

WEBVTT

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

Joan Najita: beta.

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00:00:02.460 --> 00:00:14.130

Joan Najita: beta classic problem in astronomy of how protoplanetary discs a creep looking at the new clues from disk sizes and mid infrared spectroscopy.

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00:00:15.630 --> 00:00:31.590

Joan Najita: But because i'm going to be here for several more months through at least the end of May, I was hoping that to share a couple of other I interest that I have in the hopes that people who might be interested we get together and chat about them so.

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00:00:32.700 --> 00:00:41.160

Joan Najita: The I wanted to share a little bit the organization that I work for it sort of my interests, so the organization that I work for is called an essential oil lab.

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00:00:41.700 --> 00:00:53.760

Joan Najita: which was created in 2019 from the merger of the national optical astronomy observatory and a whale and the Gemini observatory and the rubin Observatory.

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00:00:56.100 --> 00:01:07.020

Joan Najita: Altogether, were the nsf Center for optical infrared astronomy and as always we're based in tucson Arizona, and our mission remains remains the same, to create.

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00:01:07.650 --> 00:01:19.050

Joan Najita: and operate forefront research facilities, like the kid pete national Observatory showed here and to create and serve datasets as well as the tools that can use to analyze these.

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00:01:20.400 --> 00:01:34.710

Joan Najita: And this is all in the service of the idea that anyone with a good idea should be able to pursue that idea using forefront research capabilities, so if you have an interest in how your lab might be able to help you, with your research, please reach out.

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00:01:36.540 --> 00:01:44.580

Joan Najita: So what am I working on this sabbatical year what i'm doing i'm looking at a couple of different things, and one activity.

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00:01:45.420 --> 00:01:54.210

Joan Najita: is related to a White Paper that I wrote with Argentina and other colleagues way back in 1999 several decades ago.

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00:01:54.720 --> 00:02:08.730

Joan Najita: Where we predicted the impending need for massively multiplex whitefield spectroscopy what was all the whitefield imaging that people were doing in those days, very soon, they would need some complimentary whitefield spectroscopy.

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00:02:09.960 --> 00:02:17.100

Joan Najita: Well, the future is now and dizzy with the dark energy spectroscopic instrument, with its 5000 fibers.

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00:02:18.210 --> 00:02:29.430

Joan Najita: is working away at the summit of Kitt Peak on the Hale telescope serving the gap, the universe, and our own galaxy as well as neighboring galaxies like the Andromeda galaxy.

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00:02:29.970 --> 00:02:41.940

Joan Najita: And so Arjun and I are working with a couple of undergraduates Gabriel and Josh and the Milky Way science team to looking at a new data set that's been recently acquired on the Andromeda galaxy.

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00:02:43.710 --> 00:02:58.260

Joan Najita: And another topic I'm following up on a recommendation from the Astro 2020 current technical survey that calls for a new model of engagement of how we interact with local our local indigenous communities.

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00:02:59.700 --> 00:03:10.260

Joan Najita: They call for something called Community based astronomy what does that mean, and how can we do that I'm exploring that a little bit with two other undergrads London and Andres.

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00:03:11.730 --> 00:03:17.190

Joan Najita: And all the work with the undergraduate is courtesy of the research partners program at graduate.

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00:03:18.390 --> 00:03:26.670

Joan Najita: But my first love my first research love is started planet formation and started planning for me discs so today, I wanted to share some of the results here.

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00:03:27.690 --> 00:03:36.570

Joan Najita: But, before beginning I wanted to just give one quick disclaimer about the nutritional value of this talk, even though this talk is in the.

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00:03:37.170 --> 00:03:48.120

Joan Najita: ITC colloquium series, the talk itself will contain very little theory and computation but the kind of theory that involves the creating and solving equations.

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00:03:48.870 --> 00:04:02.970

Joan Najita: So, not so much nutritional value of that kind, however, I hope that it will contain something about another kind of three or more general kind of theory theories that are the structures of ideas that explain and interpret facts.

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00:04:04.050 --> 00:04:04.980

Joan Najita: So with that.

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00:04:06.000 --> 00:04:09.180

Joan Najita: Clarification here's what I hope to cover.

