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| Tiffany Kataria: | All right. Welcome, everyone. I know folks are still trickling in, but I just wanted to go through the introductions, the overview of the ExoExplorers program to give ample time to both of our speakers today. So for those of you who don't know me, my name is Tiffany Kataria, and I'm at the steering committee chair for the exoplanet Explorers Biospheres or ExoExplorers for short. Thank you for attending our second set of presentations this month. |
|  | Last month, we had our first set of presentations, this month is our second. So for those of you who aren't already aware of the program, the exoplanet Explorers, the ExoExplorers for science series is sponsored by the ExoPAG Executive Committee, and NASA's exoplanet Explorers program. And it aims to enable the professional development of a cohort of graduate students and postdocs in exoplanet research, also called ExoExplorers. Each member of the cohort will be featured in webinars, it'll be live streamed, so the exoplanet community like we're doing right now, helping to increase their visibility within the field. And the cohort will also learn from the experiences of established exoplanet researchers in the field, our ExoGuides via a combination of tailored presentations and small group discussions. |
|  | The first cohort is currently running from January 2021, is when we started and it'll be running until June 2021 this year, and it's comprised of 10 very excellent early career scientists who you'll hear from last month till June. So if you want to learn more information about the program, the Organizing Committee Chair, Vanessa Bailey, who's also on the line will post some links in the chat, so be on the lookout for those. |
|  | And so with that, it's my pleasure today to introduce the two speakers from this cohort that will be speaking. Before I get to the intros, I just wanted to remind, folks with a couple of ground rules. First reminder from our welcome message to behave rationally in the forum. Be kind to one another, let's have productive conversations. And second, we plan to save questions for each speaker until the end of their talk. So please either use the WebEx chat function, or the hand raised tool. If you hover over your name, you'll see a hand icon, so you can click that to raise your hands in the talk. And with that, I think we'll get started. |
|  | So our first speaker today is Quang Tran. Quang got his BA from the University of Chicago and is currently a third year graduate student at UT Austin. He's also a recipient of the finest fellowship, and that's actually sponsoring the work that he'll be discussing today. And so the title of his talk today, and Quang want to pull it up is “*Establishing the Epoch of Giant Planets Migration*.” And so with that, Quang whenever you'd like to get started, take it away. |
| Quang Tran: | Awesome, can everyone hear me? Okay. Great. Thank you for the wonderful introduction, Tiffany. As stated, my name is Quang Tran, a third year graduate student at the University of Texas at Austin. Before I begin my talk today, I just want to give a big shout out to the steering and organizing committees of the ExoExplorers program for all the wonderful work in organizing our cohort, the talks and all of the different workshops that we've been a part of. Thanks so much to them. |
|  | Today, I'll be talking about my work and how I'm establishing the epoch of giant planet migration, using a near infrared precision radio velocity survey with the habitable zone planet finder, HPF, a spectrograph located at McDonald Observatory. This wouldn't have been possible without the help of my collaborators, including my advisor, Brandon Bowler, and the entire HPF team and all of the work they've been putting in creating the instrument as well as commissioning it. |
|  | So this talk will be split into two different segments. The first half will be where I set up the problem and motivate why we're interested in giant migration in the first place. I'll also discuss the difficulties involved in studying this phenomenon. And the second half, I'll shift gears and discuss why or how we're investigating giant migration in a very unique way, give a progress update where we are understanding this issue, as well as lay the foundation for the next steps of the problem. As with many exoplanet questions out there, we begin with a protoplanetary disk. |
|  | Here, I'm showing a diagram of a radial slice of the protoplanetary disk. We're going to zoom in here to the bottom left hand corner to show this 150 case no line marked in blue. Exterior or further out from this boundary or radial distance we expect most giant planets to have formed. This is because temperatures are low enough at these radio distances, such that the molecules can actually condense efficiently or most efficiently into [inaudible], and eventually formed our giant planet cores and what we see in giant planet overall. |
