AstronomyCast Episode 239 for Monday, November 14, 2011: Astrophotography Part 1: The Gear

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Fraser: Welcome to AstronomyCast, 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 at Edwardsville. Hi, Pamela? How are you doing?

Pamela: I'm doing well. We've hit that point in Fall where you know winter is coming, but it's still beautiful. I hope you're having similar weather there in the Vancouver area.

Fraser: Absolutely. The La Nina year that we're having has made it just non-stop sun all the way through September, October, November…it's been amazing. Makes up for that horrible summer that we had. So we got an announcement today, which is that we're going to be going on a cruise to celebrate the end of the world, which is as you know, we love to rant about the 2012 "end of the world" prophecies, and so on December 21, 2012 we will be in the middle of the Caribbean visiting Mayan ruins, laughing at the fact that the world isn't ending, and you can come with us. So here's the details: it's called "The End of the World Cruise," or "The Great 2012 *Not* the End of the World Cruise," and it starts on December 16-23, 2012 on the Norwegian cruise lines' *Norwegian Jewel*, and so there's…David Brin is going to be the headline speaker, we're going to be doing live episodes of AstronomyCast, we're going to be doing demonstrations of astronomy, bringing telescopes… Come meet us, hang out with us, get sick of us, get sick *with* us, but uh…yeah, but we will be doing that, and you can join us. So you can go to end-of-the-world-cruise.com, and you can sign up. And you want to let them know that you signed up because of us. So how does that work?

Pamela: Well, so actually, they don't even need to go to that website except to get details. Everything you need to know is going to be on a special link off of the AstronomyCast website, and the way it works is there's this wonderful woman by the name of Zelda, who's our reservation specialist, and the only way to book for this show, not for this show, well there are shows, book for this *cruise* is to give Zelda a call and tell Zelda, "AstronomyCast sent me, and I want to celebrate the end of the world," and she'll set you up and help you figure out how to join us onboard. Prices range from $600 to a little over $1000 plus taxes and port fees, and we're really hoping to see you.

Fraser: And it's *very* important that you say that AstronomyCast sent you because if we want to be able to do this kind of stuff in the future, it's important for people to know that AstronomyCast listeners want to come on these kinds of activities and do these kinds of cruises and trips and things like that, so please let them know that AstronomyCast sent you, and, you know, drop us an email if you want more details. I suspect it's going to fill up pretty quick, so you might want to commit pretty soon.

["Audible" commercial]

Fraser: Alright, well let's get on to this week's episode. Now, there's a saying…I forget what it is, but talking about astrophotography, or doing a radio show about astrophotography is kind of like dancing about architecture, so we have put off this show for a very long time because we keep going, "well, you know, if it was video or we had photographs to show, then that would make things a lot easier," but I think that we're going do it anyway because a lot of people want this information, and your brain is filled with knowledge, and we will have great show notes and people can follow up afterward. So, let's talk about astrophotography. So here we go… No matter how good your telescope is, you're never going to see the same detail and colors as the photographs. To take amateur astronomy to the next level, you really need to attach a camera to your telescope. Welcome to the hobby of astrophotography. Fair warning: this hobby could bankrupt you! Alright, so then when we…and in this episode we really want to talk about the gear, so whenever people talk about astronomy to me and they, "Well, I looked through a telescope and it just didn't look anything like the photographs that I see on the internet or taken by the Hubble space telescope…" So what is the gear that's being used to capture those images? To take your first astrophoto, what is the chain of gear that you need?

Pamela: So it really depends on what you're trying to take a photo of. There's basically three different technology routes to go depending on your favorite target. So the folks that are out there taking these amazing images of the planets, who are taking these amazing images of craters on the Moon, of just a whole variety of stuff, mostly in our solar system, what they're actually using is webcams. Two-cam webcams are the webcam of choice, and what they're doing is taking a ton of images, finding the best ones and stacking those together. Now, on the other side, if you're target of choice is wanting to instead get the horizon, and get constellations, and just bring the whole picture together, this is the work that The World At Night (TWAN) has done amazing photos. What they're using is just off-the-shelf DSLR cameras, so that's a different route to go.

