Astronomy Cast Episode 162
Edwin Hubble

Fraser: Astronomy Cast Episode 162 for Monday November 2, 2009, Edwin Hubble. 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.
Pamela: Hey, Fraser, how's it going?
Fraser: Very well. Alright, well, so we're going to start learning about some of the acclaimed astronomers in history of astronomy. We've had a lot of people ask us for these kinds of shows, and they're kinda rough to do. So, hopefully, Pamela's got all this information bobbling around in her head... let's see what happens. Now you might know the name Hubble because of the Hubble Space Telescope. But this phenomenal observatory was named after one of the most influential astronomers in modern history. Hubble discovered that galaxies are speeding away from us in all directions leading to our current understanding of an ever-expanding universe, and leading back to the Big Bang. Let's learn about the man behind the telescope. So, we've got the name... the Hubble Space Telescope. Who was Edwin Hubble?
Pamela: In a lot of ways, he was just a small-town midwestern man who grew up to do amazing things in a very random route. He started out in Missouri. He was an athlete in high school. He wasn't your quintessential nerd... he got good grades but he was better-known for setting the state high school record for high jump in Illinois. He then went on to go to the University of Chicago where he concentrated on mathematics, astronomy, and philosophy, but he continued to play sports throughout all of college. Due to his success at basketball, at wrestling, at academics... he was one of the first few years Rhodes Scholars recipients, so he went off to Oxford University in England to follow through on a promise he made to a family member. Instead of studying science, he studied law... he studied jurisprudence. He also studied Spanish... because he couldn't seem to settle on any one thing.
Fraser: It's interesting how in the olden days, people could be a lot more "Jack of all trades." They could study a lot of different topics before finally settling on oh... something in astronomy... making enormous discoveries in the field. Now, you, for example, focus so deeply on space and astronomy and math right from day one... all the way through your PhD... extra years, etc. It's funny.
Pamela: Well, and what's amazing is looking around the field of astronomy, we still have a few of these amazing people but it's certainly a whole lot harder to have a career nowadays when you let yourself wander to many different fields. It's gotten to the point that a lot of undergraduates are almost expected to have a first-author astronomy research paper before they go on to graduate school. But at the same time, while I was down at the University of Texas we had people in our program who had spent parts of their life working on the Americas Cup sailboat teams, who'd gone off and had careers in engineering and lasers. In one case there was a woman who'd been a pipe fitter for years before deciding that she wanted to go to college and become an astrophysicist instead.
Fraser: So Hubble's in England studying law...

Pamela: Yes, he went off, having gotten his degree from the University of Chicago, to Oxford where he studied jurisprudence and Spanish. Then he came back to America, and he settled down in Illinois and started a law practice. But it's unclear if he ever actually had a case... oh, sorry, he started his law practice in Kentucky... he came back and settled in Kentucky... I misread my notes... What he actually ended up doing was teaching high school. He was teaching high school Spanish and mathematics and physics, but mostly Spanish. Then he realized this isn't where my heart is... I want to be an astronomer. He was able to return to astronomy and went to Yerkes Observatory, part of the University of Chicago, where he earned his PhD in 1917. Here's where he actually started the work he'd be most famous for. His dissertation was titled "Photographic Investigations of Faint Nebulae," which back then included planetary nebula, supernova remnants, star-forming regions, and also galaxies. We just didn't know what galaxies were at that point.
Fraser: So what was the cosmological understanding of the universe at that point? What did they think the universe was? I mean, this was only 90 years ago, right?
Pamela: Right. And it's really amazing how far we've come. Back then, people thought the galaxy, our Milky Way, was all there was. We were a disk of stars and gas and that was it. It was through Hubble's work that we began to realize that if you look closely enough at these nebulae... not all of them, but some of them... you could begin to make out individual stars. It's fabulous to look at his history of papers and see the transformation that's apparent just in the titles. If you go back to his earliest works, you have papers on the variable nebula NGC 2261, which is actually a really cool Astronomy Picture of the Day. This is a nebula that has blobs of opaque dust orbiting a star that's illuminating the nebula, causing it to change in brightness. He was then studying other additional nebulae and he starts to record the color of nebula stars, and then goes on to look at the general study of diffuse galactic nebulae. Then he starts talking about Cepheid variables and galaxies...
Fraser: Right... and Cepheid variables... these are these variable stars that vary in brightness over a set period of time, and astronomers now use them as cosmic yardsticks... as a way to determine the distance to that star and I guess to the objects that are nearby. So, did they know that Cepheids had this relationship?
Pamela: It was before this that Henrietta Leavitt was able to make that discovery... the Leavitt relationship... at Harvard University where she was initially employed as human calculator. It was because of her measurements of the Cepheids, specifically those in the Large and Small Magellanic Clouds, that we were able to find this period-luminosity relationship. Hubble used that relationship to measure the distance to these spiral nebulae. The other part of this picture was Vesto Slipher working at Lowell Observatory at about the same period had used spectra to measure the shifting of the light due to velocity... the Doppler shift of spiral nebulae. By taking these two pieces—the spectral shift and the distances determined by Cepheids—Hubble was able to build his own picture of an expanding universe. He brought into the fold with him Milton Humason who was a former mule car driver who went on to be one of the most meticulous observers at Mount Wilson.
Fraser: So we've got Hubble using these Cepheids to determine the distance to the Cepheid star and so the star is inside the galaxy, so he's able to determine the distance to the galaxy, but then he's also able to use this red-shifting to calculate the galaxy's

