David Eicher: Welcome to the Superstars of Astronomy podcast from *Astronomy* magazine. I'm Dave Eicher, editor in chief of *Astronomy*. Each month I'll share the thoughts and research of the world's greatest astronomers, astrophysicists, cosmologists, and planetary scientists with you in these hour-long chats. Superstars of Astronomy is brought to you by Celestron. From your first telescope to precision observatory-grade instruments, Celestron has the perfect telescope to suit your experience level and budget. You can find out more at Celestron.com.

And I'm very excited today to have a distinguished guest for our third show, Alan Stern. Alan is a planetary scientist, principal investigator of the New Horizons mission to Pluto, and he's been involved with 24, I think it is, planetary missions, including serving as principal investigator on 8 of them. Alan is one of the staunchest defenders of Pluto's status, and we'll talk a lot about Pluto and whether it should be considered a planet or a dwarf planet in the coming hour. He's also the founder of Uwingu, a science funding movement that is raising money in various ways in order to support research programs.

I've enjoyed knowing Alan for many years; he's always impressed me with very vast knowledge of many, many things. He's contributed stories frequently to *Astronomy* magazine, most recently writing about New Horizons in the February issue, and is of course on the magazine's editorial advisory board. So, without further ado Alan, thank you so much for joining me today.

Alan Stern: Thank you, Dave. It's great to be here. It's an honor.

David Eicher: Well, thank you. It's a treat to have you, and this is really a magical year, of course, for you, and for planetary science, and for Pluto.

Alan Stern: You think?

David Eicher: You've got a few things going on this year.

Alan Stern: Just a little. We got Rosetta in orbit around a comet, and we're bearing down on the Pluto system. It's an exciting time for sure.

David Eicher: It's very exciting, and we'll get into Pluto especially in great detail here, but before we get going on it and other things, tell us a little bit about young Alan Stern, and how you got interested in astronomy and planetary science, and a little bit about your life and where you came from.

Alan Stern: I was a little boy growing up in Louisiana — New Orleans, in fact. My family was from there for a long time, since the early 1800s, for one branch, and I grew up, as a little bitty kid, during the go-go time of Apollo and was swept off my feet by space exploration, but wanted to be a scientist. I remember getting gifts as a little guy, you know, 5 or 6 years old and getting my first microscope, 7 or 8 years old, getting my first telescope, asking for a lot of books to read, things like that. I don't really remember ever wanting to be a fireman, or a policeman, or any other profession.

I always wanted to be in the space world, and almost all the time wanted to be a scientist, and I was very lucky to be able to pursue that. Not to lose the beat, and to have enough of the right talents to do well in school and in graduate school.

David Eicher: And tell us about your college and your grad school career a little bit, where that took place and the path you took toward planetary science in that period.

Alan Stern: Sure, sure, absolutely. Well, my father took a transfer in his career, and we moved away when I was 11 or 12 years old from Louisiana to Dallas, Texas, and I went to high school there. And then I applied to a bunch of colleges, and all of them with schools that were strong in astronomy and physics, and finally chose the University of Texas in Austin. Even though I'd gotten in some bigger-name schools, the director of the department of astronomy, Harlan Smith, had personally romanced me about the 107-inch telescope and how undergraduates could even use it or write a paper before they finished school and just swept me off my feet with the hardware.

And so I ended up going to school just a couple hundred miles from home in Austin. The school was doing very, very well at the time — it still is — it's a big school.

David Eicher: It's one of the great astronomy departments now, of course.

Alan Stern: It is, and people like de Vaucouleurs were there; and at the time school was buying up Nobel laureates like —

David Eicher: By the half-dozen.

Alan Stern: Like Stevie Weinberg — yeah — and I was in a 17-story-high physics and astronomy building, you know, a Tokamak downstairs, and one of the biggest telescopes in the world, and a private plane that was taking astronomers back and forth. It was just hog heaven. I went to UT for that degree, for an astronomy

degree and a physics degree, and finished in a little under four years, three and a half years. Went straight into a master's program, which was actually an honors master's program, two master's degrees in interlocking fields, and I chose orbital mechanics and planetary atmospheres.

And did those the next two years, and finished up in 1981, and went out into the world to be an engineer because I had a degree in aerospace engineering. And then only years later went back to graduate school to do a Ph.D., and I did that work at the University of Colorado in Boulder, close to where I now live. Entered school …

David Eicher: Another great place.

Alan Stern: Great place, absolutely; a big concentration of astronomers and planetary scientists; big aerospace industry around here. I started — really I took advantage of a tragic event to go to graduate school. I was increasingly being pointed by my boss at assignments that were on the border between science and engineering because of my science background. And I had started to write grant proposals and write papers, and my boss was encouraging me to go get a Ph.D. and become a scientist full time. Well, I just didn't see a way to do it.