Fraser: Or those beautiful time-lapse ones, those are done with DSLRs as well.

Pamela: Right, and then the third direction to go is you're going to take that amazing deep image of a galaxy. You're going to take the image that looks like it belongs on the cover of Sky and Tell discovering the star-forming regions. Those are people who are generally picking up CCDs, Charge-coupled devices, that they plug into the back end of their camera. Now, in some cases, you can use DSLR cameras to do that as well, so you have options.

Fraser: Right, so the chain is a camera, and in this case, if you're going to take like wide-angle stuff, where it's not through a telescope, just the camera alone is going to do the trick, but you need to be able to open up the aperture and let it…and all to have some way to track, right?

Pamela: Yeah.

Fraser: …the stars…that's sort of step one, or you're going to get the star trails. Step 2 is you're going to need some kind of telescope that you can then magnify and then, and so the camera options vary, the telescope options vary, and then you mix and match to get the different kinds of results. So let's just start then with just the simple you know, the DSLR route to get the beautiful, wide-angle, majestic you know, panoramas of the night sky with the Milky Way above, and you know, the desert landscape in the background. What kind of gear are we looking at there?

Pamela: OK, so we're saving software for a different show just to make it clear for all those amateur photographers out there going, "But you didn't…" We know. That's coming later. So the basic starting point is buy yourself (and I'm going to show manufacturer favoritism here, don't shoot me)...buy yourself the most expensive Canon DSLR camera you can justify, and then get yourself a solid, heavy-enough-that-you-don't-want-to-lift-it-but-know-you-have-to tripod with tracking, and the reason that you need this combo is if your tripod doesn't work well, your images aren't useful, so you need this amazing tripod that's going to just keep you locked on the sky, and then you need this amazing camera because, well, electrons don't like to stay put, and if you buy a cheap camera, as the photons build up on that CCD or CMOS chip inside the camera, they're occasionally going to try to jump to somewhere else on the image and that creates background noise, and you get the lowest noise, currently, using Canon cameras.

Fraser: So if I get that really nice Canon camera, or the Nikon equivalent, we understand that Nikons are just as good, and we don't want to make this a religious war, but you take that Canon 5D and you go out with a nice, wide-angle lens on it, and if you just take a picture of the night sky, you're not going to get a good picture. It's going to be…you're just not going to get enough photons from the stars. If you're really lucky, and you've got the aperture wide-open, and you set the exposure length for a really long time, you might get some stars, but it's not going to be that same level of quality. It's all about the mount and the tracking, so where does that come from? I mean, I think most of us can go to Best Buy or Future Shop and buy that Canon camera, but it's that tracking. Where does that come from?

Pamela: So here my favorite people to go to is Oceanside Photo and Telescope because you can basically say, "I have this much money. What can I get?" and they will point you in the correct direction. If the sky is the limit, there are people out there who are doing things as insane as mounting normal everyday cameras on Paramount mounts, which are $15,000, but at the other side (and they're usually actually mounting the camera on top of the telescope on top on the $15,000 mount), but on the other side of that you we have people who are spending $100-120 and getting something perfectly reasonable, and when you spend the lower amounts of money, often what you end up doing (and this is a completely valid thing to do) is you take a whole bunch of shorter exposures, and you add them together, and in the end, you do want to be taking shorter exposures, but shorter can be 30 seconds, or it can be 5 minutes. What we found doing telescopic exposures was in a perfect world, you want to take as many 5-minute exposures as possible and then add those together.

Fraser: Right, and this is the "technique" discussion that we're going to have in a separate…in the next podcast. Right, so I can take my…but my camera needs to at least be able to let me manually control the aperture, right? Like the exposure time…?

