Astronomy Cast Episode 224 for Monday, March 14, 2011:

Orion

Fraser: 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. I am Fraser Cain, publisher of *Universe Today*, and with me is Dr. Pamela Gay, a professor at Southern Illinois University - Edwardsville. Hi Pamela, how are you doing?

Pamela: I'm doing well, Fraser. How are you doing?

Fraser: Doing great. Now, you wanted to do some plugging today…

Pamela: I did. We have a store full of t-shirts waiting for your summer apparel needs to be met, so go to Astrogear.com and get your Astronomy Cast t-shirts.

Fraser: Is it Astrogear.com, or .org?

Pamela: Both work…both work.

Fraser: OK. Alright. I didn't know we had the ".com;" I knew we had the ".org." Anyway, Astrogear.com: t-shirts, CDs, lanyards, posters…

Pamela: We have it all. Go get it now.

Fraser: Alright. Cool! Well, most people know how to find two constellations: the Big Dipper, and Orion the Hunter. You can teach a small child to find Orion, and at the right time of year, they'll find it in seconds. There's so much going on in this spectacular constellation from star formation in the Orion Nebula to the mighty red supergiant, Betelgeuse, ready to explode. Let's learn about the history and science of Orion. Alright Pamela, so I guess, first, let's pretend we're talking to that small child and help them find Orion. Where and when should be looking, and what will we see?

Pamela: Well, as we record this in the Spring, it's not there so much right now, but…

Fraser: Yeah, it's kind of sinking away now.

Pamela: Right, so the reality is if you get up early in the morning you can see it. It's currently a morning object, but the last slivers of the Dog Star actually will be…you can just tell that the dog star is starting to rise as the Sun is starting to rise in August, but until then, it will be rising before the Sun, so we'll get at least Sirius' dogs for a few more months -- not Sirius' dogs, Orion's dogs for a few more months.

Fraser: But, winter's the best time, right?

Pamela: Winter's the best time. It's an evening object. Look toward the equator. So if you're in the Southern Hemisphere, look toward the northern skies; if you're in the north, look toward the southern skies come winter, and it's one of the most recognized sets of bright stars that people have used to make pictures throughout all the different cultures of the world.

Fraser: Yeah, and clearly obvious that it's person-y, human-y-looking, right? I mean, no question, there's the three stars of the belt, and then there's the shoulder stars and the knee stars – is that what it's described as?

Pamela: Well, yeah…

Fraser: And then there's even more parts to it: there's the sword…there's all kinds of stuff. It's all there.

Pamela: And what's interesting is that we see it as person-y; other cultures see it as three sisters instead of three belt stars, and so they make up all sorts of different stories based around this set of bright stars that hangs out near the celestial equator, and it's basically a giant box wearing a belt, and so parcel up that giant box however you want it. Now, in western lore it's typically Orion the Hunter. Here in the northern hemisphere, the two stars you see generally pointing toward zenith are seen as the shoulders -- and one of these is the bright-red Betelgeuse -- and he's seen as either holding up a sword or sometimes holding up a shield as he fends off the oncoming Taurus the Bull. So, it's one of those constellations that people tend to turn all different sorts of things out of it. In fact, you can sometimes even see him in some of the drawings looking *away* from Taurus the Bull as Taurus comes up behind him.

Fraser: And so, what's the history, then, of the constellation?

Pamela: It's actually kind of as mixed-up as the pictures of the constellation are. It's not one of the prominent stories in Greek lore, but the basics that most of the stories agree upon is Orion was a hunter, and he had a run-in with Scorpio, the giant scorpion, and after they both died, they got put into the heavens but on opposite sides of the sky, such that Scorpio is up high in the sky six months before Orion is up high in the sky.

Fraser: Now do you…is it one of those situations where they already had the story, and then they sort of saw that story mapped out in the sky, or do you think it went the other way?

Pamela: See, this is one of those things it's very hard to know, especially these not-well-documented Greek lores because people have been lying on their backs, staring up at the stars, making up pictures as long as humanity has existed, and there's some archeological – not archaeological, there's some linguistic evidence that some of the star names are actually prehistoric, so before we had people to write things down, these stars were given their names, so it's unclear. Now, some of the books that we look at that mention it include Homer's Odyssey, and the constellation has got to predate Homer's Odyssey, well there's no "got to," but it most likely predates Homer's Odyssey, but the question is: how long have people's grandmas and grandpas been telling that story? We just don't know.