And then something tragic happened — the space shuttle *Challenger* crashed. And when it did, everything — everything — in NASA came to a halt because everything was launching on a shuttle in those days. There were no unmanned rockets. And they put everything on hold for three years, so I applied to graduate schools, and went to the University of Colorado at Boulder starting in January of '87, and finished in December of '89, three years later, an older than average but freshly minted Ph.D. in astrophysics, but with a passion for planetary science that had started way back at the University of Texas with Harlan Smith, and pursued my career from there.

David Eicher: I think I remember you back in those days at some AAS meetings.

Alan Stern: I think the first meeting I ever went to that was AAS was 1990 — maybe a little earlier. I'd been to some division meetings, like Division of Planetary Science.

David Eicher: Those were the days; a lot going on then.

And how was it that you came to have such an affinity for small bodies in the solar system?

Alan Stern: *[laughs]* Well, it's really not an affinity for small bodies. I have a very strong interest in finding problems that are wide-open exploration. New techniques, new places, things like that, and when I look back on my career so far, I can connect my own dots and see that that really has guided me a lot. And in addition — and of course, Pluto's nothing if not brand-new exploration — but I actually got assigned a master's project to study Pluto's escaping atmosphere when I was working for Larry Trafton on my planetary atmospheres master's.

And so published some papers back in the early '80s on that in *The Astrophysical Journal* and *The Astronomical Journal*, and was kind of doing Pluto science and outer solar system science all the way almost as a hobby, but publishing it even before I went to graduate school.

David Eicher: Very unusual.

Alan Stern: Then I did my Ph.D. thesis on comets, which is related, in that denizens of the deep outer solar system.

David Eicher: Sure, sure. And what was it — can you tell us a little bit more about your dissertation, about the details? What was it that you were studying vis-à-vis comets at the time?

Alan Stern: Well, my thesis was about — it was about challenging the notion that comets are completely pristine; that after they're formed, they're ejected to this deep freeze of the Oort Cloud, left there for 4 billion years, and then taken out to be examined. Now, that is what happens, but the thesis was about exploring a whole variety of subtle ways that comets could age with time, even though they're stored so far from the Sun and at temperatures of literally 10 kelvin or so, in some cases, where chemistry just can't go very fast and things can't evolve.

In fact, I discovered a variety of processes that did make comets evolve, and not just their very surface, but even fairly deep. And the other part of the dissertation was looking for Oort Clouds around other stars with the IRAS telescope data, which did not find any, but it was the first study to set upper limits on that; and wrote papers on gamma-ray bursts as a way to constrain the number of Oort Cloud comets in the galaxy, things like that; all that was wrapped up in a thesis that I did about comets in our solar system and elsewhere.

David Eicher: Fascinating. And it's amazing how much we've learned, of course, about comets in the last generation, since those days. But of course, they're difficult subjects, and they're distant, and there's a hell of a lot to learn yet, isn't there?

Alan Stern: Absolutely right. Our notions of what comets are have really evolved, even right up through Rosetta, which is just a spectacular mission, the first time a comet has been orbited and studied in detail. The first time we've got time domain on such an ancient and yet complex object.

David Eicher: And some of the recent imagery that we've had the resolution, the plate scale, just completely mind-blowing thinking back to earlier spacecraft images of comets. How far we've come there to really see what the surface of a cometary nucleus really is. Just mind-blowing, isn't it?

Alan Stern: Absolutely. You know, before Comet Halley we had never seen that nucleus of a comet, really at all, and it was a shocker to see how rough the surface was, how dark it was, how devoid of exposed ice, because the model people had, it was a snowball; turned out to be noy a snowball, not even a dirty snowball, but sort of an icy dirtball. And then now, half a dozen flybys and one orbiter lander mission later, we've got better than spy satellite resolution on this comet.

And I think you should fasten your seatbelt because when this puppy starts evolving before our very eyes once the water turns on, I think we're going to learn a lot more than we have already, even escorting the comet inward now for six months.

David Eicher: This could really shock and surprise people, some what happens with the science, and also, frankly, with the imagery, once this thing warms more.

Alan Stern: I think so, and Rosetta is a Cassini-class mission, with a dozen different sophisticated instruments from mass spectrometers, to cameras, to ultraviolet and infrared mapping spectrometers, dust chemistry instruments, dust microscopes. Just about every aspect of cometary science is included in this large-scale mission, and we have one heck of a comet to study, and one very capable spacecraft to study it with in Rosetta.