velocity, either towards us or away from us. Those two things were monumentous discoveries. Was that in one paper?
Pamela: The "putting all the pieces together" was one simple paper. We went from... we knew distances because of Henrietta Leavitt's work... we knew a selection of velocities due to Vesto Slipher's work... and then Hubble added to this work using Henrietta's relationship and adding more spectra and more galaxies to the sample that we had velocities for. He made his famous Hubble diagram, and in one simple paper changed our understanding of everything.
Fraser: So what was the name of the paper?
Pamela: It had a fairly boring title. It was "A Relationship between Distance and Radial Velocity among Extragalactic Nebulae."
Fraser: And that's what they called them... extragalactic nebulae.
Pamela: Right. We didn't yet know exactly... well, the debates were still happening. Saying these are other galaxies... that took a little bit of time before people were comfortable saying those words. So it went from 1925, when he first started studying Cepheids and spiral nebulae, to his 1929 paper with the famous Hubble relationship and the initial distance-radial velocity graph that he put together in one paper. All those pieces got put together for the very first time in that one monumental paper that just changed everything.
Fraser: Now, you're saying this "famous Hubble diagram." Can you kind of explain what that looks like?
Pamela: Well, it's funny to look at it today because we're used to looking at plots that contain tons of data points that are all precisely lined up on a line and all the data is taken from modern telescopes. It's this sad little graph that has huge amounts of scatter in the points that are about a line. Along the x-axis you have the distance to galaxies. Along the y-axis you have the velocity of these galaxies. He fits a line to just 22 points. We now have 100s and 100s on the graphs we use today. Based on that, he got that things are expanding... that we have an expanding universe because the further things are away, the faster they're moving.
Fraser: Well, it could have gone two ways, right? One is that we're the center of the universe and all the galaxies are speeding away from us, or the universe is expanding, right?
Pamela: Well, if it was a simple matter of we're the center of the universe and everything is moving away from us, there's no reason that things further away are moving faster. Everything could be moving away from us at a constant rate.
Fraser: Right.
Pamela: And so even if we are the center of the universe, the fact that the further objects are moving faster means that we live in this expanding system. You can only explain this relationship between distance and velocity with expansion.
Fraser: Right. So, he delivers this paper... and how was it received?
Pamela: Well, good scientists, when they're confronted with data, might let out a few expletives... might hate the scientists who came up with the idea for a little while... but then come around rather quickly to... oh, OK, new way of looking at things... new paradigm. Einstein is perhaps the one who was most happy about Hubble's results because just a few years earlier, when he was working on relativity, he was forced to add in this constant, Lambda... this cosmological constant... because his equations by

themselves said that we had to be living in a universe that was either expanding or contracting. Part of our "the universe is everything we can see... it's just the Milky Way galaxy" belief system was that nothing was expanding or contracting... everything was a steady state. And so with Hubble's results, Einstein could breathe a sigh of relief that the cosmological constant was perhaps his greatest mistake... he should have trusted his instincts because we do, indeed, live in a non-stationary environment... a non-static environment.

