

WEBVTT

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00:00:02.669 --> 00:00:03.090

Sorry.

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00:00:05.100 --> 00:00:16.080

Sarah Jeffreson: we're joined today by Diana Powell who's just joined us here at the ITC.

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00:00:17.940 --> 00:00:19.289

Sarah Jeffreson: as a Sagan postdoc.

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00:00:20.520 --> 00:00:21.180

Sarah Jeffreson: Sagan

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00:00:22.560 --> 00:00:25.590

Sarah Jeffreson: Fellow and she'll.

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00:00:27.540 --> 00:00:29.250

Sarah Jeffreson: be with us here.

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00:00:31.530 --> 00:00:33.330

Sarah Jeffreson: For two years.

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00:00:34.350 --> 00:00:35.190

Sarah Jeffreson: She Was.

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00:00:36.240 --> 00:00:37.680

Sarah Jeffreson: offered a.

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00:00:39.660 --> 00:01:10.110

Sarah Jeffreson: faculty position at the university of Chicago starting in Fall 2023. we're going to hear from Diana about "Microphysical Insights into Protoplanetary Disks and Exoplanet Atmospheres" Sp now I'll turn it over to her.

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00:01:12.330 --> 00:01:13.050

Sarah Jeffreson: Diana.

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00:01:15.150 --> 00:01:25.860

Diana Powell: Okay, so Hello everyone, and thank you so much for having me today i'm really excited to talk with you all about micro physical insights into protoplanetary discs and exoplanet atmospheres.

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00:01:26.820 --> 00:01:37.560

Diana Powell: And in this talk, I hope to demonstrate to you why we're closer than ever before to understanding the formation and evolution of planets and Bart in part due to this ongoing metaphysical revolution.

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00:01:38.790 --> 00:01:46.800

Diana Powell: And so, for the purposes of this talk micro physics refers to the physics that governs the evolution of small particles and the presence of gas.

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00:01:49.440 --> 00:01:49.710

Diana Powell: Okay.

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00:01:50.790 --> 00:01:56.100

Diana Powell: So, the key question behind all of this research is what is the origin evolution and nature of.

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00:01:56.100 --> 00:01:56.850

planets.

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00:01:57.870 --> 00:02:04.080

Diana Powell: And to address this question I characterize planets and the planetary material and protoplanetary disks.

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00:02:04.590 --> 00:02:16.020

Diana Powell: And, in particular, I use theoretical micro physical tools to appear beneath each bail bail at each stage of planet formation and uncover fundamental properties, but both disks and atmospheres.

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00:02:18.510 --> 00:02:18.810

Diana Powell: OK.

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00:02:19.950 --> 00:02:24.120

Diana Powell: So the general picture of planet formation that has emerged looks more or less like this.

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00:02:25.110 --> 00:02:31.560

Diana Powell: So planet formation against and protoplanetary discs so these discs constitute the building blocks of planetary systems.

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00:02:32.520 --> 00:02:46.860

Diana Powell: Then, once the bulk of the disk dissipates a young planetary system remains, and the second phase is not usually included and diagrams like this, but i'm doing cell because it represents a distinct observational stage with unique signatures and observing strategies.

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00:02:48.420 --> 00:02:55.380

Diana Powell: And then, as time progresses planets will find relatively stable orbits and the planetary atmospheres will also evolve.

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00:02:57.240 --> 00:03:09.960

Diana Powell: Okay, so this is the general picture, but what I really want to know is how can we relate these disparate evolutionary stages to learn about the formation evolution in nature of the full complement of planetary systems.

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00:03:12.750 --> 00:03:23.280

Diana Powell: And we're very lucky to be alive, at a time with each of the stages of planetary evolution as undergoing an observational revolution, so we have this unprecedented observations at each of these evolutionary stages.

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00:03:24.690 --> 00:03:29.370

Diana Powell: So we can observe protoplanetary discs, such as the desks observed in high resolution shock here.

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00:03:30.420 --> 00:03:41.550

Diana Powell: And as a bonus, we can also observe protoplanetary disks and they're going back to the planet formation, like the PDF 70 system shown here, where you can see two points that are thought to be giant planets undergoing accretion.

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00:03:43.110 --> 00:03:57.480

Diana Powell: We can also see beyond planetary systems directly, like the Vedic system shown in the bottom left and, finally, we now have observations of over 4000 of all exoplanets and detailed constraints from solar system planetary science and Cosmo chemistry.

