

WEBVTT

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00:00:00.000 --> 00:00:00.750

We taken.

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00:00:03.030 --> 00:00:07.950

Lisa Kaltenegger: thanks for the invitation and such a pleasure to be back and I miss you guys all so much.

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00:00:08.820 --> 00:00:19.530

Lisa Kaltenegger: Just the ssp coffee in the organic coffee in the morning is one thing that I haven't figured out how to implement, here we have a monthly coffee at the CSI, but it's just not the same without andrea's cookies.

4

00:00:19.890 --> 00:00:23.820

Lisa Kaltenegger: or some of the other delights that we're bringing in for discussion in the morning.

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00:00:24.360 --> 00:00:32.310

Lisa Kaltenegger: But what i'd like to do today is i'd like to talk a little bit about how to find life on exoplanets challenges ideas and adventures.

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00:00:32.580 --> 00:00:37.890

Lisa Kaltenegger: that's what I came up with when I got the invitation and then I was told it's 25 minutes so.

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00:00:38.280 --> 00:00:44.970

Lisa Kaltenegger: Basically what you're going to get is a challenge, ideas and and adventure everything else you can ask me.

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00:00:45.270 --> 00:00:53.190

Lisa Kaltenegger: In the question and answer period there's more challenges there more ideas your board went to about theirs, but i'll try to keep to the time that I was allocated for.

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00:00:53.700 --> 00:01:02.220

Lisa Kaltenegger: So let me just give you a very short intro to the config and institute that Evan was talking about, so we founded in about six years ago here at cornell.

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00:01:02.580 --> 00:01:11.940

Lisa Kaltenegger: it's currently 35 faculty and senior researchers in them researchers postdocs students undergrads from 15 departments at cornell that.

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00:01:12.300 --> 00:01:19.710

Lisa Kaltenegger: make up this interdisciplinary teams are you going all the way of normally you know from engineering biology astronomy.

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00:01:20.070 --> 00:01:28.830

Lisa Kaltenegger: Or, as an atmospheric science, but also to science communication music performing arts, so we trying to spam the whole arch, and this is just.

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00:01:29.130 --> 00:01:37.290

Lisa Kaltenegger: A couple of the picture off people here and Kevin was saying what we trying to do is to create the toolkit to find life and the cosmos.

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00:01:37.830 --> 00:01:46.830

Lisa Kaltenegger: In the solar system and outside of it so as cornell has a really strong history of actually having planetary and astronomy together.

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00:01:47.730 --> 00:01:59.280

Lisa Kaltenegger: Our departments planetary and astronomy so MARS and everything is actually not in verse and planetary science here it's actually an astronomy but, first and atmospheric sciences it's cold here is also a strong core.

16

00:01:59.760 --> 00:02:10.710

Lisa Kaltenegger: Of what we trying to figure out from climate change to other earth like planets all of this is built together to figure out how to find life.

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00:02:11.220 --> 00:02:18.630

Lisa Kaltenegger: On souls and bodies and also on bodies for the away exoplanets what's my research what i'm going to talk about today.

18

00:02:19.170 --> 00:02:25.860

Lisa Kaltenegger: So this is a little bit of a tour de force so what I wanted to give you is in case you're interested in some of the.

19

00:02:26.340 --> 00:02:32.190

Lisa Kaltenegger: latest updates, this is a review that I wrote in 2007 and how to correct arise habitable worlds and science of life.

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00:02:32.550 --> 00:02:41.910

Lisa Kaltenegger: With all the caveats that entails right so i'll talk about a couple of these today my talk and then again feel free to reach out and ask questions.

21

00:02:42.810 --> 00:02:49.170

Lisa Kaltenegger: So the prime challenge, I want to start all of this is actually identifying a habitable world.

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00:02:49.950 --> 00:02:57.360

Lisa Kaltenegger: And you all know that we have found more than 4000 planets so far, most of them and systems.

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00:02:57.720 --> 00:03:12.180

Lisa Kaltenegger: And this is an updated image so thanks to some Quinn that actually updated at since my review, for me, so you see the radius of the planet, that we found versus the periods and Bay that's usually how you see it and then also what I put.

24

00:03:12.180 --> 00:03:21.000

Lisa Kaltenegger: Here is the effective temperature of the planet, because that, of course, goes in into how much radiation radiation hits that world.

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00:03:21.420 --> 00:03:32.010

Lisa Kaltenegger: And he just a couple of lines as a guideline Mars earth Neptune Jupiter and you all know, somewhere between earth and Neptune is where we find most of the planets.

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00:03:33.570 --> 00:03:40.950

Lisa Kaltenegger: But if we turn this around and again Sam was incredibly kind to actually update all those images for me with the aero bars that we mail off.

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00:03:41.430 --> 00:03:51.420

Lisa Kaltenegger: So you have the mass and the radius now, and this is the irradiation the color coding is the irradiation how much Stella light hits the planet.

28

00:03:51.960 --> 00:04:10.680

Lisa Kaltenegger: And the question you're asking is, if you see patterns and again we have about 4000 objects so far that are transiting planets, but if you go down, where you want to have the math and the reviews you

get a little bit more sparse and how many planets We have, however, you kind of see groupings.

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00:04:10.740 --> 00:04:11.820

Lisa Kaltenegger: appearing again.

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00:04:11.970 --> 00:04:19.680

Lisa Kaltenegger: will probably want to have more planets, but the question that came up is whether or not they are to population of these extrasolar planets the big ones.

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00:04:19.980 --> 00:04:35.250

Lisa Kaltenegger: That are mostly hard because again bias in the observation anything as close with sorry, it is easier to find and then there's this really intriguing group of small planets, and so what I mean by that is, if you actually just assume it.

32

00:04:36.480 --> 00:04:47.610

Lisa Kaltenegger: And you have a look at mass versus radius and now we're in Arabia, so I already through all the giant planets out, you know so many nutrients are still in there, but now i'm concentrating.

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00:04:48.030 --> 00:04:53.490

Lisa Kaltenegger: On planet that could potentially be rocks and could potentially be habitats and we'll talk about that a little later.

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00:04:54.210 --> 00:05:06.000

Lisa Kaltenegger: So this is what we have so far, the and East and for Venus and earth and then, here are some guidelines of a mean them to be line, so this is 100% Iran.

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00:05:06.330 --> 00:05:12.510

Lisa Kaltenegger: This is the earth like composition in green here, and then you have 50% water here and 100% water here.

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00:05:12.990 --> 00:05:19.620

Lisa Kaltenegger: And the idea is that anything that is above this Turquoise or light blue line here hundred percent of water.

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00:05:19.950 --> 00:05:28.350

Lisa Kaltenegger: actually needs a lot of hydrogen to make for its radius for the certain math said, you have to get that radius you have to have gas.

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00:05:28.650 --> 00:05:39.660

Lisa Kaltenegger: So that line basically moves you anything above that probably also a little bit below that is actually a mini net or something with a lot of gas, and in my talk.

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00:05:40.080 --> 00:05:46.650

Lisa Kaltenegger: I will make the distinction of rocky worlds as rocks that outcasts their atmosphere, like the earth.

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00:05:47.580 --> 00:06:01.170

Lisa Kaltenegger: And then mini neptune's or gashes worlds, whatever you want to call it, as some that start with a big primordial hydrogen atmosphere that again will then make up this radio difference this big radius.

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00:06:02.160 --> 00:06:14.220

Lisa Kaltenegger: So when you look at this and I discussed this a little bit more in the review, you can eyeball it right, yes, you should do statistically in a lot of good people have done and statistically, and they they kind of get a they find really good.

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00:06:15.090 --> 00:06:29.130

Lisa Kaltenegger: answers that are still shifting but, if your eyeball it you see that roughly below to earth ready I we don't know off the planet we haven't found one yet where we actually know that it is.

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00:06:29.820 --> 00:06:38.940

Lisa Kaltenegger: eminent active that baby spice when you have a look at the mass there doesn't seem to be any mass limit like maybe around tourists masses.

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00:06:39.210 --> 00:06:49.350

Lisa Kaltenegger: below which we haven't found any kind of gashes small worlds so radius seems to be more helpful and that's really great because a lot of observation so transits where we get the radius.

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00:06:49.890 --> 00:07:04.050

Lisa Kaltenegger: So that discussion in the literature goes between the 1.6 and two or three the light and it's going back and forth, it depends on which models you're using it depends on what statistics, he means he is a patient approach and so on and so forth.

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00:07:05.160 --> 00:07:08.940

Lisa Kaltenegger: But in a lot of this is is this one data point here.

