Hi, we're scientists who are scouring the night sky for exoplanets, and then trying to determine if any might reside in the "habitable zones" of their stars. Ask us anything!

AAAS-AMA [1] and r/Science AMAs[1]

[1]Affiliation not available

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Abstract

Discoveries of planets outside our solar system have burst from a trickle to a flood in recent years, transforming our understanding of the Universe. NASA's Kepler exoplanet-hunting spacecraft and other missions have shown that the Milky Way Galaxy is teeming with at least tens of billions of planets. These exoplanets come in a variety of shapes and sizes, from smaller than Earth to larger than Jupiter, and include a small number of Earth-size planets in the "habitable zones" of their stars. Telescopes like the Hubble Space Telescope are carefully examining the atmospheric compositions of many of these alien worlds. However, the goals of imaging an Earth-size planet around another star and comprehensively understanding surface properties and atmospheric characteristics remain elusive. The launch of the James Webb Space Telescope in 2018 will help move comparative planetology forward, while astronomers are continuing to design and develop the next generation of observatories. As scientists deeply involved in this research, we welcome your questions about the current state of knowledge about the diversity of exoplanetary systems, and the challenges of direct imaging and atmospheric characterization in particular. We're especially interested in telescope concepts under development to directly image exoplanets and search for water, ozone, oxygen, and other potential markers of habitability, and envision where these may take our understanding of exoplanets in the next decade. Ask us anything! Debra Fischer, Professor of Astronomy at Yale University. Jessie Christiansen, Astronomer at the NASA Exoplanet Science Institute, California Institute of Technology, Pasadena CA. Aki Roberge, Research Astrophysicist & Study Scientist for the LUVOIR space telescope concept, NASA Goddard Space Flight Center, Greenbelt, MD Jennifer Wiseman, Hubble Space Telescope Senior Project Scientist, NASA Goddard Space Flight Center Dr. Patricia Boyd Chief, Exoplanets and Stellar Astrophysics Laboratory & Director Transiting Exoplanet Survey Satellite (TESS) Guest Investigator Program, NASA Goddard Space Flight Center

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AAAS-AMA R/SCIENCE

Discoveries of planets outside our solar system have burst from a trickle to a flood in recent years, transforming our understanding of the Universe. NASA's Kepler exoplanet-hunting spacecraft and other missions have shown that the Milky Way Galaxy is teeming with at least tens of billions of planets. These exoplanets come in a variety of shapes and sizes, from smaller than Earth to larger than Jupiter, and include a small number of Earth-size planets in the "habitable zones" of their stars. Telescopes like the Hubble Space Telescope are carefully examining the atmospheric compositions of many of these alien worlds. However, the goals of imaging an Earth-size planet around another star and comprehensively understanding surface properties and atmospheric characteristics remain elusive.
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Ask us anything!
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AAAS-AMA , r/Science , Hi, we're scientists who are scouring the night sky for exoplanets, and then trying to determine if any might reside in the "habitable zones" of their stars. Ask us anything!, *The*

Hi! First of all, thank you for taking time to answer questions in this AMA.

I understand that scientists search for water, ozone, oxygen and other markers of habitability because these are the markers of "life" as we know and understand it right now. Living things can survive in very harsh conditions. I assume it would be possible to have "life" in completely different conditions than our own. Is this a possibility that scientists take into account? If so, how?

Also, what life or life marker is expected to be found? Are we talking about bacteria/cells/viruses with DNA or RNA?

Miss_Eliquis

Aki Roberge (AR): Yeah, good questions. I too assume that life can arise and thrive in environments that Earth life couldn't tolerate. There may be other habitable environments in the Solar System (like in the ice covered ocean of Europa). But Earth is unique in the Solar System in that it is the only planet teeming with surface life so abundant, it's changing the chemistry of the whole atmosphere. This is

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probably the only kind of life we can detect from interstellar distances. So astronomers' focus on the Earth as a model isn't totally self-centered, but is kind of an observational constraint.

Hi. Thank you for doing an AMA. I have a few questions if that is ok.

