

Fireside Charla 012: Astronomy Research

De la Torre: Welcome to the *Fireside Charla*. Today I'm excited to have two of our own world-renowned Astronomy researchers join the conversation. But before I introduce them to you, let me share that San Diego State University has only standalone Astronomy department in the California State University system. We also operate a research observatory on Mount Laguna, which is a short drive east of San Diego. And we are the only campus to offer bachelor's and master's degrees in astronomy under the guidance of renowned researchers.

Two of them are joining me today, Dr. Jerome Orosz and Dr. William Welsh, who have recently made international news in the world of Astronomy. In today's charla, we're going to talk about their amazing discovery, but also why these space discoveries should matter to the rest of us, their collaboration with NASA, how our Astronomy programs are impacting students and their future as scientists, among many other things. Welcome to the *Fireside Charla* Dr. Orosz and Dr. Welsh. I want to start by having both of you share a bit about yourselves. Dr. Orosz, could you start?

Orosz: Yeah, so I grew up in Colorado, lived there for most of my life, went to college. And as a kid, I was always interested in science and in math. And one day, I must have been in second grade, my father suggested, "well, astronomers deal in science and they also have big numbers. And so maybe you should consider Astronomy." And so that's what I've been working towards ever since that time. And so I got myself educated in basic physics, took all the math courses I could in college, and eventually, here I am.

De la Torre: Thank you, Dr. Orosz. Dr. Welsh, what is your story?

De la Torre: First of all, I'm delighted to be here, thank you for having me. I grew up in Staten Island, which is just outside of the central part of New York City. And I played sports and things as a kid, but I realized that wasn't going to be a career. But science always fascinated me since I was very young. And watching the Apollo missions go to the moon was really very inspirational, but I have to admit even more so was watching *Star Trek*. And so that really got me into science. And you know, I wanted to be on the *Enterprise*. And I didn't start out in Astronomy but I knew I wanted to be a scientist. And it wasn't until almost my senior year in college that I switched over to Astronomy. And I was very fortunate to find a path that let me pursue this as a career.

De la Torre: So you both explained your interest in science and I think Dr. Orosz spoke about Astronomy and second grade being interested in it. But what made you interested in becoming a faculty member in Astronomy at San Diego State University?

Orosz: Well I, you know, went to college, majored in Physics and Math, and then got a Master's in Physics and eventually a Ph.D. in Astronomy. And faculty positions in Astronomy aren't that common and so lots of my path has been writing applications and getting rejected. And so we don't really get to choose our institutions. And you know, only very few scientists get to do that. And so basically, it's whatever is coming up at the time and you know, not everything is a good match. But a lot of places would have been good matches and just so happens that the circumstances dictated that, you know, there was a position here. At the time, I sort of needed a job and it seemed like a good match. And so that was in 2002. And so I've been here since then.

De la Torre: So we're really lucky to know that this was the right match and the right fit for us. Dr. Welsh, can you tell us your story?

De la Torre: Um, I always wanted to be a faculty in Astronomy ever since I graduated from college. But I started out on the research career path without any teaching experience. And it wasn't until many years had gone by that I realized I really do like teaching as well. And the faculty position is a great mixture of the two. And San Diego State had a long running reputation of being outstanding in *stellar* Astronomy, not galaxies and not other aspects of Astronomy, but studying stars. And that's what I was really interested in. And so we've been fortunate to come to a place that had a very strong background in stars and we can use that expertise to further our careers.

De la Torre: Okay, so let's get to the nitty-gritty now. You were critical in a very important groundbreaking discovery here at San Diego State University. And you and your team discovered the third planet in the Kepler System. What does that mean in layman's terms?

Orosz: Well, let's back up about 10 years ago and NASA launched the Kepler Space Telescope and it was a sort of revolutionary mission to discover planets around other stars. Now our specialty here at San Diego State has been binary star systems. So pairs of stars that orbit each other under their mutual gravity. And so we were fortunate enough to get involved earlier with the Kepler mission and have access to the data. And we discovered planets around certain binary stars, we call them circumbinary planets. And so our speciality has been looking at those planets around the double star systems. There are thousands of planets known around single stars. So Kepler has just revolutionized the field of planets around single stars. But our niche here is binary star systems.

Now this particular system called Kepler 47 is the only known binary system that has two or more than one planet. And so in 2012, we discovered Kepler 47, and originally found two planets. And that was the first of this kind of multiple-planets system. And then as more data came in, as we learned to look, to better look at the data, we discovered the third planet, sort of in

between the first two planets. And so the last several years we've been refining our data analysis techniques, our data analysis codes and doing other things. And that all came together last year and early this year where we published this massive paper outlining the third planet. And so this is the only non-binary system that has a system of planets, not just a single planet.