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00:07:10.290 --> 00:07:16.500

Lisa Kaltenegger: But below 1.6 arrows radio, we do not know of any planet that's definitely not a rock so far.

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00:07:17.340 --> 00:07:26.940

Lisa Kaltenegger: Below to earth radio should be safe it's somewhere between 1.9 and 1.6 if you go through the current literature Okay, so we want to have.

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00:07:27.720 --> 00:07:41.100

Lisa Kaltenegger: A planet that's most likely a rock so somewhere between two and 1.6% lower than radius then, what can we do Okay, so we look at these plans we've identified one.

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00:07:41.790 --> 00:07:47.640

Lisa Kaltenegger: Then the next concept, the next idea that we bring in here is actually a concept of what we call the habitable zone.

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00:07:48.210 --> 00:08:00.810

Lisa Kaltenegger: it's pretty badly need just to go with that because it doesn't mean that this is the cell phone where there can be habitable conditions it just means that this is the cell phone if you have a planet, like the earth.

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00:08:01.200 --> 00:08:15.180

Lisa Kaltenegger: Roughly its mass a rock that out gases and atmosphere, then actually with the certain luminosity from the star at the certain distance, you can get liquid water on the surface of the planet from all winner.

53

00:08:16.230 --> 00:08:21.570

Lisa Kaltenegger: If you get too close you start to evaporate all the water gets too hot too far away, it gets caught.

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00:08:22.680 --> 00:08:31.020

Lisa Kaltenegger: There will be some caveats I get it, so this is the simple enter, but basically this idea of a habitable sound is really a tool.

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00:08:31.650 --> 00:08:37.530

Lisa Kaltenegger: For mission proprietary ization of planet detection or planet analysis characterization.

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00:08:38.070 --> 00:08:48.870

Lisa Kaltenegger: Because, if you have liquid body of water on the surface, then, if there is life and it produces gas it's it should be able to go in the air easily.

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00:08:49.470 --> 00:08:55.770

Lisa Kaltenegger: And the only thing that we can access remotely because we can fly there is actually the atmosphere of another planet.

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00:08:56.250 --> 00:09:10.440

Lisa Kaltenegger: Maybe the surface, but that will be my target, so the atmosphere, the gases in the atmosphere is what we stuck with or what the amazing approach we have is to actually read or analyze the atmosphere of the gases off another planet.

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00:09:11.580 --> 00:09:12.060

Lisa Kaltenegger: And so.

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00:09:13.230 --> 00:09:20.520

Lisa Kaltenegger: How do you figure out what these habitable zone limit should be so you have to explore a parameter space.

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00:09:20.910 --> 00:09:26.970

Lisa Kaltenegger: And he was talking about, you can explore it and one T or into the model 3D models from a theoretical perspective.

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00:09:27.630 --> 00:09:37.110

Lisa Kaltenegger: And so, one of the most effective ways to actually lower white parameter space again there'll be some caveats is actually to us with one of the model.

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00:09:37.740 --> 00:09:47.790

Lisa Kaltenegger: And the way that we do it and there's several teams that I started to show below but, basically, the way that we do it, starting from castings work in the 70s.

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00:09:48.210 --> 00:10:05.280

Lisa Kaltenegger: is actually that we assume that you have a one view model What that means is that you have the surface of a planet and then you assume that the temperature is basically evenly distributed around back from can, and then you have different levels of height.

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00:10:06.420 --> 00:10:11.130

Lisa Kaltenegger: And usually we run this with about 50 levels of atmospheric layers.

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00:10:11.670 --> 00:10:21.360

Lisa Kaltenegger: And so what happens is and this actually be produces the earth's really well, the average temperature profile of the earth really well also works really great for Mars.

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00:10:21.780 --> 00:10:27.450

Lisa Kaltenegger: works pretty well for Venus for the part of buff that clubs so so far, you should be okay.

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00:10:27.990 --> 00:10:38.850

Lisa Kaltenegger: One of the things that it won't work for really well is, if you have, for example, a tightly locked planet we are one part of the planet gets incredible amount of heat and the other one does not.

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00:10:39.330 --> 00:10:48.930

Lisa Kaltenegger: Depending on how dense the atmosphere is if we can actually transport the heat to the other side or not, that again will change, whether or not you can make that assumption.

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00:10:49.410 --> 00:11:04.470

Lisa Kaltenegger: But let's take time to get locked planets aside for now or promise I get back to that and say okay so on average those planets that have not synchronously locked you should be able to analyze with one the model to explore arrived parameters.

71

00:11:05.670 --> 00:11:16.650

Lisa Kaltenegger: And with that you get some limits to the so called habit yourself, where do you start to evaporate all the water, so what you see here is the stellar temperature of the star.

72

00:11:17.040 --> 00:11:22.380

Lisa Kaltenegger: Of the holster and down here CC the effective stellar flux incident fox.

73

00:11:22.800 --> 00:11:32.220

Lisa Kaltenegger: And this is from my review, there are a couple of more planets now in it, but basically you see that we have about 3000 planets that are within this limits of the so.

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00:11:32.880 --> 00:11:42.270

Lisa Kaltenegger: called habitable so there's a dotted line here that is actually where our models would say it gets too hot.

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00:11:43.050 --> 00:11:52.140

Lisa Kaltenegger: But the problem is these models, whether it's one the or to a certain point in 3D actually don't have a good cloud feedback mechanism.

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00:11:52.530 --> 00:12:01.860

Lisa Kaltenegger: What I mean by that is a planet gets a lot hotter we do not know if the clouds give them a path here, what if they get your big change in height, how they change in height.

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00:12:02.310 --> 00:12:06.720

Lisa Kaltenegger: We can model it, whether or not gets the correct answer is another question.

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00:12:07.680 --> 00:12:15.540

Lisa Kaltenegger: So we have an idea of what these modeling limits are for where finance like the earth can keep liquid water, the surface.

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00:12:16.020 --> 00:12:37.290

Lisa Kaltenegger: And what we really are what I generally tend to use is actually an empirical model and the empirical model is based on an early Venus and an early Mars, the FLEX Mars receive when we know it didn't have any word on its on its surface anymore, and the FLEX Venus be safe.

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00:12:38.310 --> 00:12:48.030

Lisa Kaltenegger: There are a lot of uncertainty is there right because we don't understand the evolution of Venus very well, so it could well be that it last quarter.

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00:12:48.570 --> 00:12:58.380

Lisa Kaltenegger: Immediately after its after it was born, but those empirical limits get you out of the problem of modeling the space so.

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00:12:59.010 --> 00:13:07.590

Lisa Kaltenegger: let's say they're conservative limits that come from our one the model that says here all the atmosphere freeze out that's the outer edge.

83

00:13:07.950 --> 00:13:19.200

Lisa Kaltenegger: In here all the atmosphere will evaporate that's the Internet, but those are very conservative again because we don't have a good feedback of the clouds if you could put like a lot of clouds on the Internet.

84

00:13:19.680 --> 00:13:32.580

Lisa Kaltenegger: Then you can just push the planet inward inward inward because clouds reflect a lot so some caveats, but I think this empirical lemon based on Venus and young Venus and young earth that young Mars.

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00:13:33.450 --> 00:13:40.440

Lisa Kaltenegger: is basically a wide limit somewhere between the empirical and the conservative limit is probably where a planet looms half its water.

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00:13:40.980 --> 00:13:45.270

Lisa Kaltenegger: And it will depend on how the clouds behave and it will depend on the rotation right off the planet.

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00:13:45.930 --> 00:13:59.430

Lisa Kaltenegger: But let's just have a look at this, let me just go a little bit further intimate is classical habitable zone defined a long time ago, the standard papers, the 1993 by casting at all that started this so.

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00:14:00.000 --> 00:14:10.770

Lisa Kaltenegger: It really depends, because what the standard paper did is used and ensure it right, like the earth nitrogen CO2 and water atmosphere.

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00:14:11.670 --> 00:14:18.870

Lisa Kaltenegger: And so you can extend this limit outwards quite apt quite easily if you just add, for example, a lot of hydrogen minute.

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00:14:19.230 --> 00:14:25.290

Lisa Kaltenegger: That was a paper by your home burden guidance, but how do you keep that hydrogen there, how do you not just lose it.

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00:14:25.860 --> 00:14:31.620

Lisa Kaltenegger: So what we said about us then well if you have volcanism that produces that hydrogen, it will be sustainable.