- So i am a physics student currently and im interested how did you get a job looking for exoplanets, anywhere particular to apply and any particular branch of physics to study?
- What methods do you use to find them? I understand that the best method right now is to look for periodic dips in intensity of light coming from a star, but do you use any other method?
- Why is James Webb space telescope being delayed for so long, shouldnt it have launched years ago?

Thank you.

F1reLi0n

Padi Boyd (PB): Hi F1reLi0n, it's great to hear you're studying physics and that you're interested in joining the hunt for exoplanets. One of the coolest things about this area of research is that many different types of science are being focused on understanding exoplanets. Some teams focus on discovering planets, and others are working to understand these planets as places.

I recommend you start reading some research papers and decide which type of exoplanets research interests you most. Then look at the list of authors and the universities they are working with, and start looking into those universities for graduate school. If you see a really cool result in the news media, there is usually a link to the research paper. Start there.

You asked about methods to detect exoplanets, and you described the transit method that looks for periodic dips in the light coming from stars. That method is what the Kepler/K2 mission used, and it has become the leading way we've found planets recently (with thousands of Kepler/K2 exoplanet candidates found to date---4496 to be exact;see: https://exoplanetarchive.ipac.caltech.edu/).

But it is not the only method! The Wide Field InfraRed Survey Telescope (WFIRST) will find thousands of planets orbiting their stars at distances much further than Kepler and K2 could probe. See: https://wfirst.gsfc.nasa.gov/exoplanets.html

And planets have been discovered, and their masses measured, through the radial velocity technique: measuring shifts in the lines of the star's spectrum that are the result of the motion imparted on the star by the planet.

We are all getting very excited for the James Webb Space Telescope to launch early next year, because it will be the largest and most powerful telescope ever launched into space and can make some key measurements of exoplanets. The observatory is one of a kind and will deliver transformational science. The project did fall behind schedule much earlier this decade, and a careful replan was done with a new management structure and schedule. The project has done a very good job since that time maintaining the schedule, and the team has been doing a tremendous job integrating the spacecraft, putting the components through its final sets of testing, and readying it for launch soon.

Hi, thanks for doing this AMA.

About 25 years ago, I had the pleasure of interviewing Jill Tartar for AOL. One question asked was, "When will we be able to optically image exoplanets?" Her answer, summed up was, "In about 30 years."

Now, we're only about 5 years from that date. Where do we stand with the technology required to visually gather light and data from exoplanets, or even be able to generate images of them?

disgustipated

Aki Roberge (AR): pogobi is right - we've done it already! The first exoplanets were imaged in 2008. Here's a link to a more recent movie showing my favorite system: HR 8799, which has four super Jupiters orbiting far from their host star. This is another kind of planet that we didn't know could exist!

When you eventually find an exo planet in the habitable zone and analyze the atmosphere and discover without a doubt that there is life there..... What then? Can you spread the story to every news channel and all over social media? Or do you need to notify the government and they can release the information as they see fit? Is there a protocol for what to do after we discover we are not alone?

3n2rop1

[DF]: I love this question! When I was a grad student, Frank Drake (Drake equation) was my professor for radio astronomy and I asked him what they would do if they found a signal. He said that they would first verify, and once confirmed, they would tell everyone (not the government first). Our research is supported by the public. I'm sure that's what I would do and that is what all of my colleagues would do. We would follow the SETI protocol.

If we had to leave the Earth in let's say 75 years because of an ELE and you had to pick an exo-planet right now as a destination and hope for the best when you got there which known exoplanet would you bet bet on? Edit : grammar

NugginBumplies

Debra Fischer [DF]: OK, if we only have 75 years to prepare, our only option is to go to Mars! The distances to other stars is soooooooo far that we have no technological way to get there. I would like to find an environment like Earth - we haven't found an Earth analog yet (my team is working on finding this type of planets orbiting the closest stars).