|  | So we expect giant planet to have formed at these distances further out. And so we therefore expect them to be where we see them now, right? But actually, what we actually see is that there exists an appreciable population of giant planets interior to the water ice slide. So here, I'm showing all of the gas giant systems taken or around some stars taken from exoplanet.au with their masses on the Y axis, and the orbital separations on the X axis. I've also marked the water ice line, it's coated black line here, roughly 2.5 AU per Sun-like Star. |
|  | And so what we see in these blue circles is that quite a few of the [Dasha] systems around them like stars actually seems on the left hand side or interior to this 2.5 AU boundary. We can actually go a step further and compare the occurrence rates or frequency of giant planets at these different radio bins for Johnson et al 2010 measure, an occurrence rate of about 6.5%. For giant planets within 2.5 AU. More recently wouldn't matter at all 2019 measured a comparable occurrence rate about 6.7% for giant planets within orbital separations of three to seven AU. |
|  | And so the current rate of giant planets, the giant planets form or are seen as equal rates in both close in orbits as well as in further out orbits based on this demarcated water ice line. And so you have to ask ourselves, okay, if we expect our plans to perform most efficiently outside, if we expect to see them outside of this boundary up further off distances, where the heck are all these close and Jacqueline's coming from, right? So, here's an accurate depiction of me working on this problem every day at my desk. That we might expect these giant planets if they form further out, just somehow moved inwards to their closer in orbits over their lifetime. |
|  | But luckily, there are two fragments, two broad migration mechanism that could potentially explain this population giant planets. You have in spiraling just migration and through body dynamical interactions. Hopefully, you can see this graphic. For inspiring just migration, you have to have the existence of a protoplanetary disk. The giant planet forms at a further distance, it slowly creates material as it spirals inward. So here's just the primary shown, so it shrinks its orbital separation as you they [inaudible] mass and fills out this gap in the protoplanetary disk shown in the black here. |
|  | And so that is one possible way for it to end up at a cluster in orbit. Another possible migration mechanism is through body dynamical interactions, which include mechanisms such as COVID, cycles are planning, scattering, so these are essentially the kind of migrations. These typically consists of the effects caused by tertiary body that essentially perturb or excite the giant planet orbits into a highly eccentric one. And over time, it's trivializes into a much closer in orbit. |
|  | And so you have these two different buckets of migration mechanisms that could potentially explain this population of closing giant planets. But there is a diversity and huge range of observed properties of the giant planet population that we eventually see. Some of these properties, of course, include the spin orbit geometry of the systems. This in particular we care about received stellar spin access or planet orbit access misalignments, where it would expect from debir dynamical interactions to cause it. |
|  | You also see warm Jupiter by highly eccentric orbits, or just in general, this wide distribution of planet periods. And it's interested, it's seen in the giant planet population. And of course, you see a wide diversity of ranges of multi flares architectures, and in particular, the dearth of additional planets and systems would close in giant planets. So all these different properties, all point to a slew of different effects that could not possibly be explained by just one or the other of these two different migration mechanisms is that what we'd expect us to assess that there is some sort of overlap in Kotlik influence between these two different pathways. |
|  | But what we do want to do is disentangle these two migration pathways and ultimately determine which one of these plays the most important role or the dominant role in sculpting the demographics and the statistics of the giant planet population, as we see it. One of the ways we can do this, it disentangle these two is by looking at their different timescales. So, we can actually observationally distinguish these pathways, since they operate on such the same time scale. So in spiraling just migration must have taken place prior to 10 billion years. This is because you require protoplanetary disks if you're going to move via the disks and just dissipation timescales are typically less than 10 million years. On the other hand, three body dynamical interactions typically occur on the order of 10 to the seven, or 10 to the 10 years, so much, much longer than the different lifetimes. |
|  | So because these migration pathways operate under interesting timescales, I.e much earlier much later, in the lifetime of a planet system, we can separate them in time and ultimately look up in which time period do these migration mechanisms dominate, and ultimately, which one prevails in their influence giant planet systems, in particular, we can do so by looking at how giant planet or close giant planet systems evolve over time. |