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00:04:00.390 --> 00:04:07.410

Diana Powell: And so, with all of these data, this is really the era to start actively connecting planet formation to planetary characterization.

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00:04:08.700 --> 00:04:15.930

Diana Powell: And so the way that I approach understanding planet from nation and evolution as from the perspective of chemical compositions using micro physics.

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00:04:17.130 --> 00:04:26.790

Diana Powell: And so, in particular my research program focuses on using micro physical theoretical tools to determine how chemical compositions of discs relate to that affinity and vice versa.

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00:04:28.800 --> 00:04:40.620

Diana Powell: And so, while this ongoing observational revolution of both planets and this represents a really fantastic opportunity to connect planet permission to planetary characterization also represents a significant challenge.

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00:04:43.500 --> 00:04:57.570

Diana Powell: And so to get a quick idea of why determining the composition of protoplanetary discs is that called let's take a quick look at this vertical cross section so here are the systems host are is on your right, and the disc flares out at larger radio on your left.

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00:04:58.680 --> 00:05:11.250

Diana Powell: And so planets form and the disconnected plan which makes this a region of particular interest, however, in the mid lane is particles are moving really which will affect affect them at playing composition.

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00:05:12.630 --> 00:05:21.570

Diana Powell: And this really or motion can eventually cause the ice to retire regions of the desk or they lose their volatile material back to the gas is again altering their composition.

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00:05:22.980 --> 00:05:28.590

Diana Powell: And at the same time, the gas on the desk is being mixed around and changing the radio competition and vertical competition.

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00:05:29.850 --> 00:05:33.060

Diana Powell: And not only are discs constantly in this nine equilibrium state.

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00:05:33.570 --> 00:05:46.590

Diana Powell: But, to top it all, off there's also gas president and the upper regions of the desk that can be optically thick such that you don't see a mission from the midpoint directly, and this is all especially true in the inner regions of desks, where we know that planet formation is common.

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00:05:48.090 --> 00:05:53.100

Diana Powell: Okay, so determining useful compositions of discs difficult, but what about planets.

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00:05:55.260 --> 00:06:08.520

Diana Powell: And so, when determining compositions of planets a primary source of compositional information comes from atmospheric observations and so on the left here i'm showing a collection of emission spectra or directly observed planetary mass objects.

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00:06:09.570 --> 00:06:16.050

Diana Powell: And on the right man showing a collection of transition spectra for 10 hot jupiter's which are highly irradiated Jupiter like planets.

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00:06:17.460 --> 00:06:29.790

Diana Powell: And despite the detail, we can observe in these objects atmospheres these observations are often hindered by opacity sources such as clouds and hayes's that kind of scary compositional features and other planetary properties.

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00:06:32.850 --> 00:06:40.470

Diana Powell: And so what we're probably looking at our atmosphere is that looks something like these atmospheric slices shown here, so these atmospheres are covered in clouds.

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00:06:42.270 --> 00:06:46.980

Diana Powell: clouds can be low altitude, such that we can observe some unobstructed regions of face to face.

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00:06:47.250 --> 00:06:48.540

Diana Powell: or they could be high altitude.

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00:06:49.830 --> 00:06:53.760

Diana Powell: So high altitude clouds or completely obscure signatures of atmospheric composition.

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00:06:54.870 --> 00:06:56.910

Diana Powell: And even when clouds are low altitude.

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00:06:57.180 --> 00:07:04.140

Diana Powell: They can obscure planetary signatures, they can alter observed gas days abundances and influence planetary ready to transfer.

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00:07:05.670 --> 00:07:10.170

Diana Powell: And then, in addition to the complicating presence of clouds atmospheres will also have all.

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00:07:13.620 --> 00:07:24.720

Diana Powell: And so, both of these cases, both in discs and atmospheres many other complications with determining chemical compositions boil down to a need for a better understanding of micro physical processes.

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00:07:25.980 --> 00:07:35.640

Diana Powell: And so, in this context, on remind you that I use metaphysics to refer to the evolution of small particles and the presence of gas or many of the key common processes are shown here.

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00:07:36.810 --> 00:07:46.110

Diana Powell: So, in the case of atmospheres micro physics governs the evolution of clouds and in discs micro physics governs the evolution of small ice or rocky solids.