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00:14:32.040 --> 00:14:43.260

Lisa Kaltenegger: And that you see that the habitable zone actually can move along but outward but kind of good news for direct imaging planets because the further away, you can make a house with one at from it'll start.

93

00:14:43.620 --> 00:14:51.090

Lisa Kaltenegger: The easier it will be to actually directly image it because the brightness of the whole star is one of the big problems but.

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00:14:52.140 --> 00:15:04.050

Lisa Kaltenegger: I just wanted to throw another idea in there and the hydrogen sustainable volcanic think early Mars, when we think there was a lot of localism probably for using a lot of hydrogen a reduced environment no oxygen yet.

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00:15:04.710 --> 00:15:12.450

Lisa Kaltenegger: But what about if you throw another greenhouse gas, and this is this discussion about early Mars that actually comes into exoplanets here.

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00:15:13.410 --> 00:15:25.110

Lisa Kaltenegger: If you put in methane, for example, that should also heat your atmosphere it actually does it depending on the SVP of your stock So if you have a hot star.

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00:15:25.980 --> 00:15:34.620

Lisa Kaltenegger: F G K, yes, it does extend your hands on some output, but if you have the coolest are like an end star it actually reverses.

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00:15:34.920 --> 00:15:45.330

Lisa Kaltenegger: It starts to heat the upper atmosphere, instead of the lower atmosphere, so it actually starts to truncate the habitable zone with for these.

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00:15:46.170 --> 00:15:58.950

Lisa Kaltenegger: em star planets so just to be careful, which greenhouse gas you throw in there, because not all greenhouse gases will do the same, because the spectral energy distribution of the star is key, so the.

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00:15:59.340 --> 00:16:06.120

Lisa Kaltenegger: The the interaction between light and the atmosphere is actually key to figure out what could make out a world.

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00:16:06.870 --> 00:16:18.690

Lisa Kaltenegger: And of course the SAP and the luminosity other star actually changes with each, and so this is one of the adventures that i've promised So what about a habitable world around an evolved start.

102

00:16:19.140 --> 00:16:24.630

Lisa Kaltenegger: Maybe a melted ice moon and melted ice worlds could there be science of life on those.

103

00:16:25.530 --> 00:16:38.160

Lisa Kaltenegger: And so, if you trace out the habitable sound through time you actually see that, because of the evolution of our star right you actually start to get in a couple of billion years ago to.

104

00:16:38.730 --> 00:16:53.220

Lisa Kaltenegger: To the returns of Jupiter and Saturn so you should be able to unfreeze that I see moms again, this is a day aggression, but just to think about that, of course, this is all part of time in the evolution of a star.

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00:16:53.970 --> 00:17:03.540

Lisa Kaltenegger: And so the second point that I wanted to mention is okay, we only have are still earth has to be a key to try to find life on other planets.

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00:17:04.110 --> 00:17:13.260

Lisa Kaltenegger: And so the idea here is to generate a spectral thing and print off a habitable world or habitable planet, this is what the focus of my research generally yes.

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00:17:13.770 --> 00:17:23.640

Lisa Kaltenegger: So first is the earth spectral unique, because if it's not if other planets that don't have life actually show that then it's not going to be helped.

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00:17:24.240 --> 00:17:34.680

Lisa Kaltenegger: So if we compare the earth spectrum, as the blue line to Venus and Mars here, and this is low resolution Okay, so you only see abundant chemicals in the atmosphere.

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00:17:35.010 --> 00:17:50.010

Lisa Kaltenegger: You see, that Venus and Mars so CO<sub>2</sub>, this is the infrared visible it looks a little bit different but earth actually shows water as well ozone and here's another method So yes, the earth spectra so far as unique.

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00:17:51.090 --> 00:17:58.260

Lisa Kaltenegger: And so what we did is we created a context, so we created a spectral catalog for reference spectra and albedo.

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00:17:58.650 --> 00:18:13.170

Lisa Kaltenegger: Of 17 objects, are the most diverse objects, we could come up with in our solar system, so if you want a spectral catalog or

comparison you can just get that down from the collagen and stood chrome now EDU slash data to us.

112

00:18:14.370 --> 00:18:27.150

Lisa Kaltenegger: And I was talking about time, so the earth, of course changed through time and I wanted to bring this in because this was the first paper, I wrote, like the first real paper, I wrote at this event, with West trout and can checks.

113

00:18:27.570 --> 00:18:33.810

Lisa Kaltenegger: And so, basically we thought about how the spectral thing and print off the world change through geological time.

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00:18:34.470 --> 00:18:44.550

Lisa Kaltenegger: And so, if you think about the world in a 24 hour clock then about bomb about 3.9 billion years ago as the original live 3am in the morning.

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00:18:44.880 --> 00:18:52.200

Lisa Kaltenegger: But only about lunchtime 2.3 2.5 billion, years ago, you have acted oxygen building up in the atmosphere.

116

00:18:52.800 --> 00:19:05.190

Lisa Kaltenegger: that's, of course, of a different kind of fun and so, if you go back and forth, you have also different kind of life that that enables or whichever hypothesis, if you go with the life that also changes the planet.

117

00:19:06.420 --> 00:19:14.970

Lisa Kaltenegger: And so, all of this, you can see in the spectral fingerprint and what i'm showing you here is from a very recent paper, this is the transit.

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00:19:15.450 --> 00:19:26.460

Lisa Kaltenegger: spectra other moderators of earth about 0.8 billion years ago and a prebiotic and so you see some changes, especially the awesome feature here.

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00:19:27.450 --> 00:19:36.570

Lisa Kaltenegger: And so what we're trying to figure out if we can use our earth's as a template to identify a whether or not there are signs of life from another planet.

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00:19:37.230 --> 00:19:43.740

Lisa Kaltenegger: What evolutionary status and because it's, not to say that everything evolves at the same time, but at the same time scale.

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00:19:44.310 --> 00:19:50.970

Lisa Kaltenegger: and also to kind of identify which features, you should be looking for could be looking for in the search.

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00:19:51.600 --> 00:19:59.850

Lisa Kaltenegger: And of course there's the visible there's the near infrared infrared so each of these wavelengths actually show you differences in.

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00:20:00.750 --> 00:20:13.650

Lisa Kaltenegger: The spectral fingerprint, and this is all during a transit, we also have it for a direct imaged planet, but this is what we generally going to do with James webb space telescope and then, when the elt comes in line to.

124

00:20:14.430 --> 00:20:27.420

Lisa Kaltenegger: So the opportunity here is the small stars and so, while the small stars have a view possible high UV activity that's one of the big problems that contrast ratio is amazing.

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00:20:27.960 --> 00:20:40.110

Lisa Kaltenegger: The contrast ratio helps us find these talents and also characterize the atmosphere and we look into whether or not it's really that bad in terms of UV radiation on a planet orbiting such a star.

126

00:20:41.070 --> 00:20:48.150

Lisa Kaltenegger: And so what we found is actually yes it's really bad compared compared to current earth that has an ozone layer.

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00:20:48.870 --> 00:20:56.430

Lisa Kaltenegger: But it's actually not that bad compared to a younger as the didn't have an ozone layer and that's also had a lot of UV radiation on the ground.

128

00:20:56.850 --> 00:21:07.920

Lisa Kaltenegger: And there's some amazing work by Timothy SAS love and others that actually show that probably for the evolution of life to get started, you want a certain amount of UV radiation to actually make.

129

00:21:09.420 --> 00:21:19.410

Lisa Kaltenegger: That chemical reactions, more efficient and so this opportunity, of course, resulted in the launch of the amazing testament in in 2018.

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00:21:19.860 --> 00:21:32.760

Lisa Kaltenegger: And here, you see happy science TEAM members who were really excited that this thing didn't explode so So my first launch ever, but it was super exciting and especially our small mission that can has.

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00:21:33.750 --> 00:21:39.900

Lisa Kaltenegger: More than 1000 times better candidates right now we had like about 50 confirm planets what was the goal of the test mission.

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00:21:40.380 --> 00:21:49.230

Lisa Kaltenegger: And if you look at the data just from the primary mission of the first two years we've actually observed tests has actually observed about 40,000 stars.

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00:21:49.530 --> 00:21:58.020

Lisa Kaltenegger: long enough, that it should be able to find planets in an earth analog orbit what I mean by that is getting the same irradiation.

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00:21:58.410 --> 00:22:06.810

Lisa Kaltenegger: And it has observed a couple of hundred stars, so that you should be able to find planets and see plants throughout the whole habit so.