|  | So I'm going to look at this and particularly the occurrence rates or we're going to dial this down all the way to a singular number each frequency or occurrence rate of giant planet close and giant planet systems. What I'm showing here is this frequency value of P percentage on the Y axis and different age bands on the X axis. So starting from the far right, you have the field results with these four stars that are typically greater than one gig a year from the Johnson et al measurement of about 6.5%, and it's error bars of about 1%. On the far left hand side, you have very young stars, if it's less than 10 million years where you expect giant planets are typically to have been forming, but they're just being born. |
|  | And in the middle, you have this age range of about 20 to 200 million years. That's in the middle of what I just mentioned before, of the two different bins of migration mechanisms, it's a little older than just migration, it's definitely younger than dynamical interactions. And so the idea is by looking at the evolution of giant planet frequency over time, you can distinguish between which of the mechanisms is playing the most dominant role. For example, if you look at this intermediate age range, measure an occurrence rate of close in giant planets, that's statistically similar to the fuel result, I.e the current rate of giant planets at young ages is similar to the current giant planet are all ages in the same orbital separations, then you can expect that this migration to be the most dominant flares of giant planet migration, right? |
|  | Because on the timescales of the host stars of... Sorry, excuse me. If we expect the giant planets to form further out, then they must have migrated inward to their close in orbit as we see them today on timescales that should be shorter than the host system that we see them in I.e less than 20 million years, which is the disk migration timescale. On the other hand, if we measure statistically different occurrence rate, then we can expect that dynamical interactions to play the more dominant role because on the timescale of the systems that we're looking at, I.e 200 million years, there isn't enough time for all outshine planets to have migrated inward via dynamical interactions, such as planet scattering, right? |
|  | And so by looking at evolution over time of the occurrence rate of closing giant planets, we can slowly constrain or disentangle this migration pathway and really not tackle down the dominant migration mechanism and its characteristic timescale. So this is relatively simple. I think if you are an exoplanet scientists, people have done RV studies of planets before, people have done transit service before, people... population statistics is something not new to the community in general. And so you might ask, okay, why we haven't done this already? Well, obviously, in order to do this, we need to look at the closing giant planet population at these young ages. The problem of course, is that young stars have very strong nine non dynamically induced astrophysical variations from a slew of different sources such as granulation on the [inaudible] surface. Key mode of acoustic oscillations from the interior of the star, long term magnetic activity cycles conducted reship suppression and other rotational grinding, all of which plays or contribute different parts, different levels of noises to the observed measurements that we get such as reduced velocities. |
|  | In particular, for young star, star spot induced variability is especially pernicious. So here I'm showing a diagram of a star with no sunspots on the left hand side, and a diagram of a star with stars with an single star spot at different locations on the solar surface. So if you observe a star with no sunspots on the left hand side, then you get a spectra or line profile shape that's extremely pristine, as you would see on the left, lower left hand corner. However, with the existence of a star spot on the stellar surface, they're slow. As you observe that star, you get distortions in that line profile shape that eventually contributes different variations. In your rate of velocity measurements, that changes as a function of the location of that star spot on the surface. Right? And so you can see how the stars, the line profile shape slowly changes over time. |
|  | And because it changes as a function of location on the surface, this distortion, which ends up giving you different variations in your measurements is periodic, along with the rotation periods of the star, and so this periodicity mimics the kind of signals that we actually get from stars or sorry, from planets, which is really problematic because now you're like, "Okay, is it an activity signal, or is it a planet?" Very unclear. |