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00:04:10.650 --> 00:04:18.210

Joan Najita: so quickly, a real quick introduction of disk accretion what is it and why do we care about it, then a quick introduction.

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00:04:18.690 --> 00:04:29.160

Joan Najita: To the basic kinds of ideas that people have been thinking about how it might work it's all about angular momentum and where it goes, is it redistributed in the disk or removed in wings.

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00:04:30.090 --> 00:04:43.770

Joan Najita: Then some of the new facts that we might have been able to bring bring to bear on this question disk sizes and disk dynamics and then compare those ideas of back see where we are and what some of the takeaways might be.

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00:04:45.120 --> 00:04:53.100

Joan Najita: Okay, so on the first topic of discussion, what is it and why do we care, the reason why we're talking about discs is because, when stars form.

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00:04:53.670 --> 00:04:57.120

Joan Najita: The material that the form from has too much angular momentum to just make a star.

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00:04:57.510 --> 00:05:04.860

Joan Najita: So the excess goes into orbit around the star in the disk and material spirals in from the autodesk to the inner this making its way onto the star.

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00:05:05.490 --> 00:05:17.070

Joan Najita: And stars accrete a significant fraction of their mass through that disk creation process, and while the material is orbiting in the disk it has the opportunity to do things like four planets.

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00:05:18.270 --> 00:05:25.920

Joan Najita: Outcome of the planet formation process may depend on disk accretion, for example, and we may see an imprint of that.

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00:05:26.370 --> 00:05:35.520

Joan Najita: In the exoplanet population today, for example, we see many planets that are located much closer to their central stars and planets in our own solar system.

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00:05:36.150 --> 00:05:46.500

Joan Najita: And one idea is that these planets may have formed at large radii and coupled to the disk accretion flow and migrated in the smaller radii, where we see them today.

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00:05:48.540 --> 00:05:53.550

Joan Najita: But disk accretion can also have a connection to planet formation at an even earlier stage.

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00:05:54.870 --> 00:06:11.250

Joan Najita: For example, one of the first steps in planet formation, is the settling and growth collision and growth of the grains to make larger solids and that process is assisted by a situation that has very low turbulence, for example.

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00:06:12.960 --> 00:06:19.620

Joan Najita: In addition, once we've made say pebbles and we want to get them together to build planetesimals the building blocks of planets.

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00:06:20.370 --> 00:06:29.580

Joan Najita: That situation and we want to do it say through the streaming instability streaming instability is more efficient when the turbulence in the disk is relatively low.

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00:06:30.180 --> 00:06:41.460

Joan Najita: And once we've built our planets and our planet building blocks will be nice if we could preserve all those planets against migration, so that they're not all swept into the star, and we have to start over.

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00:06:42.210 --> 00:06:50.490

Joan Najita: So, because of those kinds of questions it matters how disks accrete do they create everywhere in the disk or just some regions.

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00:06:51.090 --> 00:06:59.640

Joan Najita: And does disk accretion naturally generate turbulence and if it does what parts of the disk are turbulent and to what extent.

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00:07:00.420 --> 00:07:09.840

Joan Najita: So we'd like to understand how creation works, just because in principle we should understand things, but also because it may affect the outcome of planet formation and therefore ourselves.

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00:07:11.070 --> 00:07:16.440

Joan Najita: Alright, so let's say we're motivated to learn about the accretion what do we know about it.

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00:07:17.730 --> 00:07:22.440

Joan Najita: Well, one of the reasons that we know discs exist is because we see accretion.

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00:07:22.860 --> 00:07:28.770

Joan Najita: onto stars, so people have been measuring stellar accretion rates for a long time, and they can tell you that they.

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00:07:29.430 --> 00:07:40.350

Joan Najita: stellar accretion rate increases with stellar mass decreases with stellar age, and the reason the background of how those observations those measurements are made is simply that.

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00:07:41.610 --> 00:07:49.410

Joan Najita: When we look at the young star we see an excess the UV excess of material that's falling onto the surface of the star.

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00:07:49.950 --> 00:08:02.250

Joan Najita: And because we know the mass of the size of the star, we can infer from the luminosity how much material is accreting onto the star

and for a typical young star that's something like 10 to the minus eight to 10 minus seven solar masses per year.

