass we have no idea where they went. Individuals going, "hey, this object needs more data," are able to help us better understand how things are moving around in our solar system.

Then there's also just follow up on discoveries. There's the objects we sort of/kind of know, but we need more data to understand them very well. Then there's the objects that are brand new that no one's ever seen before. We need to confirm those. You can get involved by saying, "I just got an alert there might be a new object. I'm going to follow up on this and help confirm if it's a new object or not." Is it just somebody had a crazy lightening bug interfering with their data? (not that I think that ever happens, but I'm trying to come up with something that could interfere with data)

Fraser: Right.

Pamela: But you do occasionally discover new things. You're out there taking images of Saturn and you do this three nights in a row and notice one of the stars in your image is slowly escaping. That slowly escaping star might just happen to be an asteroid that happens to be lined up with Saturn when you're taking pictures.

Fraser: What about some of the actual planets in the solar system. Is there stuff that amateurs can spot?

Pamela: Storms. Just as there are storm chasers here on planet Earth, there's also storm chasers that are the first ones to call out, "hey – Mars has a huge dust storm coming up!" Mars now has its own network of weather satellites, but at the same time amateurs still play a role in helping understand these.

Jupiter's junior red spot, when it changed colours it was an amateur who noticed it. Tracking the spots on Jupiter is something amateurs participate it.

Fraser: I hate to belabour this point, but I think that most people really underestimate how much of the sky is being observed at any one time. I think people have this idea that there are telescopes watching everything out in space at all times and they see everything going on. In fact, telescopes can only see a teeny-tiny slice of sky and can only look at a couple of targets a night. In some cases, Hubble will take pictures that will be of the same object for dozens or even hundreds of hours. There's no way they can look at anything but one tiny little target.

To have all these eyes out there, all the time, looking at as many things as possible, lets the astronomers catch the stuff they never really thought of. How could the people not notice there's a new storm on Jupiter? The reality is people aren't watching Jupiter everyday. They just don't know – and they're not keeping really, really careful measurements about what they're seeing.

Pamela: It's not just looking at the sky to observe parts of the sky that aren't being observed (and there's a whole lot of parts of the sky that aren't being observed). Just for perspective, the moon is about 30 arcminutes by 30 arcminutes in size. The telescopes I used for a lot of my dissertation research had a field of view that was 7 arcminutes by 7 arcminutes in size. They couldn't even see one ninth of the moon.

If your typical professional telescope is lucky to be able to see one ninth of the moon, which doesn't take up a whole lot of sky… the majority of the sky at any given moment isn't being observed by anyone.

As well as trying to keep track of what's going on in the sky, there's a ton of data that's getting taken by automated missions, different satellites, automated telescopes that also needs people to take a look at it. One of the most famous examples is looking for Sun-grazing comets in SOHO images. That's somewhere where there are lots of amateur data-mining astronomers who are sitting in their living rooms poring over data and pulling out and discovering all these comets in the process of zooming to their doom.

Fraser: You don't even need equipment for this. This is one of those situations where you can sit at home with an internet connection, the right data and be able to pull up discoveries.

Another great example of that is you look at the Sloan Digital Sky Survey, which is one of these automated network of telescopes observing vast swaths of the sky (a percentage of the sky, I don't remember the final number will be, 20-30%) at a pretty high resolution. All that data is available on the internet. When I write articles on Universe Today, many of them are like, "this team was looking through the Sloan Digital Sky Survey to measure the brightness of quasars" or "this team has turned up 10 thousand unknown asteroids". In many cases it's more about being a good programmer and knowing how to grind through that data – being a good database analyst. So in many cases if you're a programmer or a database researcher… there are lots of ideas people have, they just don't have the time or software to grind through this automatic data.

I think another good example is the Galaxy Zoo is pretty cool. Have you played with that yet?

Pamela: It's a really neat thing. The data they're getting with Galaxy Zoo… just having individuals look at galaxies by eye (because humans can visually classify things better than any computer can), by just going through, looking at these things and saying, "yes, the arms are wound clockwise/counter-clockwise, we're looking at it edge-on. This is an elliptical galaxy. This is something so irregular it looks like the letter Q".

Fraser: A computer does a really terrible job of grinding through the Sloan data, but a human can really spot them and say that galaxy's left/right/spiral/elliptical.

Pamela: This is data that astronomers have been dying to get. The sky is so big, there's so much to do, and it takes human eyes to do it. To do statistically valid samples – to look at 10 thousand objects, you're either looking at torturing a whole pack of graduate students for 3 or 4 years, or sending out to the entire population of the world and saying, "hey world – help me do science". We're finding people are more than willing to help out if you just give them the tools.

They're doing some really amazing things with Galaxy Zoo and they're also having fun. One project going on the side is trying to find galaxies that look like all the letters of the alphabet. While that's thoroughly silly and not really leading to great science, it's the type of thing that will get people interested in looking at the science. While they're looking for the elusive letter Z, they're also classifying galaxies, and their classifications will allow scientists to statistically valid and significant studies.

Fraser: I know there's some really interesting research that's already being worked on right now, and there's even a couple hints I've heard of some almost ground-breaking discoveries that might get made. There seems to be a strange imbalance of galaxies.

Pamela: Once they're done with the information, I've been promised we will be told so we can…

Fraser: announce it.

Pamela: … bring it straight to all of you.

Fraser: Then there's SETI@Home. Once again you don't even have to be there – just turn your computer on, let it crunch through data, and find aliens!

Pamela: And occasionally find things like pulsars and other things that make systematic noise in the sky.