Fraser: And how long did it take for this research to be accepted and essentially become the norm... the established understanding for astronomers?

Pamela: As far as I know... and there's always people who will tell you that it was highly controversial... but as far as I know, it was within about a year that everyone was on board with this new idea. They weren't necessarily on board with Big Bang, but they were on board with the idea that galaxies are separate islands of stars that aren't part of our own Milky Way, but they're at vast distances and they are moving away from us. The reason for the moving away... that was highly controversial and wasn't really settled until the past couple of decades.

Fraser: Right, but I guess people were already thinking that these extragalactic nebulae could be other galaxies... that was already in the thinking and people were going one way or the other. So, the controversy was already happening, and when Hubble delivered his results, that really helped weigh the evidence one way. It's not like it came out of nowhere, like the discovery of dark energy.

Pamela: Yeah, we had no clue that one was coming.

Fraser: Or even like plate tectonics... like, oh yeah and here's this... and everyone was just completely shocked and quite dismissive of the theories. That's interesting to see that it wasn't quite so bad. So then Hubble delivers his paper, and then where did his research go from there?

Pamela: Well, he had a career that kept going up until the very day he died. He was a man who was never bored. He continued to constantly publish papers. What's interesting is... as I said before... how the language of it changes. So, starting in the '30s, there he is... post World War I... this is someone who also served his country. After getting his PhD he had a job offer to go work with George Hale at Mount Wilson Observatory in the hills above Pasadena, but rather than going straight from college to the observatory, he served in WWI. Then he took a second break during World War II to go work at the Aberdeen Proving Ground on ballistics. In the space between the two wars, he went and discovered that the universe is expanding... pretty good, I think... but then he kept going and he started doing work on supernovae. He identified the Virgo Cluster, and he did extensive work on what are the different ways we can classify galaxies. We have all of these strange... and they continue to be called nebulae all the way through the '30s... we have all of these strange objects that make up our universe. He first starts using the word "universe" in his titles in the late '30s... in 1937 he has a pair of papers that use "universe" in the title. He started trying to figure out how to classify galaxies, and he looked at their shapes. We have blobby roundy elliptical galaxies. We have galaxies that have spiral arms, and some of these spiral arms have bars in them. Then of course there're the things that look like dead bugs on windshields.... the irregular galaxies. So he built the Hubble Tuning Fork diagram... working to classify all of the structures that we were looking at. And at the same time, never one to be bored, he was also off studying

supernovae, working with Milton Humason to get at the chemical composition of the universe around us... to understand what are the materials being produced in supernovae... He just kept going and continued to do new work throughout his entire life.
Fraser: And the current galaxy classification system—that's his creation, right?
Pamela: The one that you see in every Astro101 textbook... that was Hubble's work. There are a few other competing ways of classifying galaxies. One of Edwin Hubble's competitors was the Frenchman Gerard de Vaucouleurs who worked at McDonald Observatory in Texas. He had a much more complicated galaxy classification system that looked at many more parameters. No one who doesn't use it every day can remember what all of those different parameters are. It's a much more complicated system. Edwin Hubble's seems to be proving out as the one that is lasting, and we're still working to find new ways to define galaxies from a physics perspective. Early on we thought maybe galaxies evolve through Hubble's Tuning Fork... maybe they go from elliptical to spiral over time, going through these stages where they have bigger or smaller bulges... where their arms are more flung out or more close in. We now know that it's not exactly an evolutionary sequence. We're trying to understand the physical parameters that describe the morphologies. But until we have a way of saying, "these parameters define it as this classification," I think that Hubble's Tuning Fork is going to remain the one we all learn in school and we all teach to our students.
Fraser: Right, I mean you've got spiral galaxies, irregular galaxies, you've got lenticular... all these different sub-classifications... it's all Hubble. What are some other things that remain on in astronomy? We've got expansion of the universe, galaxy classification system... what are some of his other legacies?
Pamela: Perhaps the most important two legacies for the people who came after him are the 200-inch Hale telescope which he spent a great deal of time fighting to make happen. It would end up being one of the largest observatories in the world for about four decades. It was his politicking that made that happen. Now the other thing... that I felt somewhat sad reading about... the other thing he politicked for was to see the Nobel Prize committee acknowledge that astronomy is a branch of physics. There was never a specific astronomy Nobel Prize listed, funded, endowed. Throughout Edwin Hubble's life no astronomer was ever granted the Nobel Prize. He desperately hungered for one. And every once in a while you'll see that poor scientist campaigning desperately, trying to get themselves a Nobel Prize. He went to the extreme of hiring publicists, of doing his own campaigning with the Nobel committee to please, just acknowledge that astronomy is physics... is part of physics. There are rumors... documented rumors... that had he lived a little bit longer... he died in his fairly early 60s... had he lived a little longer, he was near to finally getting that long-sought medal to hang around his neck.
Fraser: And I guess, since his death, other astronomers have gotten Nobel Prizes.
Pamela: He opened the door for lots of people who have come after him. So we've seen people win the Nobel Prize for the discoveries of pulsars, for the discovery of the cosmic microwave background radiation, for the discoveries of all sorts of different things... in radio astronomy we have the 21-centimeter line, for gravitational radiation from binary black holes. Every few years now it seems that we have a new Nobel Prize being granted for work being done in the sub-field of physics--astronomy.
Fraser: Yeah... that's great. So then Hubble's name was lent to the Hubble Space Telescope. How did that happen?