Fraser: So it's hard to know whether they had the story, and then they mapped it back to the stars, or someone looked at the stars and saw the pictures, and then they came up with the story to explain it.

Pamela: Right.

Fraser: Yeah, that's interesting, and so…but then from the scientific basis, what's actually going on there? Obviously, it's a collection of stars. Is it really collected the way we see it in the sky? Like, if you could look at it from a different perspective…

Pamela: No, in fact all those stars are at slightly different distances, such that the brightest star, Rigel, is hundreds of light years away, and the nearest star in the constellation is just 18 light years away. So, we have this vast disparity in the difference between the nearest and the brightest stars, and if you're able to make a 3-dimensional map of this (and I've had various students do that as a class project), it actually shows this fabulous distance distribution even of the belt stars. So this is just a group of stars that appear lined-up, but that's only because they happen to randomly be collected in 3-dimensional space in the same direction on the sky.

Fraser: And they happen to have a luminosity that balances out from our perspective.

Pamela: Exactly. And so this is where you end up with interesting things like Betelgeuse appears amazingly bright. It is amazingly bright, in fact it's about 670 times the size of the Sun, so this is a giant, red, bright, huge star, and it's about 640 light years away. Now, compare it -- admittedly, it's one of the brightest stars in the system, but compare it to one of the other fairly prominent stars in the system, so for instance, you have Bellatrix, this is the 22nd brightest star in the sky, and it's only 240 light years away, and it's only 7x the size of the Sun. Now, what you're hearing, though, is this constant theme of "bigger than the Sun, bigger than the Sun, bigger than the Sun," and, in fact, all the bright, bright stars that you notice when you look at Orion in general are as near as we can tell (and there's a few we don't have really good data on), but as near as we can tell, all of these stars are, in fact, bigger and younger than the Sun and some of the stars that we're looking at -- these are actually younger than the Earth. So, Alnilam (Epsilon Orionis is the better name for it if you want to pronounce it correctly)…it's a 4 million-year-old star, which means the planet Earth, the planet we are standing on right now is older than this star, so someone hanging out watching the planet form who looked up at Orion would have seen it's belt missing one of the stars.

Fraser: Well, now you're jumping around a bit, so I'd like to be a little more organized here because, I mean, each one of these stars has an amazing story, plus there's the Orion Nebula, and there's other good stuff as well, so let's just start up at the top. So the upper left-hand corner…

Pamela: Upper left-hand corner…

Fraser: That's Betelgeuse.

Pamela: Right.

Fraser: And you kind of give a hint -- it's a red supergiant star, hundreds…what, 600 times bigger than the Sun?

Pamela: Yes, 640 times bigger than the Sun, so…

Fraser: So, that would stretch out to like what, past Jupiter?

Pamela: Uh, way more than that.

Fraser: Like past Saturn's orbit?

Pamela: [laughing] Yeah.

Fraser: Wow! Can you just imagine, like, having that in the Solar System?

Pamela: Yeah, it wouldn't fit so well.

Fraser: So what does it look like if we got closer?

Pamela: Well, that's the neat thing about these giant, red stars is they have very diffuse atmospheres, so it would be kind of like sneaking up on a big, red, burning fog bank, where the outer parts of the star's atmosphere are a lot like playing in thick clouds, they just happen to be thick clouds of plasma. So this is a giant star; it has a puffed-out atmosphere. This is one of the stars in the sky that's most likely to go supernova in our lifetime – that doesn't mean it will, that doesn't mean it will even do it in the next 10,000 years, but it's still sitting there waiting to potentially do it, and if this giant, red star does go supernova, it will actually be visible for almost the entire planet during the daylight.

Fraser: And like, the next 100,000 years? The next million years?

Pamela: Yeah, we don't know…so it could be tomorrow, it could be 100,000 years from now…yeah, somewhere in there.