135

00:22:07.440 --> 00:22:15.420

Lisa Kaltenegger: So that's another paper that just came out of the revised test have a sound catalog for free to ask me all of us online to have your questions.

136

00:22:16.350 --> 00:22:24.930

Lisa Kaltenegger: until the last adventure and in my last one minute or two is actually what about if we go with this time even further.

137

00:22:25.890 --> 00:22:36.810

Lisa Kaltenegger: I talked about the giants and maybe there's like melted ice worlds, but what tests gave us what's really interesting Is it actually found the first planet around the whiteboard.

138

00:22:37.680 --> 00:22:45.570

Lisa Kaltenegger: And that is a big giant planet, so we have no idea really how it got there there's a lot of good ideas that have maybe was birthed out first.

139

00:22:45.930 --> 00:22:52.950

Lisa Kaltenegger: And then started to actually come closer to him, but if there's a giant planet, it should be much easier that.

140

00:22:53.490 --> 00:23:01.740

Lisa Kaltenegger: theory to actually survive a habitable rocky planet around such a whiteboard we haven't found one yet, but I promise test is looking.

141

00:23:02.190 --> 00:23:13.470

Lisa Kaltenegger: And so, this would be an amazing opportunity, because when m starts help us a lot right because of the contrast ratio because they're not as big competitors like planets.

142

00:23:13.980 --> 00:23:20.160

Lisa Kaltenegger: Are white dwarf is a moving signal, because a whiteboard is roughly the same size as yours, a little bit bigger.

143

00:23:20.700 --> 00:23:31.080

Lisa Kaltenegger: what's really interesting is that if you do the spectrum of a white dwarf planet like this is potentially like a planet, like the earth, if you put it in the habitable zone of a whiteboard.

144

00:23:31.530 --> 00:23:35.280

Lisa Kaltenegger: And there was lots of people who worked on this, I thought about this before like Eric eagle.

145

00:23:35.640 --> 00:23:43.320

Lisa Kaltenegger: And abby and we have worked on, but the atmosphere really would be like because my wife is very different in terms of scd.

146

00:23:43.740 --> 00:23:55.650

Lisa Kaltenegger: than some like Sir, but there are signatures that he could look for and it is quite interesting these do not take into account that actually you only going to see part of the.

147

00:23:56.070 --> 00:24:01.020

Lisa Kaltenegger: White dwarf being pelted all the time right because it's pretty cool it's so small that you have to.

148

00:24:01.410 --> 00:24:11.250

Lisa Kaltenegger: change your transit code your geometry, because you cannot just assume that it will be always eliminated the same time, so that's an adventure and, of course.

149

00:24:11.580 --> 00:24:21.780

Lisa Kaltenegger: it's really interesting is what would that tell us about the tenacity of life if we found live in atmosphere and white dwarf planet, you know whether it's second genesis first genesis.

150

00:24:22.170 --> 00:24:32.430

Lisa Kaltenegger: We might just be a wasteland who knows, but the interesting thing is that the signal to noise should be there for us to figure out what the composition of such planets are.

151

00:24:33.510 --> 00:24:45.210

Lisa Kaltenegger: So with that, I just wanted to give you this is the people who helped me do this as a part of my team and, as a fan Lynn just moved to MIT so you're going to see him more often because he's now at MIT.

152

00:24:45.810 --> 00:24:59.010

Lisa Kaltenegger: And I think i'm all about 26 minutes i'm just a really going to say that avenues to introduce me, and so I asked my conclusion is in a search for the words we have an incredible diversity of worlds.

153

00:24:59.460 --> 00:25:11.070

Lisa Kaltenegger: The challenge is trying to identify the could potentially be habitats and again I need to remote detectable habitable signals so i'm looking for rocky worlds.

154

00:25:11.460 --> 00:25:19.410

Lisa Kaltenegger: At a certain distance for dinner completely frozen over, and then they haven't lost all the water because subsurface life is exciting.

155

00:25:19.800 --> 00:25:28.410

Lisa Kaltenegger: But not easy to find if you can go there and dig a hole or drill the hole in the ice right, so I have a very specific parameter that i'm looking for.

156

00:25:29.070 --> 00:25:39.990

Lisa Kaltenegger: So gino see an emt, of course, including the GMT here are our first chance to find signs of life it's gonna be extremely tough the signal to noise is going to be hot.

157

00:25:40.920 --> 00:25:51.960

Lisa Kaltenegger: versus okay diverse biota and you have to think of it through geological time it's not much, but it's way better than just thinking of the earth right now trying to find life okay.

158

00:25:52.680 --> 00:25:58.440

Lisa Kaltenegger: And then there are lots of ideas, like, for example, what life could do really hardest up environments.

159

00:25:58.980 --> 00:26:07.860

Lisa Kaltenegger: What about really young or really evolved host and then I just put your idea here because I hope that's how we gonna launch into our questions.

160

00:26:08.160 --> 00:26:15.150

Lisa Kaltenegger: But if you are interested, or at the end of survey and you want the spectral database or models so you can take the Ad how to retrieve does.

161

00:26:15.570 --> 00:26:25.110

Lisa Kaltenegger: At the Carl Sagan institute cornell.edu slash data we have the spectral data basis with different kinds of worlds around different stars around whiteboards.

162

00:26:25.590 --> 00:26:33.810

Lisa Kaltenegger: Around whatever you want kind of we're building it up in a resolution of about 100,000 and move on, so you can work on the GMT he takes.

163

00:26:34.380 --> 00:26:45.900

Lisa Kaltenegger: And you can work on GMT with that, and if you don't find something that you want to send me an email that's my address, and then you can also follow the call second Institute on Twitter, we have actually quite good Twitter.

164

00:26:46.410 --> 00:26:52.350

Lisa Kaltenegger: team trying to find out interesting things like that, and I think was that again.

165

00:27:02.280 --> 00:27:03.420

Evan Bauer: All right, yeah Thank you Lisa.

166

00:27:04.950 --> 00:27:13.980

Evan Bauer: just remind everyone again go ahead and send me your questions, as this discussion goes on, I think we're going to start with a question from Morgan so go ahead, Morgan.

167

00:27:15.150 --> 00:27:28.890

Morgan Elowe MacLeod: yeah so I mean this is amazing, and I loved thinking through as you were talking what am I mean to like think of scenarios that aren't necessarily more common, but are higher signal.

168

00:27:29.430 --> 00:27:43.800

Morgan Elowe MacLeod: If that makes sense, like the white dwarf case and so many a little bit more about the white dwarf case where there's a lot of potentially a lot of higher energy radiation coming in.

169

00:27:45.000 --> 00:27:50.910

Morgan Elowe MacLeod: In some cases, we might expect that to be kind of like boiling off the atmosphere or leading to some of separation.

170

00:27:51.270 --> 00:28:03.090

Morgan Elowe MacLeod: Is there ever a situation that you can imagine, where some of those bio signatures could survive that outflow and if they're like out flowing then do we get a bigger covering fraction or you know what I mean so.

171

00:28:03.180 --> 00:28:05.160

Lisa Kaltenegger: it's okay yeah absolutely so.

172

00:28:05.460 --> 00:28:08.490

Morgan Elowe MacLeod: I thought, maybe you could talk a little bit about all of that.

173

00:28:09.390 --> 00:28:17.190

Lisa Kaltenegger: Absolutely so once the founder and prevented Berg is the first author of our discovery paper for for that plan.

174

00:28:18.390 --> 00:28:26.220

Lisa Kaltenegger: That it's a giant planet was the surprise, because if it's a giant planet and it would have it there's no way, you can have stayed there.

175

00:28:26.700 --> 00:28:26.880

Morgan Elowe MacLeod: For a.

176

00:28:26.910 --> 00:28:32.850

Lisa Kaltenegger: While this thing exploded right there's just no way, so what that means is, it has to come from somewhere.

177

00:28:33.570 --> 00:28:41.100

Lisa Kaltenegger: it's also really hard to just catch jag and planet that flies by right if we go with that scenario, but that's not gonna work either it's not a rough but it's not a rogue planet.

178

00:28:41.670 --> 00:28:51.240

Lisa Kaltenegger: So now they've really interesting work, you know by by the several formation teams that is just in them this planet was out further first.

179

00:28:51.570 --> 00:29:02.850

Lisa Kaltenegger: survive the explosion and then the interaction of explosion, with the planet made and migrating words and the good thing the support to your question is the good thing is that that takes time.

180

00:29:03.630 --> 00:29:14.610

Lisa Kaltenegger: And so, if you put this together, you have really hot white dwarf initially but at that point, the planet is still far out because it hasn't started to move in substantially yet.