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00:08:03.600 --> 00:08:17.430

Joan Najita: So we have an idea of of the endpoint of that process, the accretion onto the star, but the question for distribution is how did the material make its journey, all the way through the disk to eventually land on the star.

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00:08:18.720 --> 00:08:34.350

Joan Najita: So that's a problem that involves angular momentum, of course, because material on the disk is rotation is supported so it has too much angular momentum to fall right on to the star, and so it needs to lose or redistribute some angular momentum in order for a Christian to occur.

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00:08:35.460 --> 00:08:52.320

Joan Najita: The two of the ideas are one that it could we could accomplish this creation through redistribution of the angular momentum in the disk where some brave part of the disk will be willing to take one for the team and acquire excess angular momentum and move to large radius.

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00:08:53.340 --> 00:09:01.200

Joan Najita: which allows some of the most of the material on the disk to migrate inward toward the star so angular momentum redistribution.

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00:09:02.550 --> 00:09:09.660

Joan Najita: and different idea is angular momentum removal, where you can take angular momentum out of the disk saying when.

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00:09:10.200 --> 00:09:26.970

Joan Najita: leaving behind lower angular momentum more specific angular momentum material that can migrate towards a star so here are two general ideas about how implement and transport my work let's have a quick look at how people have used those ideas to think about the distribution problem.

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00:09:29.100 --> 00:09:36.840

Joan Najita: So, very close to the central star within a few tenths of any you the disk is expected to be hot may be greater than 1000 degrees.

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00:09:37.500 --> 00:09:43.680

Joan Najita: so hard enough that conditional ionization can generate collisions can generate the ionization.

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00:09:44.310 --> 00:09:53.130

Joan Najita: that's needed for this material to grab on to disk magnetic field lines and generate the kind of turbulence that can redistribute angular momentum.

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00:09:53.790 --> 00:10:03.540

Joan Najita: Through a process, called the rotational instability and, if we look at the disk atmosphere at those distances, we can even find evidence.

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00:10:04.020 --> 00:10:14.760

Joan Najita: For super thermal motions that are consistent with the kind of turbulence that we expect so great we've solved the problem, potentially, for the first few tenths of a new.

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00:10:15.660 --> 00:10:20.460

Joan Najita: The problem is for all the rest of the disk, including the planet formation region.

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00:10:21.150 --> 00:10:31.800

Joan Najita: Where that this is not hot enough to produce collision ionization, we have to rely on external sources of radiation to do the job external sources of ionization.

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00:10:32.310 --> 00:10:47.700

Joan Najita: The problem is that the disc is really thick maybe it's 1000 grams per square centimeter at one to you and the external sources of ionization can only penetrate a restricted portion of that of that disk so way back when I was a postdoc.

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00:10:49.410 --> 00:10:56.100

Joan Najita: Charles gave me at this year was also at the CFA and he proposed the layered accretion picture, where we would have the.

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00:10:56.790 --> 00:11:05.070

Joan Najita: MIC needle rotational instability operating in the whole disk in the very inner part portions and that larger radio because of the limited ionization.

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00:11:05.580 --> 00:11:18.240

Joan Najita: We would also have turbulence redistributing angular momentum, but only in the disk surface region so we might have in his picture and actively or that's 100 grams per square centimeter thick on either side.

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00:11:19.560 --> 00:11:28.170

Joan Najita: Where turbulences redistributing angular momentum and materials are creating and those two active layers sandwich a non accreting dead so.

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00:11:29.670 --> 00:11:30.930

Joan Najita: So that was a great picture.

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00:11:32.130 --> 00:11:44.850

Joan Najita: But over time it's turned out to be a little challenging because the sources of ionization are lot less likely to be cosmic rays and more likely to be stellar UV and X Ray is a more limited kind of ionization.

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00:11:45.330 --> 00:11:52.620

Joan Najita: And non ideal image D processes have limited the column density over which this active layer is operational.

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00:11:53.040 --> 00:12:05.940

Joan Najita: So rather than 100 grams per square centimeter that might be a much less like a like point one to one gram per square centimeter and so, if you imagine that, by going to smaller columns your accretion rate is is correspondingly we do.