David Eicher: It's very, very exciting. And of course, as we talked about the other huge planetary exploration event this year is New Horizons, fast on the approach now to Pluto and the Pluto system of moons as well.

Give us a run-up, if you would, and you wrote a story in the February issue of *Astronomy*, and you've written before about it, and you've done a lot, of course, elsewhere. But if you would, walk us through how this mission came to be, and the unprecedented level of excitement that we're going to have with it. Because never before have we had a close-up look at Pluto, and this is really going to be, in some ways, a close look at the last great frontier of the solar system.

Alan Stern: I think that's right. I think you put your finger on it. This is in a real sense the capstone of the first era of the reconnaissance of our own solar system, and it's got a long history. It started in the late 1980s, about the time that Voyager was reconnoitering the Neptune system and Triton. There have been a lot of advances in what we knew about Pluto — discovery of Charon, the mutual events, the occultations between Pluto and Charon. Other discoveries like stellar occultation in 1988 that proved the existence of Pluto's atmosphere.

There's a lot of excitement about Triton, an analog object to Pluto, and the discovery of the Kuiper Belt very shortly thereafter, which put Pluto in context. And over a period of about 15 years, from '89 to the early 2000s, there were a series of Pluto mission studies with funny names like Pluto 350, and Pluto Express, and Kuiper Express, Pluto-Kuiper Express, all those, none of which ever really got off the drawing board. They never got past maybe some test equipment. And the scientific community was very steadfast in its support of wanting to do this because of a great nexus of different kinds of science, and a realization when the Kuiper Belt was discovered that this is the third grade zone of the solar system and after almost 50 years of exploration, no resources had been deployed there.

So there was a lot of leverage in terms of ability to make big discoveries with a single mission. And after a number of debacles where Pluto missions were canceled before they got off the drawing board, as I said earlier, eventually NASA came to a new idea, which was to throw it open to the scientific community, like Discovery missions and New Frontier missions and Explorer missions, and compete it, and see if competition could drive a better deal for the agency in terms of price and return.

And we got involved in that competition, teaming at the Southwest Research Institute, where I work, with the Johns Hopkins Applied Physics Lab and others. That was back in 2001, and by the end of the year, after a long and arduous — even tortured — process, we

came out the winners of that. And looking back on all the tattered remains of Pluto missions that never got off the drawing board, I resolved that we would do whatever it takes to make sure this one got to the launch pad. It was complicated, and it was hard work, but just four years and two months later, we rocketed off the pad in Florida on a nine and a half year journey to Pluto.

I tell people there's nothing like this in the world. We haven't been to a new planet in 25 years, since the Neptune explorations by Voyager. A lot of people are too young to remember that; probably about half the United States either wasn't born, or born too close to that date to remember it. And there's nothing like it on the drawing boards anywhere. This mission is traveling faster than any spacecraft has ever crossed the solar system. It's going farther to its primary target.

It's only one spacecraft — it's gotta get it right — and a very high-tech payload that takes advantage of being developed with 2000s technology compared to 1970s technology for Voyager instruments. We are flying into the unknown, and we are gonna bring everybody along for the ride, and I can't wait.

David Eicher: And it's gonna be very, very exciting because it will be a flyby, but the data will be returning to Earth during a very prolonged period; is that correct?

Alan Stern: That's right. In fact, we're taking the first data now, and we're very far out still — 140 million miles, a little under 1½ astronomical units. But by May, we'll be returning the best images ever made — better than any instrument on the ground or in space ever has — and it just gets better every week. So we designed this mission to be a long encounter with the Pluto system, not a weekend at Pluto, but January to July. And then we designed it to be very, very effective, with very sophisticated instrumentation, fast bus speeds, and big solid state memories, so that we can take the data it turns out about 100 times as fast as we can send it back, which is a good thing, because when you're there, you wanna be very effective; you wanna be able to really fill up those memories with data from all the different instrument investigations.

And so while you'll see a lot of good stuff as we approach Pluto, when we're right there, most everything — 99 percent — will still be on the spacecraft when we pass by, and it will take 16 months to get all that to the ground. So from the standpoint of your listeners, we'll be long gone from Pluto, but new data sets, new discoveries

will be raining down every month in 2015, and across almost all of 2016, before the transmit is complete.

And there's never been a mission like that before. It's gonna look like an orbiter in terms of continuous scientific return, even though it's long gone from Pluto.

David Eicher: And this is just to remind the listeners, this is July 14th is closest approach, but there'll be lots of excitement and electric excitement from about, well, April and May onward, when you really cross that hurdle of getting the best images of the system — better than HST. Is that proper to say?

Alan Stern: We will be better than the best images, which were made by Hubble, by mid-May.

David Eicher: Yes.