|  | This problem, again, is especially pernicious for younger stars, because as you move from older ages to younger ages, I.e as you get younger, the magnetic activity of the system increases dramatically, as well as our spot coverage. So here I'm showing images of what a star would look like, and it's magnetic activity would look like at different ages. So on the far right hand side, you have a star that similar to our sun at 4.5 billion years and you get the different ages 2,000,000,250 and 250 million and then less than 300 million years on the left hand side, where you can see the star coverage all these black splotches on the surface greatly increases as we increase in age as well as greatly increasing the magnetic activity. |
|  | What this ultimately translates to as, are measurable quantities such as... are based on the amplitude, is that for very young stars such as our sun, you get activity similar on the order of about five meters per second. So reference this, this is pretty quiet and very measurable. Two billion years, this number doubles in 10 meters per second at 650 million years, you get activities similar at about point five meters per second. And then as you reach to the age [inaudible] considering, right, which is like 20 to 200 million years, you get activity similar as high as 35 meters per second, which is still not as spooky sounding, but you can potentially go up as high as four kilometers per second, which is very, very scary, I think, if you are looking for planets. |
|  | So reference, that you've heard about one a year, so this is a Jupiter sized planet, at the first location around whatever its host star is, contributes to the RVT amplitude about 20 meters per second. So if there was a Jupiter [inaudible] you around a star 650 million years old, you would just barely have that planetary signal peak out above the activity. And this start getting extremely tough to statistically robustly measure the mass of this planet to determine that it actually is there. For a hot Jupiter, which is our most readily detectable planet, i.e contributed the biggest signal after maybe 200 meters per second, you would definitely see it at a 650 million years star or would they not say definitely, but it definitely would peak out if activity singles were at the 35 meters per second. But like I said, for the very young stars, as many people will know, these activity signals will even dominate these gigantic enclosed in planets, right so it starts getting very hairy very quickly. |
|  | So this first half, I'll recap right now what I've done so far to set up the problem. Hopefully, I've motivated why we were interested in giant planet migration. We expect giant planets to form much further out, but we see quite a bit of them closer in to their expected most efficient formation boundaries. So the origin of these closing gas giants currently remains an open question in exoplanet community. We can disentangle their origins by looking at younger stars in order to see the evolution of giant planet populations over time, and studying young stars is very difficult due to their increased magnetically induced activity. |
|  | So I'm going to shift gears now to potentially motivate the solution that we're going to posit to the community, and how we're going to do it in a unique way. One of the ways we're going to do this is observing in near infrared wavelengths because doing so is expected to reduce the radial velocity contribution of star spots by quite a bit. This is because if you look at the schematic here, I'm showing the radiation of the stellar photosphere as opposed to the star spot in red, go to zoom blue and a near our... sorry, at optical wavelengths, on the left hand side, the contrast between the two radiations of the stellar photosphere in the star spot is very high, which translates to the big variations and activity that we see in our observables, i.e our recently amplitudes. |
|  | As you move to the right hand side near infrared wavelengths, that contrast i.e the difference between these two radiation greatly reduces, and then that ultimately translates to greater reduced the activity signal. Hopefully beating it down enough so that planetary signals can really pop out. HPF or the Habitable Zone Planet Finder is an ideal instrument to leverage this wavelength dependence to ultimately detect giant planets around and stars. So I want to focus here on the near infrared aspects of this instrument. So it's extremely powerful, obviously, and I'll get into that, but it's one of the first instruments of its capabilities that really focuses on the wavelength range of about 800 to 1300 nanometers. |
|  | And so it's primed to really look for giant planets around young stars. On top of this extremely powerful instrumentation that's temperature stabilized, vacuum sealed fiber fed, high resolution, high resolving power of the [inaudible] 5000. It's also located at the 10 meter [inaudible] telescope and the Dawn [inaudible], which gives it this powerful tool set to really tackle this problem in a new and unique way. |
|  | The HPF team has demonstrated a beam precision about 1.53 meters per second around an RP standard Benard's star, which just again confirms the instruments capabilities, and proves that it's competitive with the other precision spectrograph out there. |