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00:12:06.960 --> 00:12:20.250

Joan Najita: That means that it's might be very difficult to use this mechanism to explain the known accretions so theorists are very creative and people have decided to use the same magnetic fields.

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00:12:21.240 --> 00:12:37.170

Joan Najita: And the same smaller Ionized region to transport angle meant in a different way, using magnetic winds So here we have the fields that were formerly we were focused on the fact that they might be turbulent but now we're going to let them pop out of the disk and tribal wind.

72

00:12:38.190 --> 00:12:45.210

Joan Najita: Now, the problem is that these or this feature is that these magnetic fields are pretty weak, so they can.

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00:12:46.020 --> 00:13:01.740

Joan Najita: Transport is relatively they have a small lever arm and could put out a relatively small amount of specific angular momentum, and that means that, in order to remove enough angular momentum for material to create, we need to reject the significant mass in a wind.

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00:13:02.760 --> 00:13:07.770

Joan Najita: So, if you like, the idea of inefficient angular momentum transport mechanism, this really isn't it.

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00:13:08.130 --> 00:13:23.040

Joan Najita: Because, if you think of this accretion flow is kind of like a train that's making its way to the station well here you are rejecting half or more of your cargo in order as sort of like your fuel in order to get to the station, but this is the favorite picture.

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00:13:24.210 --> 00:13:36.570

Joan Najita: Oh sorry the other half of the story is that because you're rejecting so much mass one day, we hope that we'll be able to observe this the ejected wind and show that it's actually removing the angle that we expect.

77

00:13:37.830 --> 00:13:50.370

Joan Najita: So this is our favorite picture at the moment and illustration of at least what some humans think is going on in disks and we're not quite sure, so it might be a good time to.

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00:13:51.780 --> 00:14:00.210

Joan Najita: pull some other individuals to see what they know about how discs the creep you might want to phone a friend.

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00:14:01.200 --> 00:14:14.700

Joan Najita: Ask a disk for some clues as to what it knows about how just accretion works, and one thing one clue we might want to pay attention to is the sizes of disks because these can be quite revealing.

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00:14:16.170 --> 00:14:31.440

Joan Najita: And the argument here is very simple, that if angular momentum is being redistributed in the disk then some part of the disk material has to take one for the team and move to large radius, which means that disks will spread they'll get bigger with time.

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00:14:33.150 --> 00:14:42.240

Joan Najita: On the other hand, if angular momentum is predominantly being removed in these winds then there's no need for disk spreading and disks can in fact it's more with time.

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00:14:43.650 --> 00:14:50.940

Joan Najita: Now, there can be some other processes that can affect the sizes of disks, for example, we could have photo evaporation that can remove.

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00:14:51.690 --> 00:15:01.830

Joan Najita: This from the outside, from the outside and make them smaller, we could have some stellar planetary companions that form and also make a disc truncate the disk and make it smaller.

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00:15:02.580 --> 00:15:11.910

Joan Najita: But there's not very many ways to make this bigger with time, other than through this kind of angular momentum transport so two discs get bigger or smaller with time.

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00:15:12.930 --> 00:15:18.990

Joan Najita: This is a relatively easy question to answer because there's been a lot of observations made of this literature.

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00:15:19.560 --> 00:15:25.980

Joan Najita: So the older class to or T tauri discs have been measured for several decades there gas decisis.

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00:15:26.850 --> 00:15:35.130

Joan Najita: and, more recently, the sizes of the younger class one disks and also been measured with the SME and Alma so do they get bigger or smaller.

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00:15:36.090 --> 00:15:43.920

Joan Najita: here's a slide that shows the Gaston sizes that's a function of age for the younger sources and pink and the other sources in blue.

89

00:15:44.400 --> 00:15:57.990

Joan Najita: And you can see that, over time, it looks while the younger sources or maybe 100 to 200 au in size, the older sources can be equally small but many are much, much larger sometimes as big as 600 or 808 you.

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00:15:59.070 --> 00:16:12.390

Joan Najita: So the much bigger sizes, at least in some cases, points to some kind of effective in disk angular momentum transport going on, so you can't all be magnetic winds and the simple way that we imagine.

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00:16:14.460 --> 00:16:15.120

Joan Najita: So that's one.