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00:07:47.010 --> 00:07:53.970

Diana Powell: And, by the end of this talk, I hope that you'll see how micro physics applies in several different contexts and it's crucial and understanding systems.

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00:07:57.420 --> 00:08:05.430

Diana Powell: So, to make the connection between protoplanetary disks and planetary atmospheres when you better physical models to interpret current and upcoming observations.

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00:08:06.240 --> 00:08:16.470

Diana Powell: And all idea that metaphysics will be important in making this connection and metaphysics might actually be the key to understanding, a lot more about the origin evolution and nature of planets.

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00:08:19.590 --> 00:08:25.560

Diana Powell: And so i'll start by talking about some of the initial work that i've taken towards tying planet permission to planetary characterization.

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00:08:26.790 --> 00:08:30.450

Diana Powell: So i'll start by talking about planetary atmospheres, with a focus on clouds.

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00:08:31.350 --> 00:08:37.950

Diana Powell: are then move on to discussing fundamental properties of protoplanetary just such as the total amount of mass present in the systems.

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00:08:38.880 --> 00:08:46.230

Diana Powell: And then i'll bring my techniques lead us in the two previous topics together through discussion at the evolution of carbon monoxide in protoplanetary desks.

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00:08:49.230 --> 00:08:51.240

Diana Powell: Okay, so let's talk about clouds.

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00:08:53.760 --> 00:08:58.470

Diana Powell: So we all have some intuition about clouds from our familiarity with clouds on earth.

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00:08:59.880 --> 00:09:05.850

Diana Powell: The clouds are important beyond earth and are in fact the dominant opacity source and most planetary accidents.

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00:09:07.410 --> 00:09:11.430

Diana Powell: So clouds are important traces of atmospheric physics, such as mixing and transport.

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00:09:12.750 --> 00:09:17.100

Diana Powell: clouds regulate the planetary climate be regulating ready to transfer and chemistry.

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00:09:18.480 --> 00:09:22.200

Diana Powell: And clouds must be understood, when determining atmospheric abundance.

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00:09:23.910 --> 00:09:33.000

Diana Powell: Also, often the clouds and an atmosphere are the only thing that we can see so it's, therefore, an absolute necessity that we understand clouds when we're interpreting planetary.

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00:09:33.000 --> 00:09:33.840

atmospheres.

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00:09:37.290 --> 00:09:46.140

Diana Powell: And so, given this there's a lot that we can learn about planetary atmospheres through studies of clouds so it makes sense to understand how cloud evolve and form from first principles.

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00:09:47.700 --> 00:09:53.730

Diana Powell: So on the right here i'm showing an example of some of the outputs they calculate of cloud properties and planetary opposites.

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00:09:54.750 --> 00:10:04.350

Diana Powell: So here i'm planning the mast into the cloud particles as a function of particle size and atmospheric pressure and so here, each of the different colors indicate a different cloud species.

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00:10:05.880 --> 00:10:18.360

Diana Powell: And all the properties of the cloud particle show here, such as their particle size, distribution and vertical extensive atmosphere are calculated from first principles through consideration of the micro physical processes by shown here on the left.

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00:10:20.130 --> 00:10:31.980

Diana Powell: So this cloud formation model is readily adaptable and widely applicable and has been used to predict next plane data for a wide range of planets So if you are also a few quick examples of what i've done with it so far.

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00:10:34.110 --> 00:10:37.950

Diana Powell: But before I do that I really want to emphasize that this model is not a black box.

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00:10:38.340 --> 00:10:50.100

Diana Powell: So we've engineered every single key micro physical component and have carefully considered every aspect of confirmation that it's considered in this framework, so we're really not looking at a black box we're looking at physics.

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00:10:53.310 --> 00:10:57.600

Diana Powell: And what this framework, we can predict how clouds will look at different locations on a given planet.

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00:10:58.890 --> 00:11:08.580

Diana Powell: So here i've translated calculated cloud properties into transmission spectra that looks significantly different in both amplitude and shape between the East and West lens of the same heart Jupiter.

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00:11:10.080 --> 00:11:19.620

Diana Powell: So i'm black here i'm showing the calculated transmission spectra on the east and west ones and grey i'm showing the Islam transmission spectra there were no clouds.

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00:11:20.850 --> 00:11:24.120

Diana Powell: And then blue i'm showing your Pasty continue on to the clouds.