|  | So now I think is a good time to really revisit the tagline of this talk and near infrared precision radio velocity surveys young solar analogs with the Habitable Zone Planet Finder. So with new HPF is a new exciting, near infrared instrument to look at young stars. Hopefully, the tech giant planets around them measure or constrain the occurrence rate of these giant planets at young ages, compare our measurement with the field population or older stars, and then ultimately establish the epoch of giant planet migration. Right. |
|  | Of course, in order to do this, we need to look at young stars. So this middle intermediate age range of 22000 million years. If you start at the top of the diagram I showed previously, I live with that, as a young moving group beam. Young moving groups of stellar associations that are spatially close by as well as or spatially close to each other, as well as kinematically, co-moving that are very bright, they're nearby and have been well characterized due to the extensive AO imaging that's been done on them. And so they provide excellent targets in this exact age range, because their ages are very well constrained, as well as their membership in the spot. |
|  | So pulling from these young moving group associations, we've been able to compile a target list of over 100 targets that are all very bright in J mag, young again, in the 20 to 20 million year age range, all selected, versatile, rotators are less than 30, 35 kilometers per second, ranging spectral types from all the Gs and all the Ks. And of course, on nearby, we picked a number of over 100, which is exactly the kind of constraint that we need in order to make a statistically robust assessment of occurrence rates between ages. |
|  | Moving on, if you've been wondering about what HPF data looks like, here is the raw 2D structure on the left hand side and the inset image on the far, the top right hand side focusing on the structural traces. HPF, again, is a fiber based instrument with three fibers that are simultaneously looking at three different things that every observation. One is looking at the night skyline, one is looking at, of course, your science spectrum, and the others looking at that laser frequency, comes with the web which is a well characterized, well understood [inaudible] that is used for precise wavelength calibration. So this 2D structure has been optimally extracted into the 1D structure that we all know and love, as shown on the bottom right here. |
|  | So we take this data, and then we shove it through a precision radial velocity pipeline. Here, I spent the last couple of years of my PhD developing a custom RB PRB pipeline based on the [inaudible] algorithm that you need for its matching technique. I'll explain it here using the schematic. You have the science spectrum that you take in from your science target, whatever observation, you have a high signal to noise empirically based templates created from all of your different signs spectra. And what you do is leave the sign spectrum in there, and then shift that template in small velocity stuffs, i.e in small wavelength changes. And then at each step, calculated at least squares fit between the sign spectrum in the [inaudible]. |
|  | As you do this over a large range of velocities, you eventually create a [inaudible] type grade velocity curve as seen in this third column here, and the global minimum, which then corresponds to the radial velocity of that time spectrum. So you get a bunch of relative radial velocities for your target. Using this technique, and the data that we have on hand, we've been able to demonstrate an on [inaudible] stability at the sub two meters per second level on an RV standard. Here, this is a bright K2 [inaudible]. And I'm showing a binned RV precision of about 1.9 meters per second, which is slightly better than the 2.4 optical measurement, 2.1 meter per second optical measurement for the same target. |
|  | So this just demonstrates again, that we're not going to be limited by the instrument, which is very powerful, or even our software, but more so the activity, which is going to be orders of magnitude higher than this. But hopefully, we've already beaten this down by moving into the near infrared. So we're really just primed to look for these giant planets [inaudible] stars. |
|  | So this last bit of the talk, I'm going to be discussing some of the results from the first 14 ish months of my survey that's already been going on. The paper is up on the archive, it's been accepted by AJ. So if you want to just check it out on the link, the archive number is shown on the right hand side here. And if you just have a QR code, or just feel free to scan it, right there on the left. |
|  | Again, I'm going to be discussing some of the results, but in the interest of time won't be able to discuss all of it. One of the really cool things, some hierarchical population modeling that we're doing to constrain how stellar activity ultimately contributes or formulates the RV measurements that we see. So if you're interested in any of that, those kind of results, those kind of population modeling or understand how stellar activity operates. At these age ranges, if you care about the template or the matching process, the survey design, please check out the paper or reach out to me to talk about it. |