Pamela: Yes, so there's two different factors that you want to be able to control. One is the aperture, which tells you how wide the shutter opens when it's exposing the CCD. This is basically saying how much light you get in. If you're looking at a human eyeball, your pupil is your aperture, so when someone is in a bright light condition, your pupil shuts down, and when you're in a dark condition, the pupil opens up, so you need control over the aperture. You'd think, "Hey, it's night sky observing, just open it up all the way." But I've done things like take images during meteor storms when there is a little bit more Moon than you might want, and so I closed the aperture down a little bit so that I could get longer exposures without washing the sky, so these are things that you want to play with. So on one hand, you need to be able to control the aperture, and on the other hand, you want to be able to control how long the shutter is open for. You want to be able to say, "Figure it out for yourself." And a good camera can actually take a fairly good night sky image for you without you having to do very much, but on the other hand, you want to be able to say, "No, do five minutes. I want you do to five minutes."

Fraser: Right, and so that comes together to give you sort of as much control on it, and the experimentation is interesting because I definitely would have thought to just open it wide, you know, wide-open, as wide as it will go, but I can see that constraining it down a bit depending on the light, depending on what you're seeing can make more sense.

Pamela: And it also depends on what you're trying to do. I have to admit, most of my astrophotography days were with film cameras, and I'm a CCD junkie, and some of my favorite photos to take were things like star parties, where I'd take a 30-minute to one-hour exposure with the aperture not all the way open so that I didn't wash out the sky, and I didn't get blasted when someone with their red flashlight walked by because I was trying to capture the motion of the people in front of the camera. I was trying to capture the star trails in the sky. It all depends on what you're trying to do. It depends on how bright the Moon is. It depends on do you have aurora borealis that you're trying to cope with? Are you trying to capture motion over time where you're going to keep the aperture open forever? So you need both. Now, one other tool that goes in with this is with a lot of these cameras, they have remotes that allow you to not actually be touching the camera when you open the shutter.

Fraser: Yeah, and they're not very expensive and, you know, sort of a good thing to get anyway for a digital SLR camera.

Pamela: And some of these remotes allow you to tell your camera, "Take an exposure every five minutes," allow you to tell it, "Keep the shutter open until I tell you to close it," so that you can take control. That's particularly useful if you're trying to get nighttime lightning shots when you don't know when the lightning's going to come, so you just sit there and you wait, and you control the future of your camera.

Fraser: And so, you know, key words we're looking for…and most of the high-end DSLR cameras will let you do this: that you can control the exposure length, you can control the aperture, so that's the actual body, the technology of the camera. Now, what about the lens? What kind of lens do you want?

Pamela: Yeah, it depends on what you're trying to do. The good, generic, I-don't-know-what-I'm-going-to-do lens is to get something that goes from as small a number as you can afford to as high a number as you can afford, and this is where you start to see things that are, for instance, from 18 to 100-and-something, from 22 to 55. The two double-digit number to another double-digit number – that's pretty much what you're used to on your cheapo cameras. That allows you to go from being able to see the full room that you're in at a wedding, for instance (this is where most people end up experiencing their camera for the first time), to zooming in and just getting the wedding couple up at the banquet table when you're in the back of the room.

Fraser: Right.

Pamela: Now, if you want to be able to start zooming in much more to, for instance, fill your frame with the Moon, this is where you need to start getting into triple-digit zooms.

Fraser: Right, so if you've already got one of these digital cameras, these fancy digital cameras, and many of them do, if you've got a Canon T2 or a T3 or a 5D or the Nikon equivalent, then you're 90% of the way there. You just need to get a mount with an equatorial mount that has this motorized tracking that will then let the camera turn as the Earth is rotating and keep the stars in the same position as it happens, and then do some experiments. Try the Moon, try the planets, try interesting wide-open parts of the Milky Way, and you should get some beautiful pictures, you know, with some experimentation, and the techniques that you're learning should serve you really well. So, you're saying $100, $200 to get a mount like that that will do that kind of tracking?