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00:11:25.650 --> 00:11:33.270

Diana Powell: So, as you can see, on the Westland cloud capacity is significant across a very broad wavelength range where it flattens the opposite of transmission spectra.

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00:11:34.800 --> 00:11:47.010

Diana Powell: On Islam clouds contribute to this muted and sloped optical spectra and as broad absorption feature in the infrared to the silicate and aluminum which collaborators and I will prob angioplasty cycle one.

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00:11:48.420 --> 00:11:54.060

Diana Powell: And then there's also an interesting clear window around three to 10 microns that could allow us to pure through the clients.

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00:11:56.160 --> 00:12:02.880

Diana Powell: So, to really understand the nature and composition of planetary atmospheres will be greatly rewarded by looking at these planets in 3D.

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00:12:03.960 --> 00:12:08.730

Diana Powell: So, as you can see here that Islam gives us much more information than other locations on the planet.

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00:12:12.000 --> 00:12:19.770

Diana Powell: And these models will become increasingly more you flow with the launch of aws which will allow us to uncover atmospheric trends across populations of planets.

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00:12:21.060 --> 00:12:31.380

Diana Powell: So an example of one such trend that has already been observed in hot jupiter's is shown here till the day and night side temperatures apart jupiter's or diagnostics, if he transport processes in their outfits.

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00:12:32.550 --> 00:12:47.910

Diana Powell: And what we observed, is that they're planning, as their planetary liberation temperature increases the dayside temperature is also increased linearly However, the nighttime temperatures for this really diverse range of hot jupiter's remains roughly constant even as 30 sites heat up.

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00:12:49.530 --> 00:12:59.760

Diana Powell: And so we've modeled the clouds and these atmospheres and found that the constant nighttime temperatures on hot jupiter's as a natural outcome of the abundant production of sexually active sorted class.

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00:13:01.140 --> 00:13:10.740

Diana Powell: So these sort of get clouds dominate the atmosphere capacity and so even accounting for changes in vertical mixing with changes in global circulation that a career as a function of equilibrium temperature.

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00:13:11.520 --> 00:13:15.210

Diana Powell: We show that what we're seeing across all these planets is a silicate cloud top.

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00:13:16.530 --> 00:13:20.400

Diana Powell: And so, this further demonstrates that cloud shape observations and planetary climate.

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00:13:23.520 --> 00:13:28.740

Diana Powell: And so I also working on interpreting observations of exoplanets and a mission reflection and transmission.

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00:13:29.040 --> 00:13:40.530

Diana Powell: Using two dimensional models of breaker physical clouds or I calculate how cloud properties change as they are affected alone, a super irritating equatorial jet have a heart Jupiter so cloud seeding with atmospheric dynamics.

94

00:13:41.850 --> 00:13:47.880

Diana Powell: And so here i'm showing condensed cloud mass of different clouds species as a function of planetary longitude and pressure.

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00:13:48.870 --> 00:13:54.900

Diana Powell: and using these models, we can robustly determine the impact the clouds on high resolution observations and exoplanet these curves.

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00:13:55.470 --> 00:14:04.140

Diana Powell: And this is work that will continue here and will provide the foreign models needed to understand your observations and fundamental planetary properties and the gw St era.

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00:14:06.180 --> 00:14:06.510

Diana Powell: Okay.

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00:14:07.830 --> 00:14:22.680

Diana Powell: So i'd like to talk about clouds more especially because they're so important and understanding sub stellar atmospheres, which is important, you constraining planetary properties, but for now let's turn our attention to protoplanetary discs which are the locations of planet formation.

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00:14:23.880 --> 00:14:28.620

Diana Powell: And i'll start by talking about the interesting question of how much total mass is present in the systems.

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00:14:31.860 --> 00:14:38.040

Diana Powell: And so the question of how much mass is in protoplanetary this is funnel is fundamental for planet formation and evolution.

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00:14:39.420 --> 00:14:49.050

Diana Powell: So the amount of total mass and system influences the ultimate mass and composition of formed planets by affecting the evolution of solid and gas that eventually make up the planetary system.

102

00:14:50.490 --> 00:15:01.590

Diana Powell: So the total mass also regulates several favorite planet formation pathways so, particularly the processes, where the amount of gas, which makes up the bulk of the disk mass affects the evolution of the solids.

103

00:15:02.910 --> 00:15:11.880

Diana Powell: So the question of how much mass is present in the system needs to be answered, so that we can get a handle on the initial conditions, a planet formation and how these might vary from system to system.