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00:16:16.860 --> 00:16:32.700

Joan Najita: Another clue that we might try to attain is to see whether we could have a peek inside a disk not just look from the outside, but

peek into the desk to see what kind of dynamics are actually happening there.

93

00:16:34.290 --> 00:16:44.370

Joan Najita: Now, this might be something that doesn't happen very often otherwise we'd already know the answer, so it might be only a special opportunity to make that kind of mission so with that.

94

00:16:45.420 --> 00:17:02.940

Joan Najita: in mind, let me introduce you to a friend of mine, one of my favorite stars TV town north, who is a class one source in the tourist Mecca the cloud so it's kind of an older class one source, maybe something like the very famous each cell tower source that has the nested Greens.

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00:17:04.410 --> 00:17:11.160

Joan Najita: And one thing that's really special about TV tell is that it has a very unusual spitzer spectrum.

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00:17:13.890 --> 00:17:26.730

Joan Najita: it's bitter spectrum in the region from 13 to 16 microns has some seal ice CO2 ice absorption, yes, but it also has these narrow bands of vibrational bands of molecular absorption.

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00:17:27.990 --> 00:17:32.100

Joan Najita: of CO2 each hydrogen cyanide and suddenly.

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00:17:33.270 --> 00:17:36.780

Joan Najita: This is pretty uncommon Lee seen, but it is.

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00:17:38.340 --> 00:17:48.120

Joan Najita: In absorption but it's very much like the kind is the same bands that are typically seen in the mission, the more evolved systems So here we have carbon dioxide in the mission.

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00:17:49.470 --> 00:17:58.710

Joan Najita: Hydrogen cyanide emission and acetylene emission in most disks but here in tip top we see those same bands in absorption so what's going on here.

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00:17:59.250 --> 00:18:07.560

Joan Najita: Often, when we get to the stage we'd like to try to figure it out using high resolution spectroscopy so like to sabbaticals ago.

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00:18:08.190 --> 00:18:16.980

Joan Najita: We were able to get some spectroscopy with the taxi spectrograph on the Gemini telescope, this is a very high resolution spectrograph 500,000.

103

00:18:17.580 --> 00:18:28.200

Joan Najita: And here we're looking at individual resolved mind so previously the spectrum here is a whole band of molecular mission, but here with the high resolution.

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00:18:28.530 --> 00:18:37.740

Joan Najita: we're seeing individual lines of those same species of a suddenly it CN oh here's some ammonia, this is the first detection of among disks.

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00:18:38.400 --> 00:18:49.440

Joan Najita: And because we're so excited by what we saw were able to go back the next year and get more data we saw a lot more ammonia and also water in absorption So what did these data tell us.

106

00:18:51.720 --> 00:19:09.120

Joan Najita: Well it's really fascinating because the my profiles that we see are all redshift so here's before looking at the system velocity and green all of the absorption lines that we see I read shifted relative to the system velocity I something like four to 20 kilometers per second.

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00:19:11.130 --> 00:19:19.740

Joan Najita: And because it's just standard absorption, we can analyze them in the usual way to try to it for something, but the temperature in column densities of the absorbent.

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00:19:20.520 --> 00:19:31.290

Joan Najita: And when we do that, we find that all of them all of the species that we detect have a similar absorption temperature of four to 500 degrees and.

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00:19:32.250 --> 00:19:41.520

Joan Najita: If we ratio their column densities together to enforce them molecular abundances we find that the abundances relative abundances of these molecules.

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00:19:42.060 --> 00:20:00.000

Joan Najita: are the same as those that are seen an admission and most discs so we have the same temperature and the same abundances as material that scene in a mission and most discs but the absorption columns are

really huge they're like 10 times larger than most that then the scene in a mission.

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00:20:01.050 --> 00:20:12.240

Joan Najita: So the same kinds of properties, but with large absorption columns and inflow velocities that are supersonic at several times the sounds P, what does this mean.

112

00:20:27.540 --> 00:20:36.810

Joan Najita: But we're looking at approximately a john's we see those same properties, but with a much Archer minus a column density and the material is king following at a supersonic speed.