How can you tell the composition of a planet that far away?

atheitarian

Jessie Christiansen (JC): Hi there! What a great question. For telling the bulk composition (on 'average' what it's made of), we need the density. We can measure the radius if it's transiting (passing in front of its star), and we can measure the mass if it's either tugging on its star (the Doppler technique, that Debra Fischer is answering elsewhere on the AMA), or tugging on the other planets (via the transit timing technique) - then we can calculate the average density. If the density is very low, we know it's made of gas. If it's very high, we know it's rock (or iron). If it's in between, that's where we don't have as clear an answer, because there are degeneracies - a small rocky core with a huge gassy atmosphere would have the same radius and mass as a big ice ball, for instance.

For telling more detail of the composition, at the moment we're limited to studies of the atmospheres of big planets. We typically study those by gathering transmission spectra - studying the starlight from the host star as the planet passes in front of the star and blocks some of the light. Different molecules (water, carbon dioxide, etc) block different wavelengths of light, so we can deduce the molecules in the atmosphere by seeing which wavelengths get blocked by the atmosphere of the planet.

How can you tell the composition of a planet that far away?

atheitarian

[DF]: Great question! We're asking that very question, too. Here are some of the things we do: (1) measure the mass of the planet and (2) measure the radius. It's not always easy to get both of these data points, but when we do, we can calculate a bulk density for the planet. That tells us if the planet is rocky (like Earth) or a gas giant. And we can check the chemical composition of the star to get more hints about the internal composition of the planet.

What's the most exciting system you've worked on?

280394433708491

JC: For me it was K2-138! A five (maybe six!) planet system found by citizen scientists using the Exoplanet Explorers project (exoplanetexplorers.org). We present people potential planet signals and ask them to vote - yay or nay? Then we sift through the highly rated results. There were four strong signals found by the citizen scientists using the project, and then later a fifth signal was found. Those five planets form a resonant chain: each planet takes 1.5 times as long as the planet interior to it to orbit its star! That gives us important clues as to the formation mechanisms for these planets - instead of a violent, scattering past, they must have formed smoothly, moving together in lockstep. There is potentially a sixth planet in the system that we are going to be following up with the Spitzer telescope next month!!

What's the most exciting system you've worked on?

280394433708491

[DF]: For me, it was Upsilon Andromeda in 1999, the first triple planet system that we discovered. I loved this because while I was modeling the data to reveal all 3 planets, I was listening to an interview with a biologist on the radio who said "where ever we find water on Earth, we find life." At that moment, I thought that if stars could form planetary architectures with 3 giant planets packed inside of Mars's orbit here, that planet formation must be common. I was struck by the idea that planets were common and that if there was water, life might be common.

What are your own, personal favoured hypothesises for solving the Fermi Paradox? Where the hell is everybody?

EDIT: clarified phrasing of question

the_turn

AR: Look, the only life you can detect on Earth from interstellar distances are bacteria and plants, not us. I think it's a mistake to think that technological life forms are inevitable, abundant, or even conspicuous.

What are your own, personal favoured hypothesises for solving the Fermi Paradox? Where the hell is everybody?

EDIT: clarified phrasing of question

the_turn

JC: I like the idea that we're just out in the 'burbs and haven't been found yet. There isn't really a 'good' solution though.

Hey and thanks for this AMA!

When searching for habitable zones, are you looking for zones where humans/life on earth could maybe prosper, or are you looking for zones where some kind or any kind of life form would prosper?

In other words, are you more emphasized on looking for a place for us to live, or are you mainly looking for other lifeforms?

Bonus: Any luck yet?

AAAAnT

[DF]: Excellent question. To be honest, I am not looking for a place where humans could move. I am looking for other Earth like planets b/c I am betting that these will be good petri dishes for life. If we leave this planet, I think the best way to go is with nanobot spacecraft that don't take much energy. We could send along our DNA with CRISPER instructions for replication. But, putting our bodies in a spacecraft and traveling for centuries to the nearest star system? Something probably has to change before we image space travel ala the Starship Enterprise!

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Bonus: Any luck yet?

AAAAnT

JC: It's hard to imagine all the different chemistry that could create forms of life. So, we wouldn't even know what signs to look for to cover all those bases. In fact, we might see signs of other forms of life that we don't even recognise as life! So, we're concentrating on looking for things that we know *we* need, because that is a form of life we can predict biosignatures for. It's a failure of imagination, certainly, but we'd like to be able to recognise what we find!