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00:15:16.920 --> 00:15:26.970

Diana Powell: So the most common tracers of protoplanetary this proper use our dust or different trace gases, such as CO gas, as these are relatively easy to observe.

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00:15:28.620 --> 00:15:38.610

Diana Powell: Due to a lack of probes or direct probes of the main mass constituent, which is H<sub>2</sub> gas these previous measures of this mass have relied on some tracer to HP ratio.

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00:15:40.500 --> 00:15:48.330

Diana Powell: However, we know that processes such as green growth and drift to alter the dusty gas ratio from that typically assumed interstellar medium value.

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00:15:49.800 --> 00:15:59.580

Diana Powell: And now several lines of evidence, also suggest that gas based CEO so, particularly in the commonly observed upper disclaimers is depleted or missing and discs.

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00:16:01.020 --> 00:16:07.620

Diana Powell: So this begs the question how can we measure the total mass without an assumed tracer to hdl ratio.

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00:16:08.640 --> 00:16:11.430

Diana Powell: and also what is happening to all of the CEO.

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00:16:12.600 --> 00:16:21.990

Diana Powell: And really getting to the bottom of these questions is of the utmost importance for understanding the specifics and other dis properties which will allow for an improved understanding of the initial conditions of information.

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00:16:25.260 --> 00:16:30.600

Diana Powell: And so I began addressing these questions by considering multi wavelength observations discs in the millimeter.

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00:16:32.010 --> 00:16:41.940

Diana Powell: So here actually a visualization of observations of the disk around tw Hydra or here, these pictures are the same desk, but it appears smaller and radius that longer wavelength.

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00:16:43.470 --> 00:16:51.060

Diana Powell: And to introduce some terminology, I refer to a maximum radius and which there's a mission at a particular wavelength as a deadline.

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00:16:52.320 --> 00:16:56.550

Diana Powell: And, as others have suggested, these observations, maybe signatures of particle drift.

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00:17:01.080 --> 00:17:12.030

Diana Powell: So particles drift and discs because the gas fields this outward pressure gradient that causes particles to feel a drag that

removes some of their angular momentum and causes them to drift in works towards their health star.

116

00:17:13.740 --> 00:17:22.230

Diana Powell: And so we can use these observations of particle drift to trace the aerodynamic properties of the observed particles and determine the total gas mask president and the systems.

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00:17:23.610 --> 00:17:34.950

Diana Powell: So we can do this, following the simple equation shown here on the right if we know, several key quantities, so, in particular, if we know the maximum radius and which particles of a given size are present.

118

00:17:36.660 --> 00:17:51.360

Diana Powell: And so we can improve the particle size, if the observed wavelength corresponds to the primary particle size, contributing to the observed and mission at the outer edge and then we can measure the decides to determine the radius and which those particles are the maximum size screen.

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00:17:53.220 --> 00:18:06.540

Diana Powell: And so, this method allows us to derive the disk surface density without assuming a tracer that he ratio, because we really only care about how fast the particles drift which depends primarily on their size and not on how many particles are present.

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00:18:09.780 --> 00:18:09.990

Diana Powell: Okay.

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00:18:11.190 --> 00:18:18.660

Diana Powell: So i've applied this model to seven protoplanetary discs with previous millimeter observations that show decrease in this real extent with wavelength.

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00:18:19.740 --> 00:18:23.850

Diana Powell: And so here i'm showing some of the observations for three out of the seven discs and our sample.

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00:18:27.960 --> 00:18:34.080

Diana Powell: And so we can do a lot with this modeling but one of the key things that we found is that this masses are larger than we initially expected.

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00:18:35.430 --> 00:18:46.710

Diana Powell: So here on the Left i'm showing total gashes super sensitive and black compared to previous Teresa derived surface densities, and the middle of muscle or nebula which represents the minimum mass required to form our solar system.

125

00:18:48.450 --> 00:18:59.490

Diana Powell: So that is an example or nine to 27% of their host stellar masses, so this is significantly more massive than the minimum muscle or nebula, which is only about 2% of the sun's mass.

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00:19:01.290 --> 00:19:09.480

Diana Powell: And these discs are also to the 15 times more massive than estimates from optically then destination, assuming an interstellar medium does to gas ratio.

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00:19:10.950 --> 00:19:23.490

Diana Powell: And then, for the three discs and our sample that have results your mission or estimates are 340 and 115 times more massive than previously published and they're getting that seal depletion it's not uniform across different deaths.