181

00:29:15.060 --> 00:29:28.200

Lisa Kaltenegger: So they think it will take about I can't remember what the latest says, but it will take the time until the white dwarf cools down to about 7000 kelvin maybe 6000 Calvin.

182

00:29:29.550 --> 00:29:38.460

Lisa Kaltenegger: To start migrating in and again this is where we probably want to start into the whole problem of migration 123 right and whether that applies to white dwarfs in the first place.

183

00:29:39.540 --> 00:29:42.420

Lisa Kaltenegger: But if there's really this buffer zone.

184

00:29:43.530 --> 00:29:45.450

Lisa Kaltenegger: That means that the planet comes in later.

185

00:29:46.530 --> 00:29:54.960

Lisa Kaltenegger: And the other ideas also So if you have a small planet, then, even if it is, is also moving in right, it could actually lose part of a dogma sphere.

186

00:29:55.500 --> 00:30:04.770

Lisa Kaltenegger: To kind of drag it's kind of it's not completely clear why goes in it could get a bombardment a secondary heavy bombardment from stuff that was left over on the outside.

187

00:30:05.520 --> 00:30:15.750

Lisa Kaltenegger: And so, this question of how that planet can be there is huge, because nobody really expected a giant planet of all cases they're like maybe.

188

00:30:15.960 --> 00:30:26.370

Lisa Kaltenegger: You know from the pulsar planets maybe people are thinking well, maybe not white words which you could still have some rocks going back and forth, but to have like a bona fide big giant planet is.

189

00:30:27.630 --> 00:30:33.450

Lisa Kaltenegger: was not in the current era, and so the interesting thing is, then, as you were saying.

190

00:30:33.930 --> 00:30:45.510

Lisa Kaltenegger: The second part, I think, if you have operate a planet like seriously if the planet where there are rocky planet and the white dwarf with the star would explode somehow the final survive.

191

00:30:45.870 --> 00:30:55.800

Lisa Kaltenegger: But it would get baked with radiation of you know 10,009 thousand Calvin opted, so I think that will be detrimental to life.

192

00:30:56.670 --> 00:31:08.790

Lisa Kaltenegger: While i'm saying that is that there is life at about a kilometer or more below the surface of the earth, so you could argue that maybe that kind of life would actually be able to either go dormant.

193

00:31:10.170 --> 00:31:21.420

Lisa Kaltenegger: or not care so much it really depends on how far you get down, and if you start to melt it takes to stare at the planet, you really have to build the whole thing kind of down to a couple of kilometers.

194

00:31:22.080 --> 00:31:32.340

Lisa Kaltenegger: So tenacity of life, yes, potentially, but the good thing is because we have a giant planet there that tells you that it has to come in, like.

195

00:31:32.880 --> 00:31:45.840

Lisa Kaltenegger: This planet, and so it has to come and leave the now interesting question, what about an icy world out there, make it a moon make it a rocky planet right and it's melting on its way.

196

00:31:46.530 --> 00:31:54.090

Lisa Kaltenegger: into like a water world, making it into whatever you want, you know, maybe, and this is like complete speculation right so maybe.

197

00:31:54.870 --> 00:32:10.200

Lisa Kaltenegger: You have life that develops in the subsurface frozen ocean, and then it gets uncovered when he gets smelt multiple right so that's the whole idea with the red giant phase two you don't have to start life during that time, you can just uncover it and so.

198

00:32:11.310 --> 00:32:20.790

Lisa Kaltenegger: I don't think there's something like a comment kind of like tail when you basically evaporate the whole thing, and so you would have a big surface I don't think that's going to happen.

199

00:32:20.820 --> 00:32:21.570

Morgan Elowe MacLeod: But interesting.

200

00:32:21.870 --> 00:32:24.390

Lisa Kaltenegger: We have a good chance of this being late.

201

00:32:25.440 --> 00:32:25.920

Morgan Elowe MacLeod: Raising.

202

00:32:27.210 --> 00:32:30.150

Evan Bauer: It looks like Gary had a comment related to this.

203

00:32:30.240 --> 00:32:32.400

Gary Melnick: right here yeah can you hear me.

204

00:32:33.060 --> 00:32:33.690

Evan Bauer: Yes, we got.

205

00:32:34.410 --> 00:32:41.550

Gary Melnick: Lisa you touched on what I was going to comment on, and that is that I think one has to think.

206

00:32:43.350 --> 00:32:54.720

Gary Melnick: beyond just the environment induced by the white dwarf and consider the environment in which this putative planet will have had to have existed.

207

00:32:55.050 --> 00:33:05.130

Gary Melnick: During the red giant phase when of course any any planet within sort of the orbit of Jupiter is subject to being engulfed by the star.

208

00:33:05.670 --> 00:33:17.070

Gary Melnick: But not only that those planets beyond jupiter's orbit will be subject to 10,000 times the luminosity of the sun for a.

209

00:33:17.940 --> 00:33:33.360

Gary Melnick: reasonable period of time, so your initial conditions have to start before the white dwarf phase and consider the effects on the planet, during the red giant phase, which you mentioned briefly a moment ago.

210

00:33:33.960 --> 00:33:40.770

Lisa Kaltenegger: And I completely completely agree with you, this is why i'm kind of i'm trying to sneakily bring in the time component in.

211

00:33:40.800 --> 00:33:45.540

Lisa Kaltenegger: All of this kind of work right, because that is something that will shape the environment.

212

00:33:46.110 --> 00:33:58.440

Lisa Kaltenegger: And so here, for example, when we were thinking about the evolution of the habit of the sound through the red giant face this is just a picture for our own earth right for the sun, because honestly for me stars is not half as bad because.

213

00:33:59.490 --> 00:34:14.250

Lisa Kaltenegger: We go through this through this pulses, so if you think about that you see how a planet would get warm right just for a very short amount of time here and then get cooler against outside the habit of Solomon and again.

214

00:34:15.360 --> 00:34:23.880

Lisa Kaltenegger: And if you forward this even more, let me just derail this thing, what about him start fun.

215

00:34:24.720 --> 00:34:39.780

Lisa Kaltenegger: Because an end star this another paper for 2014 actually if you put a planet at the distance was done in the habitable zone on earth's analog distance or as equivalent distance, then in the protostar face.

216

00:34:40.440 --> 00:34:48.090

Lisa Kaltenegger: He gets a lot of heat from this young answer and we've progressed our phase is actually quite long so.

217

00:34:48.600 --> 00:34:57.000

Lisa Kaltenegger: it's funny that for an answer applying it further out can actually be in that pre main sequence house on for 2 billion years.

218

00:34:57.270 --> 00:35:02.160

Lisa Kaltenegger: Before the star actually hits them in sequence, and then it's too far out there will be iced over.

219

00:35:02.550 --> 00:35:10.110

Lisa Kaltenegger: So you could imagine that the positive spin on this is, if you could imagine that life actually starts on a planet in this pre means day sequence.

220

00:35:10.500 --> 00:35:22.680

Lisa Kaltenegger: And then it gets is over, and then, when it gets red giant face it gets frozen again, you know this is again it's very much science fiction, but the evolution is key.

221

00:35:23.640 --> 00:35:32.910

Lisa Kaltenegger: And so there were a couple of papers that it actually then very much worried about em stars being capable of hosting habitable planet from the first place, because of the loss of water.

222

00:35:33.510 --> 00:35:46.860

Lisa Kaltenegger: Initially, because we get so hot, of course, there you completely ignore the deck of the heavy bombardment right, so the water delivery could be any time later and there's a recent paper really interesting, I think, by Mickey Cohen, and somebody in his team.

223

00:35:48.330 --> 00:35:57.870

Lisa Kaltenegger: Know dorian abbott that basically showed that you can lock lock the water in the box, for a long time in such a scenario so water.

224

00:35:58.680 --> 00:36:04.680

Lisa Kaltenegger: and ocean up to five or 10 times and ocean on earth can actually get locked in your trust and so during.

225

00:36:05.190 --> 00:36:14.730

Lisa Kaltenegger: A face like a premium sequence Phase four stars where it gets so hot you could actually keep that water that's locked in the rocks and when it gets cool it can come out again.

226

00:36:15.060 --> 00:36:26.340

Lisa Kaltenegger: So these are really new idea is that a geological geology community has to think through how this really could work but there seems to be a lot of options to keep the water so.

227

00:36:27.330 --> 00:36:36.750

Lisa Kaltenegger: Not for things in the inner part of the solar system when the sun becomes a red diamond, because that will get in gold Thomas, what are you going to keep doesn't matter because you're going to be part of the sun.