|  | One of the main results that I do want to talk about is this comparison between the near infrared and optical RV scatter. So this is a very busy plot, but I'll try to break it down here. In the blue, I'm showing the distribution of RV scatter on the X axis here, RV RMS that I've measured for each one of my science targets or a subsample of my science targets. In the orange, I've compiled a list of measured RV scatter or a sample of stars with similar ages 20 to 20 million years rotational velocities [inaudible] congress for a second, spectral types GK from a list of precision rate of velocities. |
|  | And so what I measure is that the median near infrared scatter or RMS for the RVs is about 34 meters per second. Whereas in the optical for that same sample of stars or similar sample stars, you get about a median scatter 16 meters per second. So, this is a reduction about a factor of two, in terms of RV scatter primarily from activity because we removed any giant planet forces, which is very encouraging. This is confirmation of the initial premise of what I initially set out to say, at the beginning of the second half of the talk, where I posited that moving to the infrared will reduce RV contributions from star spots that can be moved from the optical to the infrared. So, this is great, that bodes really well for the future prospects of the survey and how we might ultimately look for young planets around young stars. |
| Tiffany Kataria: | Hey, Quang, sorry to interrupt you. You've got about three minutes left. |
| Quang Tran: | Yeah, thank you. One other relationship that we looked at is the stellar jitter, how to build relationships without stellar jitter, changes of a function of the stellar age of the system [inaudible] et al 2015, looked at this in the optical, we reproduce those results in the left hand side. And using our subsample of stars, we've compiled here a list of... in the literature and added quite a bit of our own systems to reformulate that relationship in the near infrared showing that yes, stellar jitter does decay logarithmically with stellar age in both optical and new boilerplate links. In particularly, you have a shallower relationship in the near infrared, which I dive down deeper into in the paper, so please feel free to check that out. |
|  | So the future work about where we're headed, we're going to obviously continue the survey after four years to reach the giant planet. But about that 2.5 Aus [inaudible], we're going to measure their [inaudible] here with the field sample to constrain the nominate giant planet migration mechanism. For some of the high RMS objects of interest that we saw, we're going to include multi wavelength follow up, i.e simultaneous optical and near infrared RV coverage plus photometric observations, like via test light curves. And then finally, we're going to develop rules to mitigate stellar activity and Adrian. So I did mention some foundational hierarchical modeling done in terms of constraining the new infrared stellar activity and how that applies to RVs, but we're also going to focus on individual targets to constrain using Gaussian process to model them in the activity and ultimately back out how that contributes to RVs that we see. If you're again interested in any of that work, please feel free to reach out to me or check out the paper. |
|  | Finally, I'm going to just recap real quick. Solving the problem, how are we investigating giant planet migration in a unique way? When a search for giant planets around young stars in the near [inaudible] using the powerful HPF instrument. We've been able to demonstrate two meters per second, on an RV standard with the pipeline that we've created. We've been able to confirm on a population sense that moving into the near infrared from the optical does reduce the RV contribution of jitter of stellar activity by a bit. We found several objects, high RV RMS values in our distribution of measured RVs that could be potentially caused by closing planet. So the next steps that we're taking, we're going to follow up on the objects of interest, we're going to finally complete the survey after four years reaching that 2.5 AU. And as the tagline of the talk says, establish the epoch of giant planet migration. And with that, I'll end my talk and take any questions. Thank you. |
| Tiffany Kataria: | Alright, thanks very much, Quang. That was awesome. Any questions? Feel free to use the hand raise tool, as I said, or if you have questions in the chat. Yeah, use a hand raised tool or put them in the chat. I see one question from Vertron Medicine. Vertron, go ahead. |
| Vertron: | Yes, thanks. Thanks a lot, Quang. Just a great tool. To just push you a little bit, do you have any kind of candidates so far? I know that you want to pull up over longer times, but do you have any new really promising candidates that you have identified in your survey is some sample of [inaudible]? Can you do that? |