Alan Stern: And then by June, it'll be startlingly better. But let's put this all in context: current best image of Pluto, if instead were a picture of the Earth similarly pixilated, would not reveal North America, would not reveal the continents. And by the time we get done in July, if we were looking down on the Earth, and let's say flying over New York City in July, I can show you data products where we've actually constructed imagery of New York City at New Horizons best resolution. You can see the Hudson River, Manhattan, the East River, Roosevelt Island. You can look at Central Park and count the ponds in Central Park; count the wharfs on the Hudson.

New Horizons is just stunning in what it's gonna provide, and we're gonna look at Pluto, all of its satellites. We're gonna make composition maps, thermal maps, stereo maps with topography, black and white, color, plasma measurements, atmospheric studies left and right. It is the most powerful suite of instrumentation every brought to bear on a first reconnaissance, and it's amazing. The spacecraft is in spectacular health. The instruments are calibrated and ready to go. And most of the encounter is now planned and through the mission simulators.

David Eicher: That's really, really exciting, because of the complexity and the great distance. Everything is at 100 percent; it's all systems go. And I know, because you were gracious enough to read the Pluto chapter that I wrote for a book that's coming out this year, there's a tremendous amount of science in a lot of directions that's gonna come out of this mission. We're gonna have a pretty good

knowledge suddenly, from a relatively limited knowledge in all respects, of not only Pluto, but the moons, too, right?

Alan Stern: No kidding. I tell people what we're used to, because we've been so successful in the inner solar system, in the middle solar system, is missions that rewrite the textbook. You hear that phrase all the time. It's true. We send the next mission along with better gear, and we learn a lot that we didn't know before. But in this case, we're not rewriting any textbook; we're writing from scratch. We've never been here. This is raw exploration at its very best.

David Eicher: It's very exciting. Remind us again the closest approach distance of the fly-by. How close is —

Alan Stern: Well, we're going to bisect, aim right halfway between the orbit of Charon and the surface of Pluto. In terms of distance, it's about 12,500 kilometers from Pluto. We don't wanna get too close because we can blur the images, and we need to stay far enough out that we get good imagery of the satellites as well. Charon's got several times the surface area of Texas, so we got a big job there, searching for an atmosphere, doing the geology. Charon appears to be very different from Pluto. It appears to be a rising star in terms of what we know about it; it may even be hinting at us that there's surface activity there, things like that.

So we have a long list of objectives — over 1,000 scientific observations, and I've been waiting to unwarp this present under my tree for 25 years. Christmas comes in July this year.

David Eicher: Well, and this is daunting. Now, how do you, as you get closer and there's weeks and then days to go until closest approach, how do you consider variations that you might do in camera-pointing, in science that you might do? How much of this mission is set, and how much variation do you have to change things, depending on what you see and how you feel?

Alan Stern: Well, absolutely. So I made a decision a long time ago that we would not — that better could be the enemy of good enough. We wanna have a thoroughly tested encounter, and so we have scripted it all, and there's plenty of room for discovery, but no room for ad-libbing. We have thought long and hard about what the system might present us with that we might not expect, and if this is the case, what observations should we plan to take advantage of that hypothetical discovery. But whatever Pluto presents us with — and by Pluto I mean the system, six objects at least — I'm sure in hindsight that we're gonna wish we had a second spacecraft.

You know, it's actually unusual; in the history of solar system exploration, almost always we've sent two spacecraft. Space flight's been hard ever since the beginning. It's hard now. And having only one spacecraft stacks a little bit more weight on our shoulders to get it right. When they flew Mariner I and II to Venus, only Mariner II made it. When they flew III and IV to Mars, only Mariner IV made it. And then when the first two missions went to Jupiter, they fortunately both made it, but one was pretty sick.

Then we go on down the list — we went to Uranus and Neptune with a single spacecraft, but that was an extended mission. This is only the second time we have sent a single spacecraft to reconnoiter a planet on prime mission, the other being Mercury, which was kind of a bonus '60s mission called Mariner X — '60s–'70s mission, really. I'm a big believer in 80 percent of something is a lot better than coming home with 100 percent of nothing, so we don't wanna take risks. We try to drive all the risk out of it as best we can, so the entire encounter is scripted.

Even the discovery of new satellites wouldn't cause us to react and retarget observations. But we've planned for those discoveries. For example, if we discover new moons, we've already planned observations that will get their colors and their shapes and things like that, by blanketing the entire inner system with imagery that we can pick from once we find where the satellites would be in those images.

David Eicher: And that we can say perhaps would be highly likely, or do we not want to get into speculating?

Alan Stern: I don't think people would be surprised to find more satellites. They keep popping up every time we look deeper, and New Horizons can do better than we've ever done from any Earth-based system.