228

00:36:37.230 --> 00:36:51.330

Lisa Kaltenegger: But for other places that get thousand times 10,000 pounds the radiation just temporarily and also last point of this, it takes a while to lose all your water, yes, you lose it to space.

229

00:36:52.140 --> 00:37:04.920

Lisa Kaltenegger: But you have to transport that water to the upper part of the atmosphere where it gets photo lights and then can use the hydrogen space, so if it's just a temporary face it will take a little time, can I depends on the model which.

230

00:37:05.940 --> 00:37:09.150

Lisa Kaltenegger: Until you lose all the water even until you lose all the surface water.

231

00:37:10.140 --> 00:37:15.750

Lisa Kaltenegger: And another thing that I didn't mention that's pretty cool about the white dwarf planets shift because we had talked about them before.

232

00:37:16.200 --> 00:37:24.090

Lisa Kaltenegger: Is that the White dwarf planets actually want climate change as much as humanly possible, because the old style will actually cool.

233

00:37:24.660 --> 00:37:31.920

Lisa Kaltenegeger: So people on my fourth planet if there were an extra civilization would try to pollute the atmosphere as humanly possible see have to.

234

00:37:32.310 --> 00:37:44.640

Lisa Kaltenegeger: They were actually tried to get more green house warming and so it's kind of interesting also to think time buys in the reversal of when you start actually coops instead of when it becomes more dominant time.

235

00:37:46.020 --> 00:37:50.550

Evan Bauer: I actually have a question related to this it's been really interesting to hear you.

236

00:37:51.150 --> 00:38:01.410

Evan Bauer: Talk about all these different phases, that are not really static from the stars perspective right the red giant phase, the premium sequence is the white dwarf, maybe a little bit slower, but all these phases, where the star is evolving.

237

00:38:01.800 --> 00:38:18.180

Evan Bauer: relatively quickly and i'm wondering if you have thoughts on what those timescales would tell us about life if we discovered in those environments or or, if you think you know some some environments might have evolution that's too fast for for life, to really get going.

238

00:38:18.870 --> 00:38:21.690

Lisa Kaltenegeger: I think one of the things, thank you for the question that I wanted to.

239

00:38:21.690 --> 00:38:29.730

Lisa Kaltenegeger: point out this i've shown you a lot of kind of weird or extreme cases, but as always in science, the extreme cases is when you learn the most.

240

00:38:30.090 --> 00:38:39.630

Lisa Kaltenegeger: If you just if they get 10% more or less wet there's not many surprises in there, but when you go to a very extreme case and try to think through how plan of react, or what.

241

00:38:39.900 --> 00:38:46.980

Lisa Kaltenegeger: How the environment would practice, I think this is where you learn what physics you don't understand what you have to put in your mouth and sell better new months.

242

00:38:47.430 --> 00:38:56.220

Lisa Kaltenegeger: And so, your point is is very interesting one, that we do not know how long it took for life to evolve on the earth right, we know that it was there about 3.5.

243

00:38:56.580 --> 00:39:09.720

Lisa Kaltenegeger: Years ago that's where everybody agrees on, so the common number is about 750 million years and the geology community that that's how long it takes for life, like in the years to get started.

244

00:39:11.010 --> 00:39:24.120

Lisa Kaltenegeger: We have any big problem there because it actually coincides the first signals of life that we have in the rock records coincide with delayed heavy bombardment, so there is the ultimate that keeps going up and down is that the LIFE actually started much, much faster.

245

00:39:25.140 --> 00:39:33.540

Lisa Kaltenegeger: And so, if you go with that, and if you go to 750 million years, then I can come up with what timeframe do need for life to get started.

246

00:39:34.140 --> 00:39:49.740

Lisa Kaltenegeger: And if you go with less that you have more phases, where it can be, however, I think one of the other things that we really don't know, and so the origins of life initiative at Harvard has fantastic work on trying to figure out how life could get started, but.

247

00:39:50.790 --> 00:39:56.700

Lisa Kaltenegeger: We do not know, and this is one of the key points about the evolution of life is did life get started.

248

00:39:57.090 --> 00:40:05.250

Lisa Kaltenegeger: It just needs to get started in 1.11 place on the bottom of the ocean right, and then it can just inhabit the whole planet.

249

00:40:05.850 --> 00:40:17.430

Lisa Kaltenegeger: So if it can be somewhere on the bottom of the ocean and the black smoke or and doesn't need to be I respected me to be interviewing the surface, but maybe it doesn't, then you have basically.

250

00:40:18.540 --> 00:40:27.090

Lisa Kaltenegeger: change the whole playing field, because now, you can ice over the planet, you can put it wherever you want to maybe put as much radiation on it, you can put your robot and salad is you know.

251

00:40:28.290 --> 00:40:40.260

Lisa Kaltenegger: can start on ice sheets that swim on top of water that's another idea for the evolution of birth and so your question about how long you know you want that face to be.

252

00:40:41.340 --> 00:40:53.460

Lisa Kaltenegger: Also, is really nicely and linked to the star, because if you go for an n started that the earth didn't have the problem about what depletion because the pre main sequence space for the sun is so much faster.

253

00:40:54.360 --> 00:41:07.620

Lisa Kaltenegger: When n starts be long and so forth, and start also the red giant phase, a going to be forever and the main sequence face of course forever, but the red giant faces they creeping along happily.

254

00:41:08.850 --> 00:41:22.050

Lisa Kaltenegger: And there's nothing you and then it's just going to call out, so the white the white fourth phase, should also be okay, except that it's getting colder and colder, and so we know so little about life.

255

00:41:23.610 --> 00:41:30.660

Lisa Kaltenegger: That, I think, if you just consider subsurface environments as a viable option for the emergence of life.

256

00:41:31.410 --> 00:41:44.400

Lisa Kaltenegger: That most places, whatever the radiation on the surface, would be could be habitats, as long as you don't want the LIFE to them be on the surface and again there's the problem about remote tech ability.

257

00:41:44.700 --> 00:41:54.120

Lisa Kaltenegger: Does it's not on the surface, if you're telling them nice layer and then Ocean and the gases don't come out there's no way I can see it remotely if I can't go there and drill a hole through yes.

258

00:41:55.650 --> 00:41:59.820

Lisa Kaltenegger: So, all this is bundled into we want to be able to actually spot it.

259

00:42:01.530 --> 00:42:02.040

Lisa Kaltenegger: remotely.

260

00:42:04.770 --> 00:42:08.580

Evan Bauer: Okay, I think next on a has a question about my doors.

261

00:42:10.560 --> 00:42:14.490

Ana Bonaca: Thank you for this wonderful time that says very thought provoking indeed.

262

00:42:15.600 --> 00:42:17.880

Ana Bonaca: and able to tailor the law but.

263

00:42:19.020 --> 00:42:22.380

Ana Bonaca: My question as as we've kind of a lot about.

264

00:42:24.870 --> 00:42:32.580

Ana Bonaca: kind of the the evolution of technical ability and life through the life of the star.

265

00:42:33.660 --> 00:42:46.140

Ana Bonaca: So I guess my original question was kind of how is the the white dwarf search progressing and if you're able to target which tests white horse of different ages and if you expect that to theoretically.

266

00:42:47.790 --> 00:42:56.970

Ana Bonaca: kind of give you some clues as to what the kind of population of planets would be in such systems and whether you can get some clues.

267

00:42:57.810 --> 00:43:12.540

Ana Bonaca: Regarding life, based on that, but I think more generally, it also holds I was struck by this number of the 600 habitable zones discovered are tracked in test and.

268

00:43:12.870 --> 00:43:13.440

Lisa Kaltenegger: discovered.

269

00:43:13.890 --> 00:43:14.910

Lisa Kaltenegger: Just before we.

270

00:43:15.480 --> 00:43:16.170

Lisa Kaltenegger: Look at.

271

00:43:16.800 --> 00:43:19.410

Lisa Kaltenegger: Look at stars long enough that we should find those plans.

272

00:43:21.090 --> 00:43:30.810

Lisa Kaltenegger: Because of the orbital different sorry, thank you very much for bringing this back up, because this is one of the going fast so it's just the amazing thing is that we actually have enough data in the.

273

00:43:31.560 --> 00:43:45.690

Lisa Kaltenegger: Question what's what's great right to have found or to have seen a planet in transit three times around 614 stars out to the equivalent orbit of Mars.