Fraser: Yeah, but it's a fairly young star. It just happened to be…

Pamela: Massive.

Fraser: …very massive, and is in this red supergiant phase of its life, so if we looked at it like what a million years ago, it would have looked quite different, right?

Pamela: Right, and well, so a million years ago… These stars -- they move off the main sequence very quickly, so we don't know exactly where it is in its phase right now, so a million years ago, it might not have looked too different, but in its past this would have been a giant, blue star. So, it's a large star; it's currently a red supergiant, and in the past it would have appeared a whole lot bluer.

Fraser: Wow. So, I mean, it is one of the most spectacular stars. It's one of the stars that I know Hubble is able to resolve a disk of the star it's so big.

Pamela: And they can actually see Sunspots on its surface, so this is something that it gets Sunspots that would take up large fractions of its surface that we can track and measure the variations in the light due to these Sunspots.

Fraser: Yeah, like Sunspots bigger than the orbit of the Earth…it's just mind-bending. OK, so that's that. Right away, one of the most important stars in the whole night sky is in Orion, but then one of the other ones…like, why don't we skip down to the bottom, what is it, the bottom right-hand corner? With Rigel, right? That's one of the other most important stars in the night sky.

Pamela: So this is also known as Beta Orionis; it's another supergiant. Here, it's not quite done doing the interesting stuff, so Betelgeuse -- it's moved over to the right-hand side, it's still undergoing a lot of mass loss, but Rigel because it's bluer, it's much, much hotter, it's burning much, much faster, it's at a much higher temperature and when it's done, it's also likely to go supernova, but the fact that it's still blue tells us that we probably have a little bit longer to wait compared to Betelgeuse, which, because it's red, means that it's further along in its evolutionary state. It's kind of neat how looking at this system you can see two giant stars that are both going to end their lives in similar, but not identical ways, but because of the difference in color, we can tell that they're actually undergoing different things down deep in their cores.

Fraser: Right, and I wonder, again, if we can see…there's a really great animation which I'm sure a lot of people have seen, where it's these comparisons of the different planets, and eventually you're comparing the planets against the Sun, and then the Sun against other stars, and I know Rigel is on this animation (we'll link to it in the shownotes), but it's kind of like the Sun compared to Rigel is like the Earth compared to the Sun. It's unbelievable to see how big Rigel is when you see it compared to the Sun -- like it's, what is it, 78 times bigger than the Sun? And just astonishingly different, and it's super-hot, right?

Pamela: Yes, it's super hot – thus the blue color, and one of the neat things about it in terms of just giving yourself perspective on things is, so Betelgeuse is fainter and closer, so when you look at it, you see it as fainter, and it's closer. Now, when you look at Rigel it appears brighter, and you think, "well, maybe it's even closer than Betelgeuse," and these two things are similar in brightness, but…or similar in luminosity, but the reality is that Rigel is 770 light years away, so it's a more distant object that appears brighter in the sky. It's also a smaller object because it hasn't bloated itself out yet, so the fact that it's young and blue means that it's still pretty compact – it's 78 solar radii, which is still giant, but the smaller size, it's bluer color means that even though it's at a greater distance, it still appears brighter in our sky.

Fraser: And Rigel is a neat target for telescopes because it's a visual binary.

Pamela: Right, so if you have a small telescope -- you can't do this one with binoculars, sorry, unless they're giant binoculars…but unless you have truly insane binoculars, find yourself a small telescope, and when you take a look at it with sufficient magnification, you can tell that there's actually two different stars there. Now, the separation between these stars is huge -- they are 2200 a. u. apart. You're not going to see them moving; you're not going to see anything else. They're simply two stars that are very loosely orbiting around each other.

Fraser: Wow! Any of the other stars in Orion very cool, or doing something interesting?

Pamela: Well, I mean, they're all kind of cool. What's amazing is this is all part of the giant star-forming complex as you look out in that direction, and individual stars don't necessarily belong to the complex, but as you scroll through the system, there's bits and pieces of nebulosity just about everywhere. And then as you look at the individual stars, you start being able to pick up things such as Mintaka, which is Delta Orionis, which is upper right-hand if you're in the Northern Hemisphere belt star; lower left-hand Orion's-hanging-upside-down belt star if you're in the Southern Hemisphere. This is another one of these multi-star systems, and in this case, you have a blue star, you have a white star, and it's an eclipsing binary system, so you can actually see slight variation in the brightness of the stars, which is just something really cool to be able to go out and watch with your own eyes.