David Eicher: Sure.

Alan Stern: I would not be surprised to find more satellites. In fact, I'd go as far as to say I'd be surprised if we found exactly zero more.

David Eicher: Right, right. And —

Alan Stern: We know —

David Eicher: I'm sorry.

Alan Stern: No, please.

David Eicher: We know the basics, in a very simple way, about Pluto and about Charon, and we know some chemistry spectroscopically, and we know a little bit about atmosphere. We know that these are dark objects. Is there anything that you're anticipating as far as characteristics of these, basic science, that is most exciting to you? You know, the details of what these surfaces are like?

Alan Stern: You know, it's a great question, but we spent so many decades being surprised by the richness of nature — not predicting, say, river valleys on Mars, or volcanoes on Io and other satellites, or oceans on the inside of worlds — I could keep going down the list. I don't make predictions about the Pluto system. It's not just a whole new system and a whole new planet, but it's a whole new class of planet, and I just say, "Fasten your seat belt and enjoy the ride." This is all about exploration.

David Eicher: And some of the most amazing things may indeed be surprises here as well.

Alan Stern: I hope so. I think that could be some of the most exciting stuff. But regardless, we're gonna come home with data sets like we've never had before. Resolution equivalent to the seventh mission to Mars; mapping data sets that have a spectrum at every pixel at a quarter-million locations all over the close-approach hemisphere of Pluto. Several maps, 3-D maps, kinds of things I was talking about earlier, that are gonna give us a lot to chew on for a long time.

David Eicher: And as you said before, when we talked about things, I mean this is not really just going to see a planet — and we'll talk about the nomenclature and the IAU and all that stuff shortly here. But it's a system; it's a system of six bodies here, at least. So this is really a little system of worlds, and don't you think with the imagery and with the science that we'll get, even fairly rapidly, let alone that which comes later, people will see this as a system of worlds. Don't you think so — the Pluto system?

Alan Stern: I think so. I think that for your listenership, which is very savvy about space and about space exploration, they're ready for this raw meat of new exploration. But for the public, I don't think they are. I don't think that the general public — I don't think people even know we have a mission to Pluto yet. Maybe they're becoming dimly aware of it, but they've never seen anything like this, or at least not in a very long time. It's kinda the last train to Clarksville, *The Last Picture Show*, so I think that there's a historical aspect. I think people will tell their grandchildren, you know, "I was there. I remember back in 2015 when we did that."

I think reporters will tell their grandchildren, "That's one I covered that really sticks out. It's really something. It was the end of that reconnaissance that Sagan spoke about, where in one or two generations, humankind goes from all points of light to real worlds, almost overnight in terms of a civilization perspective." So being the farthest out and the last one, there's a certain romantic aspect to this as well that I hope we can use to engage people into what we do in space exploration, from the ground and from space, in new ways, that hasn't captured some kinds of people over the years, that we have a chance to do in a whole new way.

David Eicher: This is the last frontier of the original worlds, if you will.

Alan Stern: Absolutely.

David Eicher: Now let's talk a little bit about Pluto and the status as a planet or a dwarf planet, because this, again, aside from schoolchildren still being obsessed in some places with this issue, astronomy enthusiasts certainly are, and I've posted things on social media even this past year, few weeks, and it really still gets people's ire up on whichever way they're oriented here.

Alan Stern: You know, I think most people know the IAU made a colossal mistake, and the only reason they haven't backed out of it is probably that they're embarrassed to do it. You know, there's so many levels at which this is scientifically — let me use the technical term — screwy, that I don't almost know where to start. Probably most profound is that astronomers are not experts in planetary science, and I can only imagine the reaction of astronomers if I got together a meeting of talented planetary scientists, and we started categorizing galaxies, and quasars, and the depth of the intergalactic medium.

These are really smart people, but they're no closer to planetary science than a podiatrist is to brain surgery. *[laughter]* You should let an expert work on you.

David Eicher: Right.

Alan Stern: And you know…one of my team members, Rick Denzil, a professor at MIT New Horizons, co-investigator, longtime expert in Pluto, said that he thinks that perhaps the biggest lesson the public will learn in this flyby is that Pluto was a planet all along because the attributes of the world always drive you to that conclusion. Atmosphere, moons, seasons, core, polar caps, all

those kinds of things — what else would you call it? And it really doesn't matter where it's located.

The zone clearing thing was just an arranged way to keep the number of planets small, which is kinda crazy in astronomy since we have endless numbers of stars and galaxies and everything else, and we don't care about memorizing their names. We should get over that old-school, 20th-century notion that we'll remember the names of all the planets, either, any more than we have to memorize the names of every river and mountain on Earth. You just don't need to know that. You just need to know that there are a lot of them.