128

00:19:25.020 --> 00:19:38.730

Diana Powell: And so, these results indicate that does maybe a more robust resort of total mass because we uncover a reduced gashiness ratio that's roughly consistent across example, while the CO2 H2 ratio various more strongly and i'll come back to this later in the top.

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00:19:42.270 --> 00:19:47.460

Diana Powell: Okay, so here i'm planning to make usability parameter as a function of radius and the autodesk.

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00:19:48.600 --> 00:20:02.430

Diana Powell: And so to make you parameter less than approximately one is where you would start gravitational collapsing under your own self gravity and so all the discs in my sample are stable to gravitational collapse, except for one disc which approaches the limit of to make you stability.

131

00:20:03.900 --> 00:20:16.050

Diana Powell: and, interestingly, this morphology also show some indications of features that could be due to the gravitational instability and high resolution images, but not all the discs an example have low key values at certain radio.

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00:20:17.610 --> 00:20:27.810

Diana Powell: And so we think that when you first warm discs they're creating because they are marginally unstable and the smart smart

instability might be helping to raise spiral arms that throw material onto the star efficiently.

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00:20:29.010 --> 00:20:38.400

Diana Powell: And we still think that all of that is going on, after this early phase of star formation, you really need something like MRI or disc lens to kick in to drive further accretion.

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00:20:39.990 --> 00:20:43.800

Diana Powell: And it's really a big mystery how this variable to accrete efficiently at times.

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00:20:45.000 --> 00:20:56.850

Diana Powell: But maybe if scientists are actually close to gravitational instability, you do not need a lot of these efficient processes to be happening because at least some discs so at least the brightness of this to my sample seem to maintain much of their mass.

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00:20:59.940 --> 00:21:04.110

Diana Powell: And in our modeling thus far, it has not been required to know unexpected desktop systems.

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00:21:05.580 --> 00:21:10.110

Diana Powell: But, given our results, we can now use models of calculation to compute the dust substance abuse.

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00:21:11.310 --> 00:21:19.200

Diana Powell: So here i'm showing the service and seeds for the disc of tea towel or the blue line is the total gashes sufficiently derived using that method.

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00:21:20.130 --> 00:21:29.520

Diana Powell: And then the solid black line is the observed that surface density and here the dashed lines are dust service density is derived using an analytic and numerical treatments a particle calculation.

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00:21:30.960 --> 00:21:39.120

Diana Powell: And so, for the listener sample we derive the plenary dusty gas ratios of around 10 to the minus three, which is a common outcome of models of brain growth in draft.

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00:21:40.500 --> 00:21:50.100

Diana Powell: And so, and these models, the dust drifted into the energy is where undergoes further evolution, but you can also pay consistent

picture here with some of the drifting dust being incorporated into planets over time.

142

00:21:52.080 --> 00:21:58.320

Diana Powell: And it's worth noting that, and these models that this is formed with an initial dust mask that's a factor of 10 greater than its presently observed.

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00:21:59.550 --> 00:22:06.690

Diana Powell: And also being able to constrain that dust and gases surface into these using this method can allow us to empirically constrain the desktop pass it.

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00:22:07.050 --> 00:22:13.380

Diana Powell: Which is particularly exciting, because the desk capacity or man's one of the largest sources of uncertainty and studies have protoplanetary desks.

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00:22:15.570 --> 00:22:24.990

Diana Powell: Okay, so we can learn a lot using this model that I hadn't talked about here so from the aggregate nature of the solid particles that we observed to the nature of the disk morphological features.

146

00:22:26.130 --> 00:22:36.900

Diana Powell: But overall here's this new picture of this where they may be more massive than previously appreciate it, so the total dust mask is the same, but the total gas mask this about an order of magnitude fighter.

147

00:22:38.250 --> 00:22:50.010

Diana Powell: And these qualitative changes the models of protoplanetary discs has significant implications with theories of planet formation, particularly for any process where the amount of gas is affecting the evolution of solids so that will be affected by this picture.

148

00:22:51.240 --> 00:23:01.170

Diana Powell: And I also want to emphasize that our model does indicate that there was more does NASA really times which helps bring agreement between the discrepancy and discuss masses and the masses extra solar systems.

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00:23:04.830 --> 00:23:11.310

Diana Powell: So we've discussed the total mass and disks but what has happened to all the seo gas in the system and the systems.