Fraser: So, when you say eclipsing binary…so, you've got one star that's orbiting in front of the main star?

Pamela: That's exactly what's happening. So, this is one of those times when if you very carefully watch the star over time, you can see every 5.73 days that the stars slightly change color and slightly change brightness.

Fraser: But they're too close for you to actually be able to pick them apart with the telescope.

Pamela: Right.

Fraser: Right, OK, you just measure it in terms of brightness. Well, then I think then we should talk about the probably the prize of the whole constellation, which is the Orion Nebula. And this is something you can actually see with the unaided eye. I mean, if you go out with really nice, dark skies – like where I live – you can see this kind of furred, you know, this kind of fuzzy, blurry bit just underneath the belt stars, and that's the Orion Nebula.

Pamela: Right, so this is a giant star-forming complex. There's the Trapezium stars – these are bright, white, hot "O" stars, many of them varying in brightness. As you watch this entire region over time, you can…actually if you get extraordinarily lucky – and this has happened before – occasionally, you get to see a new star blowing off the cloud of gas around it. Now, admittedly, this has only been known to happen once, but it's kind of cool to know that it's happened. So, as you look at this system and explore it, or you get to see what stars look like when they're just forming and haven't fully pulled themselves together yet… And what's interesting is you get all the different types of nebula in here in terms of gaseous nebula: you have dark nebula like the Horsehead Nebula, which is this cold cloud of gas in front of the more brightly luminous background, you get reflection nebula, where you have the light from stars passing sideways through clouds, and getting reflected towards us, and the reflected light we see is blue, you also see the red nebula, where light is trying to pass from the back through the clouds of gas and only the red makes it through to us, so there's lots of physics to be understood by staring at some of the most beautiful things in the sky that you can access with a backyard telescope.

Fraser: And so if you can get your hands on even a good pair of binoculars, you can actually see (I'm trying to think of what you can see with good binoculars) sort of a fuzzy, blurry bit still there.

Pamela: Right. You can make out the Trapezium stars.

Fraser: Yeah, and it's almost like they're kind of enshrouded in fog a bit, and then as you get to better and better telescopes, you don't really see the color until you're actually taking some photographs.

Pamela: Right, so some of this where we really suffer is the human eye. It's made up of two different cells, and only some of those cells are sensitive to color, and the ones that are sensitive to color don't work in low-light conditions, and so it's the cells that are simply sitting there going "light/no light," and forming black and white images that typically trigger when you're looking at the night sky.

Fraser: So, to really appreciate what it looks like, you want to hook up a CCD camera to your telescope.

Pamela: Right. So all of these things are part of the Greater Orion Molecular Cloud Complex. It's 1500-1600 light years away, and M-42 -- Orion's nebula is just part of this, the Horsehead Nebula is just part of this, and it's made up of all these different types of nebula. It includes Barnard's Loop as well, which is a loop of gas, the Flame Nebula, which is famous for its red color… This is one of the areas of the sky that in order to see amazing things, really, all you have to do is take an everyday -- admittedly film, but an everyday film camera, point it at the sky, and try taking a photo for a couple of minutes. Now, if you're not zoomed in at all, not tracking at all will cause it to be slightly blurred, depending on what type of lens you have, but it's enough to start picking up color in a very dark site, and the color is a reflection of the fact that this is where stars are being born. Now, if instead of using a 30 mm, or a "whatever mm," small camera in your backyard, you resort to the Hubble Space Telescope (which is always fun, I highly recommend it), the Hubble is actually able to make out what are called "proplets" -- these are caterpillar-like structures embedded throughout the Orion Molecular Cloud Complex that are stars getting ready to emerge, but they're still surrounded by the nebula of gas that they're forming from, so these are basically stellar cocoons waiting for solar systems to emerge.