Hey and thanks for this AMA!

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In other words, are you more emphasized on looking for a place for us to live, or are you mainly looking for other lifeforms?

Bonus: Any luck yet?

AAAAnT

AR: Actually, both at the same time, since our experiment to find other lifeforms is guided by what we know about life on Earth.

Hi, welcome to reddit!

I'm curious about objects outside their star's theoretical Goldilocks zone -- I know the high-gravity environment of gas giants might allow some moons to maintain liquid water despite perhaps being further away from the star, possibly rendering them habitable.

Is this something you're looking for right now, or are those kinds of readings (moons orbiting gas giants) still beyond our current capabilities?

VonAether

(PB): Ah yes, exomoons! One of the most-thought provoking results from our own solar system is that the giant planets Jupiter and Saturn have moons with a really impressive amount of water. Check out: http://theconversation.com/water-water-everywhere-in-our-solar-system-but-what-does-that-mean-for-life-76315

So when we search for habitable places we should also consider giant exoplanets potentially orbited by small water-rich moons.

But the signal from such an exo-moon is challenging to find. Depending on the moon's orbit, it may or may not show up in the transit signal of the planet. Or it could be so small it is below our detection threshold. But there is a team who thinks they see evidence of an exomoon, and it is convincing enough that they won time on the Hubble Space Telescope to confirm. That observation took place late last year, so stay tuned for the results! See: https://www.cnet.com/news/nasa-hubble-kepler-moon-exomoon-1625-b-i-alien-life/

Hi, welcome to reddit!

I'm curious about objects outside their star's theoretical Goldilocks zone -- I know the high-gravity environment of gas giants might allow some moons to maintain liquid water despite perhaps being further away from the star, possibly rendering them habitable.

Is this something you're looking for right now, or are those kinds of readings (moons orbiting gas giants) still beyond our current capabilities?

VonAether

JC: We're basically looking for everything right now :) Exo-moons is something the field has been very excited to find for awhile, but as of yet we have no confirmed detections.

If enacted, will the cancellation of WFIRST affect the field of exoplanetology in any way? Would the cancellation of WFIRST have implications for future planned space telescopes like LUVOIR?

Pluto_and_Charon

JC: A big component of the WFIRST science case is a microlensing survey of the Galactic bulge. Microlensing is a planet detection technique that is more sensitive to planets further away from their star, unlike the other techniques (transit and Doppler) which are more sensitive to planets close to their star. So, WFIRST will complete the census of exoplanets that missions like Kepler and soon TESS will have started. It will be a real blow for understanding planet formation theories if we're unable to explore the outer regions of these extrasolar systems.

As for the downstream implication, it's hard to know. As Aki Roberge (also on the AMA and who may chime in here) said yesterday, in order to expect big investment, we need to have big goals. So, if we build a science case for LUVOIR that represents not just the interests of the scientists but also those of humanity as a whole, then we have a strong argument for funding.

If enacted, will the cancellation of WFIRST affect the field of exoplanetology in any way? Would the cancellation of WFIRST have implications for future planned space telescopes like LUVOIR?

Pluto_and_Charon

AR: WFIRST is planning to carry NASA's first advanced coronagraph instrument into space, as a technology demonstration for future missions like LUVOIR. Coronagraphs are used to suppress the bright light from a star so you can directly see the faint planets orbiting it. The WFIRST coronagraph development project has already made great strides in the lab, but there's more to do. And that's what I'll say about that!

Short and simple question:

How important is AI to your hunt for exoplanets, and how rapidly is it improving?

aft2001

JC: We are using some types of AI (machine learning) to search for signals already! And we are hoping to continue developing the technology further. One of the good things about the NASA missions is that all the data are publicly archived after a certain amount of time, so as our algorithms get more sophisticated, we can go back and scan through the data again and see what we missed!

If you could change one thing about how exoplanet research has been done what would it be?