De la Torre: That's incredibly remarkable. So can you provide some more insights about the Kepler 47 planetary system, Dr. Welsh, and its position in the galaxy?

De la Torre: Sure, I'd be happy to. But first, let me add something to that. Note that Jerry just made, very interesting background to this was that an SDSU alumnus from the 1970s had originally started working on this project and had been doing so since the mid 1990s. And he was part of the Kepler mission. And we actually wound up joining his team when we were working with Kepler. And so it's kind of great that we have a SDSU connection going all the way back to the very beginnings into the 1970s and he's been a world leader in this field. We came along, we joined him, and our combined force has really allowed us to excel and to do things that no one had done before.

So the Kepler 47 system is a pair of stars. One is very similar to the sun, one is much smaller and dimmer, but they go around each other about every week, seven and a half days. And around the system are three planets. So we've got a total of five bodies in the system. It's a wonderful celestial dance of planets, and they interact with each other, and they pull and tug, and they speed each other up and slow each other down. And they make their orbits tilt up and down. And that's one of the reasons why we didn't catch the big planet until much more recently, it was kind of hidden from view. It's the big planet that we missed, and we missed it in 2012. But more recently, it came along and it's really the big daddy of the system. So it's kind of surprising we missed it in the early times, but we completely understand why, and it wasn't there in the early data and that's the real answer.

De la Torre: That's wonderful. So why should people here on Earth even care about this? Dr. Orosz?

Orosz: Well, there's a couple ways of answering that. I mean, everybody's curious. Everybody wants to know, you know, what's happening. And people are just naturally curious about, I think, nature and science. And so we study Astronomy because we just want to know, and so there is that just sort of curiosity aspect. And then there's also- the science of Astronomy is, you know, drives lots of technology like CCD cameras, you know, cameras in your iPhone are cheap because of, you know, technologies developed by astronomers, developed in the aid of Astronomy. And so I think it's just the technical aspects and the technology and just the sheer curiosity. You know, you look up in the sky and you see all these thousands of stars and just to

think that each of these stars probably has one or more planets, and you start to wonder, you know, what are these planets like? These planets, are they inhabitable? If, you know, if they're inhabited what are these creatures like? And your mind wanders.

De la Torre: So Dr. Welsh, I think I have to agree with Dr. Orosz. Every time I look up in the stars at night I'm imagining new worlds. Can you share with me why you think people are so interested in understanding the galaxies?

De la Torre: Sure, I guess there's two ways to answer that. And the first is a quote from Johannes Kepler himself, who the spacecraft was named after. And he said, "Studying the heavens is nourishment for the soul." And I completely agree with that. It really fulfills a sort of inherent curiosity of humankind. But on a more practical level, we know that at some point, the Earth will become burnt to a cinder by our sun, and we're going to have to leave the nest. And the more we know about the universe around us, the better we'll be able to make that jump when the time comes. It's not for billions of years, so there's no worry about this. But you know, the more we know now, the easier it will become. And we don't want to wait billions of years, we don't even want to wait thousands of years, we want to start to travel to the stars sooner. And I think it's just curiosity, the way people wanted to sail the oceans and see what was on the other side, we want to do the same. And the more we know about these things, the easier it will become, and the better prepared we'll be and the technologies that we need to make those travels and journeys.

De la Torre: Very, very exciting. Dr. Orosz, I was curious about the relationship with NASA and Kepler. So how did that come about? And why is it important for us to understand and applaud this important relationship?

Orosz: Well, this goes back 10 or more years. And so NASA, with these big missions often has what they call participating scientists. And so it's a way to gain outside expertise other than the people at NASA working on this. And so there was a call for proposals, I guess around 2007 to 2008, calling for participating scientists and the Kepler mission. And Bill and I have been doing, you know, research on extrasolar planets then. They're sort of like binary stars where you have two bodies, except one body is a planet and not a star. And so we were working on extrasolar planets. And this seemed like a very good opportunity to get, you know, to get funding and to have access to the Kepler data. And so the rules of the program are such that they're only allowing one proposal per institution. And so we decided that Bill would be the principal investigator on this proposal. And so we put it together and sent it in and then we didn't hear much and then one day Bill got this letter in the mail, saying, "Congratulations." So he comes to my office with this letter, saying, you know, "I got in." And so that was, I guess, 2008 sometime,

and then it's been a wonderful ride since and huge opportunities. And I can't be more grateful for this.

De la Torre: So how much did, Bill, our access to the Mount Laguna Observatory play when we talk about our successes with this particular project? Because most people don't really fully understand the importance of having an observatory, about SDSU research and Astronomy, and the Astronomy department. So how did all those important elements affect your capacity to have a relationship with NASA and do the research you're doing today?