113

00:20:37.500 --> 00:20:46.890

Joan Najita: So now we know everything that we need to calculate the accretion week because we know the approximate distance where we're looking it's the same property have seen an admission.

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00:20:47.340 --> 00:20:53.910

Joan Najita: We know the approximate vertical competency let's say it's a 10th of the lineups a column, and we know the inflow velocity.

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00:20:55.440 --> 00:21:05.850

Joan Najita: We put those numbers together and it turns out that the accretion rate through the disk atmosphere, the source, this 10 to the minus eight to 10 minus seven solar masses per year.

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00:21:06.540 --> 00:21:17.940

Joan Najita: So a territory level accretionary the accretion rate that we usually observe falling onto the star is being transported to the tiny, tiny disk atmosphere.

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00:21:19.350 --> 00:21:20.070

Joan Najita: What time is it.

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00:21:21.660 --> 00:21:26.160

Joan Najita: it's about 100 of a gram per square centimeter thick.

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00:21:27.450 --> 00:21:34.740

Joan Najita: So we have layered accretion in the disc atmosphere now, you might see that sounds a lot like what Charles gamma proposed a long time ago.

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00:21:35.130 --> 00:21:38.850

Joan Najita: And that's sort of true but also sort of different it's still there to creation.

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00:21:39.360 --> 00:21:52.080

Joan Najita: But the column is much, much smaller so in the original pictures like 100 grams per square centimeter thick and now the same mass is being transported through a much thinner region because the inflow velocity is so much.

122

00:21:53.460 --> 00:22:10.830

Joan Najita: Different in that way it's also different because, while 100 grams per square centimeter is really hard to observe we're looking at transport through the atmosphere which, by definition, is the part that we can observe, so it looks like we're observing disc accretion in action.

123

00:22:12.150 --> 00:22:22.080

Joan Najita: This is pretty unusual we didn't expect to see this and I don't think really anybody ordered that, and so we were kind of puzzled whether what we were seeing really made sense.

124

00:22:23.190 --> 00:22:33.360

Joan Najita: And it took us a while to feel confident enough to actually write this up, so one year we were sitting on a bench at Aspen Center for physics determine to write our paper.

125

00:22:34.140 --> 00:22:46.500

Joan Najita: and wondering what we would say when our colleagues Johan shoe came over and wanted to tell us about a paper that he had just finished with gemstone and so maybe as a testament to the value of in person interaction.

126

00:22:47.550 --> 00:22:58.410

Joan Najita: It turned out that that was very relevant to what we're thinking about so in john's paper, he has a disk threaded by these green magnetic field lines.

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00:22:59.040 --> 00:23:09.630

Joan Najita: And the material is accreting in the surface at supersonic speed what at high speed, so the material is moving inward and that drags the magnetic fields in.

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00:23:10.080 --> 00:23:19.020

Joan Najita: But they're still coupled to the disk at large radius, so now we have a torque where the material that's close in wants to speed up, but it is.

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00:23:19.530 --> 00:23:32.100

Joan Najita: Being slow down, so it rotates at sub kepler in speed which helps it to move inward meanwhile the material that this mid plane fields to pull forward, and so it gains momentum and wants to move to larger media.

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00:23:32.850 --> 00:23:42.540

Joan Najita: The result of all of that is that there's supersonic inflow at the dis surface of several times and sounds so very much like what we had observed.

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00:23:44.550 --> 00:23:52.320

Joan Najita: So that gave us some confidence, but then, when I looked in the literature, it turned out that there's some other circumstances in which you could get something similar to.

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00:23:52.770 --> 00:24:10.290

Joan Najita: It turned out that our old friend disk winds magnetic wins is also predicted to produce this sort of feature in some flavors, so this is work that shooting by worked on and when I was last year as a postdoc I mean as a sabbatical visitor.

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00:24:11.550 --> 00:24:21.930

Joan Najita: And in the special case or one case we have net vertical field anti life with this rotation, you can end up with a supersonic surface accretion flow like we measure.

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00:24:22.410 --> 00:24:31.350

Joan Najita: On one hemisphere, of the desk so there's actually more than one way to explain what we see you can get the supersonic accretion flows, either in the.