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00:23:12.510 --> 00:23:21.150

Diana Powell: And so i'll use my remaining time to discuss this, because we really want to know the answer to this question because seo has been used as a tracer for a broad range of fundamental this properties.

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00:23:21.510 --> 00:23:33.420

Diana Powell: which could be biased if we are assuming that there's more seo relative to HQ than reality, and also because seo as a primary carrier carbon and protoplanetary this, and this is important when we talk about planetary inheritances.

152

00:23:34.710 --> 00:23:41.610

Diana Powell: And to answer this question i'll combine the two methods that i've used so far in this talk so modeling clouds and modeling discs.

153

00:23:44.280 --> 00:23:49.620

Diana Powell: And i'll start by saying that it's definitely not just my modeling that indicates that seo is depleted and tests.

154

00:23:50.940 --> 00:23:59.640

Diana Powell: On the left here i'm showing us your abundance in the disc CW Hydra as a function of radius compared to the abundance that we would expect from observations of the interstellar medium.

155

00:24:00.960 --> 00:24:03.900

Diana Powell: So you can see that seo gas appears to be significantly depleted.

156

00:24:05.130 --> 00:24:16.830

Diana Powell: And then, the same is true of we will get large samples of discs so here i'm showing an almost survey at this and lupus where the dissent several orders of magnitude and dust mass but fairly constant gas nasa's estimated from cl.

157

00:24:18.360 --> 00:24:24.630

Diana Powell: To ensure we observed, much less CEO and just than we would expect or then will be predicted using previous models.

158

00:24:27.540 --> 00:24:35.760

Diana Powell: And to address this problem, a couple of my model for protoplanetary this properties, with an adaptive version of the models that I used to study cloud formation and exoplanet atmosphere.

159

00:24:37.350 --> 00:24:41.220

Diana Powell: And this context I modeling the formation of ice on dust and desks.

160

00:24:44.730 --> 00:24:54.390

Diana Powell: And, in particular, the nuclear fission and growth processes in the scheme include the kelvin effect which quantifies the stability of particles through considering the strength of the molecular service bonds.

161

00:24:55.560 --> 00:25:06.270

Diana Powell: And so I like to think of a Calvin effect in terms of geometry when ice molecule on the surface of a large screen, will be able to buy into more neighbors than it would on a on a small particle that has more curvature.

162

00:25:07.980 --> 00:25:12.210

Diana Powell: And so, in short, the calming effect causes large particles to nuclear and grow more easily.

163

00:25:14.820 --> 00:25:20.820

Diana Powell: And the particle sizes are important here, because they actually regulate the level of depletion that we observe and of gas face seo.

164

00:25:22.290 --> 00:25:26.700

Diana Powell: So if we approximate a vertical temperature structure and the desk as shown here on the left.

165

00:25:28.110 --> 00:25:32.760

Diana Powell: Where the disk would be roughly ISO thermal until it reaches a height or service layer heating as efficient.

166

00:25:34.170 --> 00:25:45.420

Diana Powell: than outside of the baseline and the midway in the discus cool enough for us to for my desk variants so there'll be a region of the desk or is it stable and a region where evaporation or photo disruption to occur.

167

00:25:47.220 --> 00:25:55.230

Diana Powell: So if the ice particles that point and then that plan our small, then they can be laughter to the upper regions and a battery such that CEO gas is not significant leader created.

168

00:25:56.880 --> 00:26:01.200

Diana Powell: On the other hand, if the ice particles large it can deplete the soil gas in the mid plane.

169

00:26:02.250 --> 00:26:14.730

Diana Powell: And so that's what i'm showing here on the right so once the initial abundance of seo gas solid solid black is depleted in the mid plane, as shown in grey then there's the steep concentration gradient which will it be smooth by vertical diffusion.

170

00:26:16.080 --> 00:26:21.690

Diana Powell: And this could ultimately lead to a level that position of CEO and the observed upper levels, as shown in solid bread.

171

00:26:22.890 --> 00:26:28.650

Diana Powell: And so, this is the so called finger effect which can lead to a large depletion of seo gas in the upper desk.

172

00:26:32.310 --> 00:26:43.380

Diana Powell: Okay, so let me quick book, I should say so that's the vertical evolution, but the gas and dust in the system of all really as well, so let me quickly walk you through this picture of the evolution of seo and deaths.