De la Torre: Well, you're absolutely right. An Astronomy department without an observatory is like a biologist without a microscope or something like that. It's really important that we have that facility that we can train our students and also do research. And Mount Laguna is small, the telescope at Mount Laguna is small by today's standards, but it has a great advantage and that is it's our own telescope, and we can do whatever we want with it. And so we can do studies that are very long duration which you can't do at other telescopes. Typically you'll travel someplace like Hawaii or Chile or someplace in the middle of the Atlantic to get your data, and you only have like maybe three nights the whole year. If you're lucky, maybe you get six nights, and you hope the weather isn't bad. But here at Mount Laguna because we own the telescope, we can do these long-term studies and continue to monitor things that were just not feasible with bigger telescopes. So it's been a very important part of our research, in almost everything we do.

But I have to say, for me, the most exciting part is the ability to train our students with a hands-on observatory, where they actually get to go up there and learn and collect data and make mistakes, and really get a good experience out of this. So it's really important from a teaching point of view, and from a research point of view, but also just connecting things together and being able to follow up discoveries that we made with other telescopes. So we don't make these discoveries with our telescope at Mount Laguna, the Kepler telescope does, but then we can follow up and get additional data that are supplemental to the study and really kind of put things together and clean up and make everything come together so we understand the system.

De la Torre: So it sounds like that we have been doing some exceptional research with our great scientists today. And now that we end our charla, I wanted to make sure that they could bring up any other important points about Mount Laguna, the research in the Astronomy department here at SDSU. So I'll turn to you, Professor Orosz.

Orosz: Yeah, so as Bill said, Mount Laguna has been a very good resource for us, because, as Bill says, if we need to spend six months looking at a system or, you know, two months, we can do that with our students. And so the Kepler telescope was a survey instrument. So it looked at a big area of the sky and discovered lots of interesting, you know, interesting systems to us. And

so with Mount Laguna we had several summers where we had students just following up on these observations in different colors. The Kepler telescope is basically one big band pass with all the colors together, and with Mount Laguna we could separate out the colors and do different filters. And the students I think loved it, you know, they were getting to go up there and in the summers especially and observe and so that was a really useful tool for us just to get them the experience and to get data, and everybody had a great time. So that was a really fortunate thing for us.

De la Torre: And Dr. Welsh, any further comments you'd like to add?

De la Torre: Sure. Our Mount Laguna observatory has some really exciting projects on the horizon. We've got a brand new evryscope which is just starting to take data. We've got other proposals that are in the works. And while it's an old facility- if you think about it, what was your phone like 40 years ago? And that's what our telescope is, it was built 40 years ago. When you think, "How can we still use that thing?" But our faculty and our staff are very clever and we can figure out ways to make new discoveries with old equipment. Plus, add new equipment that charts things that have never been done before. It's sort of the Golden Age of Astronomy. We're still a science that's led by data and discovery. So we're still pointing telescopes towards the sky and making amazing discoveries and trying to figure out what it means. And that, to me, is the most fun part of it.

De la Torre: So I just want to end with asking you what really excites you about the future of Astronomy, and the future for our students in this field?

Orosz: Well, the future in Astronomy is what you might call big data. And so we have these large instruments that will just constantly monitor the sky over and over looking for things we never imagined. And so every time you have these new facilities like the Kepler mission, or the large synoptic survey telescope, which is an eight meter telescope in Chile coming online soon, you find things that you never imagined that were there. And so I can't predict the next things we'll discover because we have basically just a fire hose of data. And what's exciting for students is, it's just so much stuff that no one person can do it all. So there's always something for you to work on that's interesting. And so you don't have to worry about getting scooped because basically everybody is getting scooped because there's just so much data. And so it's a great time for the students to get involved, learn about, you know, data science, observational Astronomy. And these skills that they learned if they don't go on to be an Astronomy professor are very useful because, go to Silicon Valley and Google and you know, all these big companies with big data, local high-tech industry in San Diego as well. And so even if you don't land a faculty job, there's always work, technical and rewarding work available for people that are trained in these types of, you know, research.

De la Torre: Echoing Jerry's statement there, I think one of the most exciting things is that I don't know what we'll be studying 10 or 15 years from now. 20 years ago, or let's say 25 years ago, planets around other stars were not known about. And we now know over 4,000 planets in the last 25 years. So it's really remarkable this idea of studying stars around binary systems. Theorists said, "That's not possible, you won't find any of those." And in 2011, we found the first one, and now we have about 15 of them. So it's really neat, and I can't predict what we'll see 10 years from now, but we know it'll be really exciting and a lot of fun. And that's what I look forward to the most.

De la Torre: Well, this is an exciting time for San Diego State University with Dr. Welch and Dr. Orosz and the great work they're doing in Astronomy. And I want to thank you both because I do think the students are going to learn so much in the future, and they will be transforming things that we couldn't even imagine today. Thank you so much.

Orosz and De la Torre: Thank you.