Fraser: And, there's actually…you said M-42, and there's also M-43. They're all kind of connected in that exact same region, so you can actually…they are almost a little hard to distinguish.

Pamela: Right, so M-43 is the one that I think is in many ways has been made famous from the Hubble camera. If you've ever seen the image that's all blues and yellows fading to oranges with bright white stars embedded throughout it, and it looks kind of like a watercolor? I know that's kind of vague…google M-43 and you'll know what I'm talking about.

Fraser: Yeah, yeah that's M-43.

Pamela: Yeah, it really looks like a watercolor painting.

Fraser: And then you just sort of mentioned briefly the Horsehead Nebula, but what's that?

Pamela: And so this is what's called a dark molecular cloud. So what happens is if gas gets thick enough, just like if clouds get thick enough, light can't pass through them. So in these cases, you have a background that's made luminous through stars that have emerged, have burned off the gas and dust around them, and that backlighting of the cloud causes the cloud to just stand out the same way a thunderhead might stand out against a bright summer's day. And it's these dark molecular clouds that collapse in on themselves to begin forming stars, so where you see things like the Horsehead, where you see things called Bok Globules – these are the future sites of star formation, but right now they're just sitting there going, "I'm cold, and I'm dark, and I'm going to block all the light behind me." And so, the Horsehead is just stars waiting to be born.

Fraser: So if you have a powerful enough telescope, can you make out the Horsehead, or does it still require CCD camera?

Pamela: I've been able to see it through a 30-inch telescope, and actually…

Fraser: [laughing] A 30-inch telescope? Yeah, OK!

Pamela: [laughing] There are amateurs out there… Now, I haven't tried with smaller telescopes, but…

Fraser: Well, of course! Why bother if you've got access to a 30-inch telescope?!

Pamela: Well, it was random. It happens… but based on when it was discovered, I'd assume that you don't need too giant of a telescope as long as you have really, really good skies. Now, it was discovered in 1888 on a photographic plate. This isn't an easy target that your friendly 4-inch telescope is going to pick up, but with perfect skies, perfect telescope you should be able to pick it up with smaller telescopes.

Fraser: Very cool. Was there anything else in the constellation, or have we kind of covered all that?

Pamela: I think this is just the perfect place to start learning. It's one of those places that you can say, "this is where star-forming starts; this is where my observing of the sky starts," and then use it as a branching point to explore. One of the neat things about Orion, well, it's so stupidly easy to find: you look up, and you look for the giant red star, and the giant blue star in the corners of the box. Once you've got that, you can use it to move over to Taurus and Aldeberan – the giant burnt-orange eye of the Bull. You can go across the diagonal from Rigel, up through Betelgeuse and find yourself over at the constellation Gemini, and see Castor and Pollux. You can follow the line of the belt stars into the left if you're in the North, and you can get yourself down to the Dog Star, Sirius. So, this is a starting point to learn your way around the sky. When I was a kid learning the constellations, I could always find Cassiopeia, and I could always find Orion, and just like some people's knowledge of cities grows around subway stations, my knowledge of the sky grew around these two constellations.

Fraser: Yeah, exactly the same for me…you know, I learned the Big Dipper and I learned Orion. It was almost like that was a gift that I got from my father was…you know, early on he taught me where Orion was, and he taught me where the Big Dipper was, and then later on, when I took up Astronomy as my own hobby, and I got myself the sky charts and I started to learn all those other constellations, again now, I can find Cassiopeia, and I can find Andromeda, and I can find, you know, Boötes, and all of those, right? But in the beginning, it's those two, and especially Orion, when it's like the night sky, and it's winter and the sky is so clear and it's crisp and it just blazes on the night sky. So, if you haven't taken the time to teach your children, teach your friends, teach your parents, your students how to find Orion. It should last a lifetime.

Pamela: And if you really want to blow their minds, while they're standing there looking at them, tell them that all the things they see as single stars…well, most of them are actually multiple stars, and most of them weren't there to be seen when the Earth was just starting to form.

Fraser: Yeah. Cool! Well, thanks a lot, Pamela.

Pamela: It's been my pleasure, and go to Astrogear.com! Buy t-shirts!

Fraser: [laughing] Cool!