274

00:43:46.290 --> 00:43:57.900

Lisa Kaltenegger: Now the signal to noise is another question, then, there are some gaps in the test event that's another question, but these are our best targets for follow up so Basically, this is what.

275

00:43:58.290 --> 00:44:09.030

Lisa Kaltenegger: Our team, it is now really looking at trying to find those times sorry so but thank you for clarifying, so this is my shows that we've 46 confirm finance and thousand 800 to us but.

276

00:44:09.480 --> 00:44:21.930

Lisa Kaltenegger: A couple of them are actually already in that so called habitable zone so we're very excited and creek which which which answer to one yes for test we looking at all white boards, that we can and for.

277

00:44:22.080 --> 00:44:30.330

Lisa Kaltenegger: me is that sorry oh actually there is quite a so sorry yes there's actually quite a bit there's like within I think 40 parsecs there about 100.

278

00:44:30.780 --> 00:44:45.690

Lisa Kaltenegger: You know I might be a little bit off, but there's there's quite a few, and so the one that I showed you that Andrew actually found that the child on and on, with put the test team is about 25 parsecs away so it's not great, he was a much better once.

279

00:44:47.910 --> 00:44:52.230

Lisa Kaltenegger: We basically looking at all of them in that 22nd cadence that that test.

280

00:44:52.230 --> 00:44:59.700

Lisa Kaltenegger: Now, has will help a lot, because a habitable planet or sign in the habitable zone around the whiteboard has about a two minute transit.

281

00:45:00.360 --> 00:45:06.390

Lisa Kaltenegger: mm hmm because you know this thing is not very limited, so this is there's also ground based searches right and then.

282

00:45:07.590 --> 00:45:16.440

Lisa Kaltenegger: I think now because I n during the testing have found this this giant planet now, I think this is all like easier to get time again and trying to find it.

283

00:45:16.860 --> 00:45:17.730

Lisa Kaltenegger: And so, in.

284

00:45:17.760 --> 00:45:22.800

Lisa Kaltenegger: Your point, yes, we definitely want to get like a population, if at all possible, because.

285

00:45:23.280 --> 00:45:30.450

Lisa Kaltenegger: Even with hubble you can actually be the atmosphere of these things right, this is either not even but cannot even this or have legitimacy.

286

00:45:30.870 --> 00:45:43.380

Lisa Kaltenegger: We can do that, and one of the things that's really interesting but I didn't know before I did this work is that you can't get the math through our week for White for fun because they're just no lines.

287

00:45:44.520 --> 00:45:44.940

Lisa Kaltenegger: it's.

288

00:45:44.970 --> 00:45:56.940

Lisa Kaltenegger: Right, so the mass you actually have to get differently, and they did it with spits out for the giant planet and what they did is they basically said okay if we would have been more natural than this, we would have seen ever spitzer.

289

00:45:58.290 --> 00:46:03.030

Lisa Kaltenegger: would have actually had enough radiation participants fits and now we're spits out of the way.

290

00:46:03.360 --> 00:46:10.050

Lisa Kaltenegger: We are just hoping that there's going to be planetary systems okay basically if I said forensic type of variation.

291

00:46:10.320 --> 00:46:17.370

Lisa Kaltenegger: To get that you know, there are other ways to bed and polluted by tours is probably going to be better but that's a really interesting other.

292

00:46:17.820 --> 00:46:28.500

Lisa Kaltenegger: aspect of the search bar planet around fight towards that I hadn't appreciated before because we're like so, then you did rv enter was like Have you ever seen the spectrum for like okay.

293

00:46:31.320 --> 00:46:31.860

Lisa Kaltenegger: interesting.

294

00:46:33.210 --> 00:46:44.490

Lisa Kaltenegger: But again what I really like in this hour what I think is really important is this into this scenario, it because you know as an astronomy astronomers we understand the stories and their environments and their.

295

00:46:44.490 --> 00:46:51.960

Lisa Kaltenegger: solution, and then you know modeling tenants has to come in they're modeling life and how to react to different kinds of radiation on late.

296

00:46:52.410 --> 00:47:12.420

Lisa Kaltenegger: You know this, this whole set of adventures that I didn't talk to you about because I was running out of time running out of time, like on very, very deliberate and i'm putting in the life on earth is completely different and changed through time, and so this is just one one it's like.

297

00:47:12.840 --> 00:47:14.790

Lisa Kaltenegger: When my brother likes things like the targets.

298

00:47:14.850 --> 00:47:24.450

Lisa Kaltenegger: survive pretty much everything, how do you find the target group well tardy brexit back to fun, but there's a lot of life that's extremely colorful and extreme environment.

299

00:47:25.200 --> 00:47:32.760

Lisa Kaltenegger: So then, when you can do so, we have a database or sorry the database for these kind of different lives from extreme environments.

300

00:47:33.090 --> 00:47:41.010

Lisa Kaltenegeger: Then you get this kind of colorful planets you know whether you get done as a question, but if one of these life forms would be dominant.

301

00:47:41.580 --> 00:47:49.560

Lisa Kaltenegeger: And you walk through yellowstone you have all these different colors you know if you had a plan and they were just a little bit different I think one of the key things is also to think about.

302

00:47:49.920 --> 00:47:58.290

Lisa Kaltenegeger: That doesn't have to be green trees doesn't have to be green grass, you know and um but we already have a wide variety.

303

00:47:59.280 --> 00:48:07.950

Lisa Kaltenegeger: of other kinds of life that we know that we just usually don't think about, and so this color database for circular graphic typically a color catalog of life.

304

00:48:08.400 --> 00:48:20.460

Lisa Kaltenegeger: I think is helping us break out of this other mode that we have that we think about life very specifically by looking around us and seeing only very specific kinds of so.

305

00:48:22.050 --> 00:48:24.060

Lisa Kaltenegeger: it's gonna be interesting yeah.

306

00:48:24.660 --> 00:48:44.610

Ana Bonaca: For sure, and so kind of tied back to through the how we started like down this path of kind of our population or how many do you think we would need like it is interesting occurrences through to be able to kind of convince ourselves that we actually have detected life.

307

00:48:46.110 --> 00:48:51.150

Lisa Kaltenegeger: So you pointing out something very, very tricky right, because I think it's really, really good.

308

00:48:51.630 --> 00:49:04.620

Lisa Kaltenegeger: Extraordinary discoveries extra ordinary evidence right yeah so when we looking at these atmospheres, and I didn't get into much detail, but the combination of oxygen for ozone with will reduce and gas like methane.

309

00:49:05.040 --> 00:49:15.420

Lisa Kaltenegger: Is our golden fingerprint for life in the atmosphere so far and what that means is test, if you have oxygen and met them, they have the act of a couple of reaction to CO2 and water.

310

00:49:16.290 --> 00:49:26.280

Lisa Kaltenegger: And so the key point in that is if he see together at the same time, the atmosphere for planet that tells you something has to cram the produce the oxygen a huge amount.

311

00:49:26.760 --> 00:49:31.590

Lisa Kaltenegger: Because, if not, it would have already reacted with the method to CO2 and water, and you can see it anymore.

312

00:49:32.400 --> 00:49:41.580

Lisa Kaltenegger: And that is our idea of those old if there's a lot of oxygen, and this is not to hotter planet, because then you can split the water and create the oxygen.

313

00:49:42.210 --> 00:49:47.940

Lisa Kaltenegger: And the planet isn't completely CO2 covered, because then we can split the CO2 and create the oxygen.

314

00:49:48.600 --> 00:49:54.480

Lisa Kaltenegger: Then we don't have any other explanation than there to be in life, so we extremely conservative infamous.

315

00:49:55.290 --> 00:50:00.660

Lisa Kaltenegger: Of course isn't really interesting defeated read because i'm promising and as it should be.

316

00:50:00.960 --> 00:50:08.700

Lisa Kaltenegger: If we find the first signatures of life, even if it's the golden fingerprint which would throw all of our skepticism added right.

317

00:50:08.940 --> 00:50:13.560

Lisa Kaltenegger: What else could it be could it be booking isn't that we don't understand, could it be this, and this, and this.

318

00:50:13.860 --> 00:50:24.000

Lisa Kaltenegger: For example, prosper and Venus right Oscar in the clouds of Venus now led to lots of people actually looking at this novels of Venus looking into the clouds of Venus looking at where this could be you know.

319

00:50:24.570 --> 00:50:29.580

Lisa Kaltenegger: And that's that's very healthy for the earth The good thing is that we understand the earth.