173

00:26:44.970 --> 00:26:51.540

Diana Powell: So the autodesk CEOs continually mixed down towards development plan or efficient I submission occurs on large particles.

174

00:26:52.590 --> 00:26:55.890

Diana Powell: These large particles then drift inwards towards their hosts stars.

175

00:26:57.150 --> 00:27:07.200

Diana Powell: And, once this is particles trippin words to the harder it is for the desk they released their volatiles to back into the gases and then some interesting cycling of material occurs around the ice fine.

176

00:27:08.550 --> 00:27:14.490

Diana Powell: And then there are also now being enhanced abundance of co gas and the interest that is a created onto the host star over time.

177

00:27:18.330 --> 00:27:31.560

Diana Powell: And so we find good agreement here between our results and observations as i'm showing a blocky through me and then our modeling we find that this process depends strongly on the fusion, which contributes to the absurd variants of co depletion and different discs.

178

00:27:32.790 --> 00:27:39.900

Diana Powell: So in the large part here, you can see that the amount of observed that feature in an autodesk depends on the amount of diffusion that is operated and the lifetime of this.

179

00:27:41.310 --> 00:27:55.470

Diana Powell: and using this model i'm able to constrain the solid and gashes co inventory at the dismissal and more planets form and constrain the bulk just a few cities and mixing characteristics and then also resolve and consistencies and estimates at this mass using different tracers.

180

00:27:56.490 --> 00:27:59.640

Diana Powell: So those are three crucial parameters that control planetary formation.

181

00:28:02.370 --> 00:28:07.410

Diana Powell: And I should also say or note that this process will also be applicable to other volatiles in this.

182

00:28:08.580 --> 00:28:17.220

Diana Powell: So the micro physical processes information both regulates the observed abundances of seo gas and is crucial in determining the radio composition of protoplanetary discs.

183

00:28:18.300 --> 00:28:31.620

Diana Powell: So something that will be working on here is modeling the distribution of other volatiles and disks and so, particularly for species that admit readily and our dominant carriers of oxygen and carbon and nitrogen which are important planetary building blocks.

184

00:28:35.370 --> 00:28:40.800

Diana Powell: And so, one of the other things that i'm interested in working on here so in the vein of connecting planet formation and evolution.

185

00:28:41.400 --> 00:28:52.290

Diana Powell: As to determine the radio and temporal composition well the compositional distribution and protoplanetary discs through modeling observations of different volatiles species using my models of ice formation and publish it.

186

00:28:53.790 --> 00:29:02.250

Diana Powell: And then I will also wild atmospheres of planets and the same planetary system, but the detail, accounting for clouds with an initial focus on young planetary systems.

187

00:29:03.840 --> 00:29:14.220

Diana Powell: So, with the compositional gradient of planets and the same planetary system and the radio and temporal composition of protoplanetary discs will have the ideal sample to systematically relate these two objects.

188

00:29:15.420 --> 00:29:20.220

Diana Powell: And so we'll be looking at comparable radio distances, with as little separation and time as possible.

189

00:29:20.940 --> 00:29:33.900

Diana Powell: And so the detailed comparison over several systems like a 78 or 8799 and beta pick as well as a slew of desks, we can get we can begin to get a sense of where these planets are likely to have originated and then just as a function of radius and tie.

190

00:29:37.320 --> 00:29:52.860

Diana Powell: And so, in conclusion, i've talked about understanding sub seller atmospheres is in cloud metaphysics and I discussed uncovering fundamental properties of protoplanetary this using particle aerodynamics and explanation so i'll leave my conclusions up here and very happy to take questions.

191

00:29:56.640 --> 00:29:57.300

Sarah Jeffreson: Here, like.

192

00:30:02.970 --> 00:30:03.660

Sarah Jeffreson: Thank you.

193

00:30:05.220 --> 00:30:05.640

Sarah Jeffreson: For.

194

00:30:06.960 --> 00:30:09.690

Sarah Jeffreson: really interesting talk.

195

00:30:12.840 --> 00:30:13.500

Sarah Jeffreson: Diana.

196

00:30:14.610 --> 00:30:15.360

Sarah Jeffreson: Yes, like.

197

00:30:19.020 --> 00:30:24.870

Sarah Jeffreson: Who you already have a few questions here on.

198

00:30:26.580 --> 00:30:27.420

Sarah Jeffreson: St.