135

00:24:31.710 --> 00:24:42.180

Joan Najita: coronal accretion flow case that john explained, where we're angular momentum goes out in the dispute plane, or you can explain it with magnetic winds tech you remove angular momentum.

136

00:24:42.570 --> 00:24:56.310

Joan Najita: And also cause supersonic appreciate flows so let's now have a quick confrontation or assessment of the how the various ideas stack up against the observation.

137

00:24:57.930 --> 00:25:04.380

Joan Najita: So we have our two ideas that we've just been discussing the magnetic when case and the coronal equation case.

138

00:25:04.830 --> 00:25:21.330

Joan Najita: In the case of magnetic wins the momentum is going out in the wind that allows the star to accrete yea sometimes it can produce a supersonic surface accretion flow when the magnetic field in the angular momentum director are properly oriented and you're looking at the right atmosphere.

139

00:25:22.500 --> 00:25:31.230

Joan Najita: But because angular momentum is going out in the wind, the disk won't really get bigger with time, and so this picture can only explain some of the observations.

140

00:25:33.180 --> 00:25:42.450

Joan Najita: Then we have your hands picture of the coronal accretion case here angular momentum is redistributed in the disk that allows the star to accrete yea.

141

00:25:43.050 --> 00:25:57.240

Joan Najita: It equates to a supersonic surface accretion flow like we see also great and implement and goes out in the mid plane so disk will get bigger with time also like we observed it checks, all the boxes, but the only flaw.

142

00:25:58.260 --> 00:26:00.570

Joan Najita: Is that this theory is for ideal image.

143

00:26:01.590 --> 00:26:06.300

Joan Najita: And we're pretty sure that ideal image D doesn't really apply into this midpoint.

144

00:26:07.530 --> 00:26:08.940

Joan Najita: So that's a bit of a bummer.

145

00:26:10.230 --> 00:26:21.120

Joan Najita: and obviously we even though we have some new clues to how distribution works, we still have a ways to go to figure out how it all fits together in terms of a real picture that.

146

00:26:22.560 --> 00:26:24.300

Joan Najita: explains explains what's happening.

147

00:26:25.590 --> 00:26:36.060

Joan Najita: So as a human who would like to tell you a good story for an IDC colloquium that's a bit frustrating that I can tell you a better story right now, but it gets that's part of the process of doing science.

148

00:26:36.420 --> 00:26:38.130

Joan Najita: And it comes with the territory, I guess.

149

00:26:38.220 --> 00:26:54.750

Joan Najita: of working on these sort of classic problems in astronomy which is maybe code word for very difficult, and so I wonder whether we'll ever really figure this out, and I was thinking about how that sentiment of the difficulty of understanding nature.

150

00:26:55.770 --> 00:27:07.920

Joan Najita: Is captured in a poem by another New England theorist Emily Dickinson who begins in this well known poem white mystery provides a well.

151

00:27:09.420 --> 00:27:17.730

Joan Najita: By contemplating the world and it's impenetrable circus it's live class that hides the mysteries been.

152

00:27:18.990 --> 00:27:29.670

Joan Najita: And she ends up describing the difficulty of knowing nature and how the more you try sometimes the less you may seem to know.

153

00:27:30.840 --> 00:27:32.610

Joan Najita: A sentiment that kind of resonates here.

154

00:27:34.380 --> 00:27:45.480

Joan Najita: She ends up being pretty pessimistic, you know, on knowing nature, but I think that's for our own situation here about this it's not quite so grim.

155

00:27:46.260 --> 00:27:58.500

Joan Najita: Because I think there's some useful takeaways that we can things that we can take away from the observations that are sort of independent of our ability to explain everything that we've seen.

156

00:28:00.150 --> 00:28:00.930

Joan Najita: For example.

157

00:28:02.730 --> 00:28:03.570

Joan Najita: In the poem.

158

00:28:04.650 --> 00:28:26.220

Joan Najita: The lid of the well is an impenetrable surface that hides the mysteries beneath it, but here in the disk the lid the disk atmosphere is actually doing something interesting, it may be, where the action is as far as disk accretion is concerned, and it reveals more than it conceals.

159

00:28:27.780 --> 00:28:42.480

Joan Najita: It also suggests that those atmospheres that we've been observing for decades may be doing more than just shining it may they may be the maitre accretion zones of disks and in that sense they mean, but much easier to observe description and we had previously thought.