Maybe you wanna know the names of the half-dozen most famous or something. And our view is so expanded from what it was, even in the '80s, with the explosion of knowledge about small planets and the depths of our outer solar system and all kinds of planetary types orbiting other stars, that like a lot of my colleagues in planetary science, we're very inclusive. And we're learning that there are many more kinds of planets than were in our imagination, and if it turns out that the small ones dominate over the big ones, well, so be it. That's just data.

David Eicher: And as you said — and I remember you gave a very excellent talk at the Northeast Astronomy Forum about this subject, and talked about well, why is location so critically important? A house is a house, whether it's in the countryside or in the middle of the city. And for that matter, stars orbit stars, so why can planets not orbit planets?

Alan Stern: Absolutely. I think this location thing — it's a real red herring in so many ways. As an example, astronomers made this giant faux paus with zone clearing because (a) no zones are actually cleared, and (b) the problem is as you go farther outward, each zone gets bigger. The volume involved just gets bigger and bigger, just because of r^3, the distance from the Sun. Pluto's zone is bigger than all the real estate from the Sun to Neptune times three. How could you expect it to clear the zone? You could put the Earth in the Kuiper Belt — it wouldn't qualify, because it couldn't clear a zone that big.

So you see, it's a red herring. It's not about what the object is. It's only about where it is, and as I say, it was arranged hastily by non-experts looking to keep the list small, and I don't think that's very scientific. Frankly, planetary science, it's arbitrary, and I think people just walk away, and fortunately, IAU has no police force,

so. You go to a planetary science meeting and just sit in the back of the room and listen to talks on Pluto, or other dwarf planets — even satellites like Io and Ganymede — and even the Moon is referred to as a planet, all the time. It's not a political opinion — it's just what scientists call these worlds.

David Eicher: Ganymede —

Alan Stern: Absolutely.

David Eicher: Large moons, and —

Alan Stern: Yeah. Well, I think because we live on a planet, somehow we think that they're a special type of object, right? They're more important than stars. You never say a star was demoted to be a brown dwarf; you say it was reclassified.

David Eicher: Absolutely unquestionably true. The frame of reference on the universe standing or sitting on a planet here has everything to do with that notion. I think you're dead right.

Alan Stern: Yeah. So in July, Pluto's gonna get *promoted* to be the most popular planet in the solar system, thanks to New Horizons.

David Eicher: Well, that's fantastic, and of course, as you said before as well, a dwarf planet can be a planet, too.

Alan Stern: Well, I coined the term dwarf planet, so I feel very strongly about it. I wrote an article in *Icarus* in 1991 arguing that there should be a very large number of small planets; it's a mathematical series of arguments, not an op-ed piece. And I needed a term for what to call these guys, and in analogy to dwarf stars and dwarf galaxies, at the outset of the paper I defined this term dwarf planet as a class of planet. Just like we have giant planets — that's an adjective out front — dwarf planets, it's just an adjective out front for the little ones.

David Eicher: And it's a completely different animal, and that was the year before the discovery of QB_1, was it not?

Alan Stern: Absolutely, yeah, yeah. Any at that time, when people were looking for Kuiper Belt objects, then they were looking for small things; things tens of kilometers and small hundreds of kilometers across. QB_1 was about 100 kilometers across. Not looking for planets. Not looking for analogs of Pluto, of which we've now discovered eight or 10. And then there's every prospect that we'll find much larger objects deeper in the solar system. So I always

like to just let the data inform me, rather than let my preconceived notions inform how I should categorize the data.

David Eicher: Trying to package things neatly.

Alan Stern: You know, as we grow up we find out there are more shades of gray.

David Eicher: The universe is always more complicated than you anticipate it will be, isn't it, ahead of time? And I think it was, remember Martin Harwit wrote this book in the early '80s or late '70s, *Cosmic Discovery*, in which he claimed that 23 percent or something like that of phenomena in the universe were known, so get ready to have everything you believe upset.

Alan Stern: I do. I do, and it happens again and again.

David Eicher: Yeah.

Alan Stern: Who thought that most of the planets in our solar system were small? Who thought that the largest zone in the planetary system was undiscovered in the early 1990s? It's like we had a map of the Earth minus the Pacific Ocean in 1990. And who expected pulsar planets? Who expected balsa wood planets? Who expected super Earths or hot Jupiters? Over and over we're surprised by the richness of nature. Let the data inform the science.

David Eicher: Always as it should be. And you think it should be fair to say — just to sort of close this loop again — we will see this as a system of worlds. We'll see this as both a dwarf planet, with attendant smaller bodies, and a planetary system, really, with bodies orbiting around it, as we get closer and closer and closer to July, and even thereafter.