Pamela: To get the cheapest, barely functional tripod that will just barely make you happy, and you're buying something used -- that's where you're looking for a couple 100 dollars.

Fraser: OK, so that sounds great, and that I think a lot of people…they don't realize. They're ready to do astrophotos, they just need that one last little investment. So then, that covers one whole section of astrophotography, but you talked about the three, so let's talk about the planetary stuff, right, where you're connecting a webcam up to a telescope. So we're going to need that mount, same mount. We're now going to need a telescope, that we have attached that now, you know, we've talked about telescope in the past -- a few hundred dollars, but then we need like a webcam?

Pamela: Right. So here you blow your wad getting this amazing telescope, getting an amazing tripod, getting some sort of a tracking system, you've spent $1500 or more, $15,000, $30,000 easily, and then you go out and you spend $100 or less getting some

sort of a webcam. Lots of people use two-cam webcams -- there's a whole bunch of other ones out there. And the idea is with the webcam, you're taking image after image after image after image, and as the sky constantly varies, sometimes you get moments of absolutely amazing scenes, and sometimes you're like "that's a blurry blob. Someone sneezed on my telescope," and by systematically combining all of the most amazing images taken by the webcam, you can build up these highly detailed images of these really bright planets. This only works with bright sources like planets where you can get enough photons in that one frame that the webcam records, but the folks doing this are able to do amazing things. One of my favorite sites to go look at is the Clay Center Observatory at Dexter Southfield High School. They've taken images of the International Space Station; they've taken images of Mars passing behind the Moon that are absolutely to die for.

Fraser: Yeah, my favorite community on this is a place called IceInSpace and the guy leading that is a guy from Australia name Mike Salway, and he takes pictures of Jupiter that you would swear came from the Hubble space telescope.

Pamela: Yeah.

Fraser: They are unbelievable -- how good he can get those pictures and it's amazing, I mean, he's got a good, I think he's got an 8-inch telescope, good mount, but the trick is that he's mastered this technique of using the webcam, and then stacking the images, and we'll talk about that in the next show, but the point being, you know, you've got that really nice tripod, that great equatorial mount, you've popped off your digital SLR camera, and you've plunked down your telescope of reasonable quality – it doesn't have to be an insanely great telescope, and then you've got that webcam that's taking that video through the eyepiece, and that's how you get these amazing pictures, and it is, you know, best bang for your buck – an amazing way to do astrophotography.

Pamela: And what's neat is with this technique you can also do things like get images of asteroids that are passing through your field, you can get timings of when asteroids occult stars, and so there's so much different science that you can do while also getting amazing images.

Fraser: And there's another guy, I'm going to mispronounce the name, I think, Thierry Legault, who is...he is from France, and he does time-lapse images of the International Space Station, the Space Station passing in front of the Sun, and he's gotten…you know, you can see the solar rays, and you can see every module on the Space Station, you can see when the Space Shuttle's attached to it. He's done images of various satellites that are tumbling and about to re-enter the Earth. It's quite an amazing hobby, and again, it's not that further along. If you've already invested in the telescope, you've already got the equatorial mount, it's just a few hundred bucks more to move down this road as well. It's a really rewarding hobby. Let's move on to the final stage of this hobby, and this is the part where you get bankrupted, which is where you're trying to produce those beautiful deep field and nebula and galaxies and clusters of stars…and that's where you start to spend the big bucks.

Pamela: And this is where I'm reminded that research shows that a hard-core hobbyist will spend as much on their hobby as they spend on their car. And I have to admit as someone who rides horses, that's about true, given the fact that my car is a 1998 Jeep Wrangler, and I've had my horse for enough years that it's had time to acquire value, I guess, is the way to look at it.

Fraser: Yes, I'm obsessing over a $10,000 mountain bike, so...