160

00:28:45.510 --> 00:28:48.210

Joan Najita: Another idea that comes out of these observations.

161

00:28:49.530 --> 00:28:51.720

Joan Najita: Potentially as has a nice takeaway for planet for nation.

162

00:28:53.280 --> 00:28:56.670

Joan Najita: If we have the situation where we have a fast current.

163

00:28:57.750 --> 00:29:13.980

Joan Najita: As fast accretion current current overlying a deep deep the pious emotion that contains 99.999% of the mass so very shallow layer on top of 1000 grams per square centimeter.

164

00:29:14.550 --> 00:29:23.400

Joan Najita: Effectively we've separated out the accretion function of the disk from the planet formation function of the disk and that potentially allows for a very calm environment.

165

00:29:23.910 --> 00:29:37.950

Joan Najita: For planet formation even that early times because there's no need for that larger reservoir to be accreting or be very turbulent that's really great for the initial stages of planet formation, where green growth.

166

00:29:39.060 --> 00:29:44.220

Joan Najita: is helped by a lot of by Lester students, if we want to combine our.

167

00:29:45.300 --> 00:29:56.430

Joan Najita: pebble centimeter size pebbles into the planet or small size, building blocks of planets using the streaming instability this kind of low turbulence situations highly advantageous for that.

168

00:29:57.660 --> 00:30:18.600

Joan Najita: And if our planet building blocks and planets are forming in a giant reservoir of non accreting material that certainly helps to preserve those materials against loss to the central star so potentially too hopeful messages for planet formation overall.

169

00:30:19.890 --> 00:30:21.720

Joan Najita: And with that I wanted to just sum up.

170

00:30:24.270 --> 00:30:34.920

Joan Najita: So when we get to the limit of what we as humans can figure out with our brains and computers, it could be useful to phone a friend and ask for help.

171

00:30:36.510 --> 00:30:46.470

Joan Najita: Our disk friends have answered and they get have given us a couple clues maybe not the ones that we originally expected it looks like disks get bigger with time.

172

00:30:47.160 --> 00:30:55.350

Joan Najita: And that points to some kind of effective in disk element and transport mechanism so not just the usual picture of magnetic wins.

173

00:30:56.610 --> 00:31:09.180

Joan Najita: And discs may also create through the supersonic surface accretion flows that we're kind of predicted and magnetic disks but not really recognized as a potential signature, something we could try to confirm.

174

00:31:10.410 --> 00:31:17.310

Joan Najita: So that's exciting, but the models currently, as I mentioned, account for only some of the observations that all of them, we have some work to do.

175

00:31:17.760 --> 00:31:25.890

Joan Najita: But nevertheless, I think there's some pretty interesting implications of these results for our understanding of accretion and planet formation.

176

00:31:26.280 --> 00:31:37.980

Joan Najita: That disc accretion may occur in a very visible part of the disc that we did not imagine and discs as a result may be largely quiet and which is very hospitable for the formation and survival time.

177

00:31:39.090 --> 00:31:39.600

Joan Najita: Thank you.

178

00:31:45.900 --> 00:31:46.350

Thank you.

179

00:31:50.760 --> 00:31:55.740

Sarah Jeffreson: Well, thanks so much.

180

00:31:56.820 --> 00:31:58.620

Sarah Jeffreson: To me, Joan.

181

00:32:00.660 --> 00:32:01.260

Sarah Jeffreson: Poor.

182

00:32:06.000 --> 00:32:11.010

Sarah Jeffreson: Interesting talk I just like to.

183

00:32:12.390 --> 00:32:13.740

Sarah Jeffreson: Mind every.

184

00:32:16.020 --> 00:32:17.130

Sarah Jeffreson: plan.

185

00:32:18.270 --> 00:32:34.920

Sarah Jeffreson: To send through questions to me in the chat and I will I will call on you and on so just while we're.

186

00:32:38.880 --> 00:32:48.300

Sarah Jeffreson: waiting on me for those sitcom Ian I just like to ask.

187

00:32:51.030 --> 00:32:59.910

Sarah Jeffreson: How some the plot she shows le are this had the.