Alan Stern: I think so. I think when people see the picture, they'll do what I call the *Star Trek* test, you know? At the beginning of every *Star Trek* episode they show up somewhere new, turn on the viewfinder, and the audience knows in a fraction of a second if they're orbiting a planet, or there's another spaceship there, or it's an asteroid or a star. They don't need to survey a solar system to integrate orbits and start figuring out what's where. Make that judgment very quickly. It's a lot simpler problem than the astronomers have made it out to be, and I think in planetary science, we got it about right.

David Eicher: You see it, you know it, and everyone knows it in *Star Trek* in the early part of the episode, except for the guy who beams down with the red shirt who never makes it back.

Alan Stern: Right. Yeah, right. There are no red shirts on New Horizons.

David Eicher: Right. Right. Let's talk a little bit about Uwingu, because we have a problem in this country and in this world, but maybe especially in the United States, of not nearly enough support from our Congress and from others for scientific research. And so you've done something with Uwingu to try to raise monies for real science projects. Tell us a little bit about how that came to be and what you're doing these days with Uwingu. And I should say that *Astronomy* is a supporting partner of this effort.

Alan Stern: And I appreciate that support, and thank you for bringing it up in the interview. Uwingu is really a dream for those of us that are involved in it. We're trying to show a new way to fund space research and space education, not by asking people to give out of the goodness of their hearts — please do that for groups like the National Space Society, the Planetary Society, PASP, et cetera, as a nonprofit. But we're trying to go a different way, to cast our net broad to people that aren't so interested in science and space exploration as your listeners may be.

To just give people who wanna touch space new and interesting ways to do it. And so we've launched a series of projects, and our business model is very simple: that half of every dollar we raise pays our bills and helps us develop new projects. The other half goes straight to grants. And our first year out, we started small. We raised about $9,000. Not bad for volunteer weekends and nights project by just a handful of people. Last year, which was our second year commercially, we did 30 times better.

David Eicher: Wow.

Alan Stern: And I hope to see steep growth in 2015 and 2016, and over time, really make a difference. Probably the most prominent project we're carrying out right now is in association with Mars One, the commercial Mars mission folks, in which we're creating a new map of Mars, grandfathering in all the already-named features, and letting the public name features after anyone and anything they want, as long as it's not profane or pejorative. And use the money to generate that grant fund — we call it the Uwingu Fund. But the Mars One people need a complete map.

90 percent plus, of all the craters on Mars have not been named in 50 years of space exploration, so we're kinda giving the public the same power as a rover driver for a NASA Mars mission, or an Apollo astronaut. You know they named all the features in their landing sites themselves. But now we're opening it to the public, and we've created a much more complete map than was available just a year ago. We've more than tripled the number of named features, and in addition, we're engaging people in all kinds of ways where they're humanizing Mars — naming it after loved ones and so forth.

And the Mars One missions are not only, by contract, going to be using our maps — no one else's — in their missions, both robotic, and hopefully in the future, human. But they're also gonna physically carry the map to Mars, which is very special to people who go to our website and name features for relatives and loved ones and coworkers, or about their favorite teams or artists, or their hometowns or whatever. And interestingly, we have people from over 60 countries involved.

David Eicher: That's amazing.

Alan Stern: Some of the biggest spenders are not in the United States. We have about 40 percent of the sales taking place in Europe and Asia already, and we're just excited to just see people who love being a part of space exploration in a different way get engaged. We've done other things. We had a project late last year called Beam Me to Mars, where anybody could put in a message, and we sent them by radio telescope at the speed of light to Mars on November 28th, the 50th anniversary of the first mission to Mars to launch.

And then we sent all those names and good wishes to the head of NASA, to the appropriators in Congress, and to the United Nations Secretary General, and said, "Look at this big stack of paper, people who really care about this stuff."

And it helps fuel grants for space research and education. And we like making a difference in individual scientists' and educators' lives, and we think we're doing that. We're at the very earliest days, but we work on it every day and every week.

David Eicher: Well, that's fantastic, and we really are proud to support this effort. You can see more about it by going to Uwingu.com. That's U-W-I-N-G-U.com, and you'll see everything you need to know about it. And tell the listeners, Alan, if you would, where the word Uwingu comes from.

Alan Stern: Yeah. Uwingu is a Swahili word. We wanted to choose something that wasn't so America-centric, and it means "the sky." It means the sky in Swahili, and we think it's a beautiful name and a nice one-world type image for a company that intends to connect people to space and to the sky from all over.