Pamela: Right, so we each have our different hobbies, but for the astrophotographers, this is where you get the guys and the gals out there who are spending $15,000+ on a Paramount mount, on a DFM mount, on something from astrophysics that tracks like any professional system, where they're building the domes, where they're getting the 20-inch Richy-Cretiens for their backyard, and then they're dropping a few $1000 on a CCD camera, and soon they have something the size and cost of an SUV.

Fraser: Right, it's a, what, a $10,000 mount, a $10,000 telescope, couple of $1000 on the camera, plus your dome, plus the remote equipment, plus, plus, plus…I mean you're looking at about $20-30,000 to do that, but to just do the entry level, again, couldn't you take your equatorial mount, your reasonably good telescope, and then…? But the point is you're pulling off that webcam, and you're putting on that CCD.

Pamela: Right, and you can do a starter system with everything you need for $5,000, so mount, plus telescope, plus CCD, plus the computer you need to go with it -- $5,000 to get bottom-of-the-line, I'm-going-to-figure-out-if-I-want-to-do-this-and-make-it-so-that-my-spouse-doesn't-totally-kill-me-for-the-amount-of-money-I'm-about-to-spend.

Fraser: And so you'd be very happy with the amount of imagery you'd be doing at that point.

Pamela: Right, and this is where you can start doing things like sitting on a target, and you use a completely different technique at this point, so you also have to now start to buy little pieces of glass. So CCDs, the really good CCDs are only black and white imagers, they go photon/no photon – that's all they care about. But it's the fact that they only care about photon or no photon that allows them to be so sensitive and have such high resolutions because they don't need to leave space for other detectors that are sensitive to red and green if they're sensitive to blue. Instead, all of the little detecting bits are crammed together simply doing photon/no photon, and you choose what color you're looking at by going out and buying a piece of glass. So you'll use a red filter to get the amazingly high-resolution image of just the red light coming from that object, you'll use a blue filter to get the blue part, and you can buy filters that either allow you to capture specific types of gas -- the oxygen lines, the hydrogen-alpha lines -- these are narrow band filters, or you can buy broad band scientific filters if you're interested in starting to do photometry, and you can still do beautiful color images with this – that's what Hubble does. You can also, then, buy the flat-out ham of photographer filters: the red/green/blue filters, as well.

Fraser: Right and so it's the different glass in each filter is going to cost you some money, the CCD, the quality of the telescope, as we said, this gets expensive, but about $5,000 to take a good crack at it, and I think you can probably get a taste of it. I mean, if you…the webcam probably isn't going to make you happy, but if you could probably get an entry level CCD in there and get a taste of it. Just attach that to your existing…if you've got a good telescope with an equatorial mount.

Pamela: And the reason that you want to go for the CCD instead of staying with your DSLR camera is the CCDs have their electronics cooled, and I mentioned early on in the show that electrons don't like to stay put. Well, if you cool them down, they move around a lot less, so if you start getting into a system that is either thermo-electrically cooled, or if you spend a lot of money, you start getting a system that's cooled with liquid nitrogen -- these systems are able to suppress what's called "dark current." This is the flow of charge around your detector simply because the sucker's turned on, and by suppressing that dark current to the point, in some cases, of being barely there and detectable at all, you are able to get much longer images with much less noise in the image.

Fraser: Very cool. Alright, well, that was…I think that was good, Pamela. I mean, I was nervous that we wouldn't be able to talk about something that's all about photography, you know, imagery, but I think that was really good. I think that was really helpful and gave people a good idea of the landscape. Next episode, we're going to talk about the techniques, so what are the ways that you actually will set up your camera, set up your telescope, places to go to actually get the imagery that you might see in the magazines and on the internet. So that was great! Thanks a lot, Pamela.

Pamela: My pleasure.

Fraser: Talk to you next week.

Pamela: OK. Bye-bye.