| Quang Tran: | Yeah, I do... let me go back to these... [inaudible] over here. So we do have a handful of targets in this [inaudible] right here that tell if you can see my mouse circling around the diameter in the 150 to 200 RMS range in our distribution of observed RV scatter, right? And so this could be activity very much so but it could also be, like I said before, a hot Jupiter because that's what exactly the range that a hot Jupiter would contribute in RV. Right? So we're going to definitely follow up on those. Some of these targets actually have enough [inaudible], I could shove it through a periodic gram and really get down into the signals. And then they demonstrate some periodicity in the test flight curves that we can start removing whether or not it's a planet or activity. I haven't focused too much on those exact objects., so I can't give you a name or whatever, unfortunately, but once those come out, you'll definitely see a paper. Thanks for the question. |
| Vertron: | Mm-hmm (affirmative). |
| Quang Tran: | Tiffany, I think you're muted. |
| Tiffany Kataria: | Thank you, Quang. Yes, Elizabeth Newton has a question. Elizabeth, if you want to go ahead and ask yours. |
| Elizabeth: | Thank you. Yeah, I'm not [inaudible] expert. You had that plot showing that shallower slope of jitter versus age, I didn't quite... Oh, yeah. I was wondering, it looks like maybe the errors are actually larger than... this might not be like a conclusive thing you could say, but it looks like it's possible that the intrinsic jitter in the infrared could be higher at older agents than in the optical. And I was wondering if that was anything that you expected, or whether that would be super weird. |
| Quang Tran: | Yeah, so I do dive deeper into this. So this is what I was hinting at earlier that... I do mentioned this in the paper. But our older ages for sure, I think the intrinsic instrumental floor is lower than optical. This is just that if you look at TK door, so this is selecting for that spectral type range, you just get more lines in the optical for example. As well as the fact that near infrared spectra graphs just don't hit as deep. You're getting like maybe one to two meters per second incremental precision, right, but some of the extremely precise optical spectrograph they're hitting stuff meter per second precisions on very quiet stars at that age range. Right? So it's a confluence of I think both of those things instrumental, yeah, a confluence of those different influences does cause that tribe up at older ages that you see for sure. |
|  | One thing I will add really quickly is that at younger ages, you'll see because it's shallower that it does pivot down with the younger ages, which I think confirms exactly what we're talking about is that moving into the infrared from the optical. At younger ages, it definitely beats down on that instrumental effect, and you just get a reduction no matter what. And I think it pivots, I discussed some of this in the paper activity right around the age range that I'm picking out. So we're still getting that positive influence. |
| Elizabeth: | Okay, thank you. |
| Tiffany Kataria: | Alright, last question to Mark Twain. Mark, go ahead. |
| Mark Twain: | So thanks for a really nice talk. I was curious about the modeling game you expect for the tools that you mentioned to be developing, or the treatment of solar activity. And I think I'm [inaudible] that in your own signal. How much of that activity do you expect to be able to remove? |
| Quang Tran: | Yeah, that's a really good question, actually. And I'll just briefly touch on it right now, because I haven't really dived down too deep into it, because that's the next step. One of the things that people have done really well, the papers [inaudible] me right now, Quang by 2015, I think that, that is a prime example of this. You essentially look at simultaneous photometric coverage, i.e the light curve, which should have traces of activity in it, if it jumps up and down a lot, you run a Gaussian process model and train that model on the different activity indicators on a semi periodic sinusoidal model. Those different parameters then inform you about how the activity changes, and the notionally contributes to the RVs. So that's just an overview. |
|  | What I've seen that from my own experiment is that the RMS from the model fit, i.e from the radial velocity fit after you done this Gaussian process training and informing your RVs, the scattered reduces that quite a bit, i.e the RMS from the observed minus the model and whatnot, decreased by a bit, but the math determination depending on the age of the system, it doesn't improve as much as you want. So if you already are at like 20% of an error budget in terms of your math determination, then you might be able to drive it down to even 10%. But if you're already at 10%, then you're not going to increase your math determination of your planet as low as five or even 1%. So, that's the kind of level of constraint. But I think that's really important, because at 20% to 10% of 200 meters, you're really hitting that planet, [inaudible], really. |
| Mark Twain: | Great, thank you very much. |