Pamela: Well, one of the original goals of the Hubble Space Telescope was to finally figure out what is the expansion rate of our universe. That particular piece of information... the fact that that could even be solved for... was a direct result of Hubble's initial plot of distance vs. velocity. If we live in a universe with constant expansion, you can look out and measure distance-velocity, distance-velocity for objects at ever-increasing distances and make this nice long beautiful line and measure by fitting the line how fast our universe is expanding. And if it's not expanding at a constant rate by doing that same experiment as you make your plot of distance vs. velocity for ever-increasing distances, you'll see it curve... either up or down... depending on whether we live in a decelerating or accelerating universe. Because his science led to that understanding, and because we needed something as wonderful as the Hubble Space Telescope to be able to make measurements fine enough to actually get a really high-quality line that everyone would agree to, they named this telescope that would solve his problem after him. What's amazing to me in a lot of ways is... yeah, he did this great science... yes, it was because of him that a lot of people were inspired to go on to fund and support the building of the Hubble Space Telescope... he was an amazing scientist. But there's lots of amazing scientists out there who have led to us having this wonderful nerdish reputation. If you ask anyone "What's an astronomer?" they imagine this crazy hair-do... they imagine Einstein... let's face it... Einstein was sort of kind of an astronomer, really he was a physicist, but they imagine Einstein. Not only do they imagine Einstein, they imagine Einstein in a lab coat. There's no reason to wear a lab coat in astronomy... parka... you want a parka!

Fraser: Yeah!

Pamela: But Hubble is someone who had sports records. He boxed through... he wrestled through college, rather. And with the fame of his discoveries, he was actually one of the A-List celebrities of the Los Angeles area. He was a confidante, according to Time magazine's top 100 people of the last century, he was a confidante of Aldous Huxley and a friend of Charlie Chaplin and Helen Hayes and William Randolph Hearst. He played with the most famous of the famous celebrities and was their friend. He was this powerfully-built handsome man whose students, it's rumored, swooned for him. I don't know how many scientists have students swooning for them... It's just an amazing picture to have this person who... had more pictures gotten out of him... could have also changed how people envision astronomers.

Fraser: Yeah... well, it was well-named, I think.... the Hubble Space Telescope... I think it's great. It's a way to sort of remember, every time you say the name and you learn about the research that it's doing, 90 years from that amazing time to now, to know how big and how enormous the universe actually is, and how it's expanding. The mysteries just keep unfolding, so thanks, Edwin Hubble! We really appreciate that.

Pamela: He really falls into the category of hero. He was a soldier, an athlete, an academic, a celebrity... whatever type of hero you look for, he probably filled the bill.

Fraser: He got a Nobel Prize from me.

Pamela: If only we were the ones granting them...

Fraser: Yeah... shoot... alright... well, thanks a lot, Pamela. Thanks for doing a biography, and for those of you who are hoping for some biographies, I think we've got some more that we'll try to roll out over the next few months. Alright, thanks a lot... we'll talk to you next time, Pamela.

Pamela: Sounds great, Fraser. I'll talk to you later.