David Eicher: Well, that's really fantastic. Congratulations on what you're doing with that, and I'm sure it'll continue to gain momentum as it rolls along. And you know, change always ruffles a few feathers, and very early on, when people heard sort of glimmers about this — there was, "Well," there was, "We're naming things — that's artificial," and the National Star Registry was a shame. This is not taking money from people and delivering a document to the Library of Congress to trademark, to register a copyright of a sheet of paper.

This is really funding science, something we need a lot more of in this world, to push research forward, and there's a big, big difference there in how people should perceive this, and what it's really doing in the world.

Alan Stern: Well, thank you. That's the way we see it, too, and hopefully some of your listeners will even get engaged, just by hearing about this show. And go out and sign up for our newsletter, or engage in one of the projects at Uwingu, and tell your co-workers and your friends about it, too, because we're really out to instead of going deep after all those people that love space exploration, to go wide and give people who just wanna touch it because they like seeing a sci-fi movie, or they think space is cool, to find ways to engage. And that's a new concept.

David Eicher: Yes, indeed. Let's talk a little bit, Alan, about — because you have so much experience, and we talked about your early background getting into planetary research, and your degrees. Where do you see the future of science, of astronomy, of planetary science, of studying distant and small and large bodies in the solar system — where's all this heading over maybe the next generation? Where do you see things going in the coming years?

Alan Stern: Wow. What did Yogi Berra say? "It's hard to make predictions, especially about the future?"

David Eicher: Right, right.

Alan Stern: I'm sure whatever I say will look quaint before you know it. But when I look at the big picture, one of the I think real trends is

towards space commercialization. Look what Elon Musk and SpaceX are doing. Look what many other companies are doing, not just on the launch side and human spaceflight side, but even on the robotic mission side; lots of private ventures for new ways to connect people to the Internet and space; new ways to engage people with real-time imaging from space. I think space commercialization is gonna really make a huge difference, and make a difference in how we explore the solar system over the 21st century. I think that's one of the biggest trends.

David Eicher: That's a huge trend. You just think that this will really be multi-national, too; that there will be companies here, there, and everywhere partnering?

Alan Stern: Well, just look — Mars One is a Dutch company, as an example, and we see Swedish-based systems and others coming along. I think we're still the teens; we haven't even got to the Roaring '20s with the birth of aviation equivalent in space flight yet. So I think it's gonna be very, very exciting over the next few decades. I think there's gonna be a real resurgence of human space flight and human space flight exploration for the moon, the asteroids, and Mars — all of them. I think a lot of countries are getting involved; a little slow to spool up, but 15–20 years from now, I think it's gonna be really exciting.

David Eicher: That's fantastic. And we're really, if you look back as well a little bit, over your career, and even further, then this is a really, really special time to be around, and to be interested in where we are in the universe and the composition of our solar system, isn't it? I mean we really can appreciate it now better than ever before, in so many ways.

Alan Stern: Absolutely. Absolutely. And can I just say a word or two about New Horizons before we finish?

David Eicher: Of course, yeah, yeah, yeah, yeah.

Alan Stern: There are so many ways that people can get engaged if they want to. You can go to our website — just type in your browser "Pluto New Horizons." You can find us on Twitter. You can find us on Facebook. You can find us on Tumblr. You can go to our Countdown page, SeePlutoNow. You can sign up for Pluto Picture of the Day, which aren't just pictures from the mission, but pictures of the people, the spacecraft, the launch, all the different aspects of the astronomy surrounding the mission.

There are lots and lots of ways to get involved, and we even plan to let people petition for kits from us to set up their own Pluto parties called Plutopaloozas this summer around the encounter. Have one at your astronomy club. Have one at your workplace, or your Boy Scout troop, Girl Scout troop, whatever. Just apply through the website and get a Plutopalooza kit, and turn people on to astronomy and space exploration and to how great our society can be when we do things like this for all mankind.

David Eicher: That's fantastic. Well, we certainly will. It's gonna be a unique and historic and amazing year, and I know that *Astronomy*'s readers will definitely be among the group that is very, very engaged with New Horizons, all the way through the experience. And it's happening already, as you mentioned, so now is the time to go to the website or to start following, because things are only gonna get more exciting, and they're exciting right now. So thank you, Alan.

With that, unless there's anything else that you'd like to conclude with, I thank you so much for joining us today, and I know the magazine readers, as you know, and all of our people online, are very excited to hear what you say, and they're gonna be following along and look for more content from Alan in the magazine as well a little bit later this year with regard to New Horizons.

Alan Stern: Well, thank you, Dave; this has just been tremendous.

David Eicher: Thank you so much, Alan, and we'll have you back again, and good luck with this historic and amazing mission this year.

Alan Stern: Thanks. See you soon.

David Eicher: See you soon — take care, Alan.

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