320

00:50:29.910 --> 00:50:43.950

Lisa Kaltenegger: But what about if it's a 10 times the mass of the earth two times or assistant, and you know what we don't understand if y'all let it completely Reebok and it could be weird I think what's really important is that we get wavelength information.

321

00:50:44.460 --> 00:50:52.470

Lisa Kaltenegger: There is not one gas, then you should look for or you know, even if the combination of oxygen and methanol alternate method is going to be the golden fingerprint of life.

322

00:50:52.770 --> 00:51:04.110

Lisa Kaltenegger: You need to know what the CO2 is to say how much of the oxygen comes from there, you need to know where the water is to see how much of the oxygen comes from there, so it will be a pot pourri of evidence right.

323

00:51:04.950 --> 00:51:11.160

Lisa Kaltenegger: But whenever somebody sells you want a gas, you know this is life or not life, the most.

324

00:51:11.820 --> 00:51:19.530

Lisa Kaltenegger: Challenging assumption, and that assumption is that we understand planets well enough to identify one gas without.

325

00:51:20.070 --> 00:51:27.960

Lisa Kaltenegger: Its its surroundings everybody i'm saying it's around in well enough as a unique life indicator and we haven't found any yet.

326

00:51:28.410 --> 00:51:43.620

Lisa Kaltenegger: That that was big through and again, like the phosphate on Venus super interesting right, but it could be geologically or the method and Marcus it could be not life right a lot of these gases can be not like, especially when sin in isolation, so.

327

00:51:44.850 --> 00:51:47.970

Lisa Kaltenegger: there's where we have this discussion with steady people usually they're like well.

328

00:51:48.000 --> 00:51:53.370

Lisa Kaltenegger: If somebody says hi we're here nobody's coming to you write a message is an English.

329

00:51:54.390 --> 00:51:55.500

Lisa Kaltenegger: Language that we understand.

330

00:51:55.860 --> 00:52:04.950

Lisa Kaltenegger: If we have oxygen and messing with water, and you know we'll have an amazing telltale sign of life on this planet, but you know, yes, both throw all of our skepticism honestly.

331

00:52:05.340 --> 00:52:20.430

Lisa Kaltenegger: it's just something else we don't know that could generate that and that's what we should do, but I think we going with something that we cannot explain, other than for life as our best evidence and one question George how many planets Do I need.

332

00:52:21.660 --> 00:52:26.190

Lisa Kaltenegger: How many places a date for one of them to make life, maybe it's all of them right.

333

00:52:26.310 --> 00:52:27.480

Lisa Kaltenegger: Then it's going to be easier.

334

00:52:28.200 --> 00:52:43.410

Lisa Kaltenegger: One in 1000 then we're going to have to keep looking, so I think this is also by testers some point, because it gives us these new hundreds 10s hundreds, so we have close by ones that we can scrutinize.

335

00:52:45.120 --> 00:52:46.110

Ana Bonaca: very exciting.

336

00:52:47.580 --> 00:52:48.000

Ana Bonaca: Thank you.

337

00:52:49.980 --> 00:53:00.870

Evan Bauer: Thank you Lisa I think we're probably close to wrapping up discussion, so I, I guess, I just want to ask you if you have any any closing thoughts, you want to share give you a chance to.

338

00:53:01.800 --> 00:53:03.150

Lisa Kaltenegger: To yes.

339

00:53:04.260 --> 00:53:05.520

Evan Bauer: For the last two or three minutes.

340

00:53:05.580 --> 00:53:13.620

Lisa Kaltenegger: Okay, I can share one last adventure that's really now going far out okay so because he wanted some ideas that actually spark so.

341

00:53:13.980 --> 00:53:17.400

Lisa Kaltenegger: When we did this database of reflectivity for life, we can across.

342

00:53:17.760 --> 00:53:27.390

Lisa Kaltenegger: different kinds of life it's incredible the diversity of life if you're an astronomer and have them done by all the cheap it's incredible that they were to give life but it's out there on the planet, so.

343

00:53:27.750 --> 00:53:37.110

Lisa Kaltenegger: that's goes without saying, but one of the things that people were very worried about is actually this high UV radiation of an m star planet right.

344

00:53:37.710 --> 00:53:46.440

Lisa Kaltenegger: And so we look in with some biologist about what life can do, or what life death on the earth to actually mitigate harshly via radiation.

345

00:53:46.860 --> 00:53:57.660

Lisa Kaltenegger: And so, most of there you go under the surface of the water, you find right what blocks UV radiation you go under subsurface be fine blocks UV radiation, but hard pressed to find in the first place.

346

00:53:58.380 --> 00:54:14.160

Lisa Kaltenegger: But what we found was really interesting, and this has worked by one of my postdoc Jacqueline me James and we found that there are some corals when you hit them with UV radiation that's when you go diamond you should have a blues UV lights and you can see the beautiful.

347

00:54:15.300 --> 00:54:19.800

Lisa Kaltenegger: biota underwater I learned that so next time I ever go diving and every one of those.

348

00:54:20.310 --> 00:54:29.220

Lisa Kaltenegger: But the important part of this is that actually there's a coral and we do not know how it does it that's actually pretty interesting you hit it with UV light.

349

00:54:29.640 --> 00:54:40.980

Lisa Kaltenegger: It will break down the UV light and we imitate and visible light that's not harmful to the r&d that it lives in some cases where they would get destroyed from UV radiation.

350

00:54:41.910 --> 00:54:50.490

Lisa Kaltenegger: And so now, if this developed on the earth, where it's not critical right we don't have that much to be radiation, we also don't know why these columns develop this.

351

00:54:50.910 --> 00:55:01.860

Lisa Kaltenegger: there's a lot of other species that also do by a fluorescent or by over manassas but this one is the specific point that I wanted to make because we found it by thinking about how UV radiation.

352

00:55:02.760 --> 00:55:10.830

Lisa Kaltenegger: So you can see them actually in some of the aquarium in the deeper aquarium where they have like black lighting.

353

00:55:11.250 --> 00:55:28.530

Lisa Kaltenegger: You can see some, this is not a greatest picture, but some of them here, I actually saw resin and the flow rest at a specific way, and so this bio fluorescent signatures this idea that we came up with again for out, but that we should be.

354

00:55:30.450 --> 00:55:41.190

Lisa Kaltenegger: Not not thinking about bio signatures that there are not in our daily life, because if they were a life so by a flower essence evolved lots of different types of years.

355

00:55:41.580 --> 00:55:50.400

Lisa Kaltenegger: So if you were a planet around that and star that has to be flares, then it would be in your favor to develop a similar strategy.

356

00:55:51.000 --> 00:56:10.140

Lisa Kaltenegger: And the great thing about that would be that it would be a time signal, so what I want to leave you with is this idea that there will be this harsh flare from a young actress i'm start, and then a little bit later the whole planet lighting up in the visible.

357

00:56:12.840 --> 00:56:24.210

Lisa Kaltenegeger: Whether that exists, I don't know that it's important to not be constrained for all of your work by what you know, on the earth currently.

358

00:56:24.900 --> 00:56:40.950

Lisa Kaltenegeger: Two sinks to me mitigation strategies that we have one life has developed here on the earth and see if such mitigation strategies could be beneficial of planets that are in a completely different environment and whether or not they they leave science that because it for.

359

00:56:44.520 --> 00:56:46.170

Evan Bauer: Thanks for leaving us with that and.

360

00:56:47.100 --> 00:56:48.360

Morgan Elowe MacLeod: yeah that's really amazing.

361

00:56:49.680 --> 00:56:52.320

Lisa Kaltenegeger: And now you should go and write science fiction stories, you know.

362

00:56:55.830 --> 00:57:07.740

Lisa Kaltenegeger: I think you know if you have any great idea if you have any ideas or any other questions feel free to to to send me an email, you know i'm sorry i'm not there for coffee I wish I were I promise I will come by.

363

00:57:08.880 --> 00:57:15.450

Lisa Kaltenegeger: Once we allowed to see each other in 3D again and then hopefully we can have a discussion on many of the different aspects.

364

00:57:17.130 --> 00:57:25.530

Lisa Kaltenegeger: And I want to say it's super nice to see everybody again, you know, so thank you for the invitation and I hope it starts.

365

00:57:28.290 --> 00:57:30.660

Morgan Elowe MacLeod: So thank you so much, this has been really wonderful.

366

00:57:31.890 --> 00:57:33.390

Morgan Elowe MacLeod: Thank you to everyone on the call.

367

00:57:35.970 --> 00:57:37.320

Ana Bonaca: Thank you, thank you Lisa.