Fraser: Then, there are some things you can do outside anyway, that doesn't necessarily require your computer. It doesn't necessarily require a telescope. I'm thinking looking for meteors.

Pamela: Every year we get a whole bunch of meteor showers – the Leonids, the Perseids, the Gemenids are coming up next week.

Fraser: Yep.

Pamela: To help us better understand the distribution of the junk in the solar system, left behind by the comets and asteroids that formed these meteor showers, people can go outside and just draw on a celestial map where the meteors they're seeing seem to pass through the stars, and write down the times.

By writing down the positions and the times of all the different shooting stars you see, we as astronomers can better map out where the tail of Comet Enke is, or the tail of all these other objects that have led to these meteor showers.

Fraser: Is there a place people can go to turn their data in?

Pamela: Sky and Telescope Magazine, every time there's one of these coming up, lists the appropriate body for the particular storm that's coming up. They're a great resource for finding where to report your meteor shower findings.

Fraser: I usually send people to amsmeteors.org, which is the American Meteor Society. I also get emails fairly often from people who say, "I saw something really bright flash through the sky. What was it?" I tell them to report it as well. If you're just outside at night and you see a really bright fireball, that's very important. You can report that to one of these meteor agencies. We'll put a list of places in the show notes as well.

Pamela: One other resource that's useful is the website heavens-above.com. It will tell you if you actually just saw a satellite. There are some satellites up there that do make fairly bright appearances in the sky. You can sort out the meteors from the satellites by going to heavens-above.com

Fraser: I'm looking through our laundry list of things that we thought of. There's a couple I think we missed or weren't able to categorize. One is occultations.

Pamela: Occasionally, we'll see asteroids or even planets or the moon go in front of background stars. By getting a bunch of people all across the planet, they can look at these occultations. We can actually start to determine the shapes of asteroids, or the shapes of mountains on the moon a lot more accurately. This is another thing people can get involved in. there's an international organization: IOA, the International Occultation Association. Get involved and go out and just watch a star wink out and time what time it occurs.

Fraser: What if you find a meteorite on the ground?

Pamela: This is one of the great mysteries: I found a rock. It might be a meteor – what do I do with it? Take it to your local geology department. If it is real, they might be scientifically interested in it. Here in the United States you actually get to keep it. You can probably make some scientist's day by going, "here, do you want to play?" and letting them take slices out of it to see what our solar system's made out of.

Fraser: We've got a couple more here: auroras?

Pamela: You can look and see how it is that the Sun's particles that it spews our way interact with the Earth's magnetic field by looking up, observing what colours you see. A lot of times your local weatherman will report when this is going on and tell you who's tracking what particular event.

The next thing I think you're going to get to is there's also galaxies out there that vary similar to how stars vary: blazers. Occasionally you can hook up with researchers at your local university who are interested in active galaxies. If you have larger telescopes (here we're talking 12 inches and above, and CCD equipment), you can also observe the active feeding of black holes in the centres of galaxies.

Fraser: There's one last one, which I think is very near and dear to my heart: fighting the spread of light pollution. Many cities are just getting brighter and brighter, and I know that amateurs have been working to try and catalogue just how light polluted the skies are above various regions of the world. In many cases there are dark skies associations that you can report how bright the sky is at night, and they can keep track of where things are starting to go pretty bad. You just need your eyes – no expensive telescope.

Pamela: The International Dark Sky Association and the Globe at Night both do programs to measure light pollution. If you do like playing with technological toys there's a little Canadian device that's a dark sky meter. You can go out, use it to measure how dark your sky is, and then report what you measure through the internet.

Fraser: I think hopefully we've given the listeners enough of a list of places to get going, that I think you could spend your whole life participating in this scientific research.

I really think this whole area has opened up in the last 10 years, with the real advancement of CCD technology and a lot of automated tools that let you guide telescopes. It's made guided telescopes that can detect this kind of really faint fluctuations in brightness within the reach of most amateurs. You get a really nice telescope you can use it for science at the same time. It's just opened up the floodgates and really encouraged this kind of collaboration.

I think astronomy could really serve as a model to other research fields. I think that in a lot of other places, there's the scientists and then there's the amateurs or the enthusiasts. In many cases the difference between someone who is an amateur/enthusiast and someone who's a professional is in many cases just some additional schooling, but in many cases one person's a little more street-wise and the other person is more book-smart. I think the more of that kind of collaboration we can help bring together, science as a whole will take off.

I've said it before, I'll say it again. We're in the golden age of astronomy, and this is one of the corner stones of that golden age.

Pamela: There's no reason to be using your telescope just to look at Messier objects. Do that to inspire people, to inspire yourself occasionally – we all need to take our favourite pretty picture now and then. You can do science: all of you listening right now can go out and do science. Get involved, find some way to help increase our understanding of the universe.

Fraser: We also get the emails from the person who wanted to be an astronomer as a kid and… I don't know, become a banker. Listening to Astronomy Cast has reignited their interest in science. Here's the part where the rubber hits the road: if you really are interested in science, if you're interested in astronomy and want to rekindle the childhood aspirations, there's a way you can do it (especially if you're a banker!).

There's lots of ways you can get involved and the scientists really need your help. You've picked the right hobby.

Let us know! We'd love to hear if you're already an amateur that participates with a professional observing or if you want to make that transition. Drop us an email and we'll give you personalized tips and try to match make. If you're a professional astronomer and need more amateurs, let us know. We'll try and make some love-connections.

This transcript is not an exact match to the audio file. It has been edited for clarity.