KerrMetric

AR: The thing I'd change is what the environment in astronomy was for women and others. I'm sitting right next to a pioneer of the exoplanets field (Debra Fischer), who had to put up with some things she really shouldn't have.

I come from /r/eve (EVE Online video game) where they are currently working with the CoRoT Telescope, under Prof Michel Mayor, to identify problem exoplanets through mass human sourcing.

I merely wish to say good luck and happy hunting.

Slyvery

JC: Awesome! Thank you for participating in the EVE online project!

If you could decide the first targets of the Webb telescope, which would you choose?

DrDepp

Jennifer Wiseman (JW): Hi! Great Question. A lot of astronomers have been thinking about this, and have proposed some great "Early Release" science targets for some of the first observations from JWST. A great variety of targets has been selected, from exoplanets to distant galaxies and more. Just the kinds of sources I'd choose too! You can read about these Early Release observation plans at this link. After Webb launches in 2019 and has a few months to get ready for science, it will start these early release observations.
https://jwst.stsci.edu/news-events/news/News%20items/selections-made-for-the-jwst-directors-discretionary-early-release-science-program

Which exoplanet has surprised each one of you the most? :)

Miss_Eliquis

[DF]: most surprising to me was Kepler-444. When we were finding the first planets in the mid-late-90's (with the Doppler method), the planets were typically "hot Jupiters" (Jupiter mass, but 4-day orbits) and I helped show that these planets were preferentially found around metal-rich stars. The glaring implication was that ancient stars (which are all metal-poor) might not have planets! Would this imply that ancient and wiser civilizations might not exist? As time went on, we learned that high metallicity was not required for small rocky planet. Enter Kepler-444: super metal poor, one of the oldest stars in the Milky Way galaxy, and 5 small rocky planets. That one knocked me over!

I've heard some people claim that there may be more "rogue planets" that drift between stars than there are planets actually orbiting stars.

Is that plausible?

artifex0

JC: There was a study that came out a couple of years ago that analysed the frequency of single-lens microlensing events in the Galaxy, and inferred that there must be a very large population of rogue planets in between the stars to create all these single-lens events. These data have recently been reinterpreted and the rate was brought down considerably, but a factor of at least 10 IIRC. So, probably not 'as many' as planets actually orbiting stars, but still a heck of a lot!

How did you guys get into the field (educational and financial wise)?

AlexFromAnotherWorld

[DF]: My family didn't have money to send me to college, but I really loved learning. I ended up working my way through a BS degree at the University of Iowa and then a MS degree in physics (San Francisco State Univ), then going to UCSC for my PhD in astrophysics. I did not know if I would get a job (there were not many women in the field in the 1980's and 90's) but I was happy learning and doing research. So, I would say that I was committed to doing what I believed in and I would not give up.

How did you guys get into the field (educational and financial wise)?

AlexFromAnotherWorld

(PB:) I knew I wanted to be an astronomer when I was choosing colleges, and I chose a place where I could use the telescopes and do research as an undergraduate. For spending money, I worked several hours a week running a telescope that was used by students taking astronomy 101. When I chose graduate schools, I went to a place where I could study physics but do research in computational astrophysics and stellar dynamics. The great thing about graduate school in physics and astronomy is that most students receive a stipend for teaching or research, and the costs of their classes are covered as well. It is not a lot of money, but it does make graduate school a possibility for many people. Once I got my PhD I took a postdoctoral position at NASA Goddard to work on a first-generation instrument on the Hubble telescope. I caught the space science bug, and I have been happily involved in many NASA missions at Goddard over the last years. All the missions are space telescopes that study time variability, but the range of energies they have probed spans X-rays to optical.

Many other astronomers follow a similar path, but then teach and do research at universities.

How did you guys get into the field (educational and financial wise)?

AlexFromAnotherWorld

JC: I did my undergrad degree in physics and physical mathematics, and my PhD in astronomy. Then I did a postdoctoral research fellowship at Harvard, before joining NASA, first as a scientist on the Kepler mission and then as a scientist at the NASA Exoplanet Archive.

How did you guys get into the field (educational and financial wise)?

AlexFromAnotherWorld

JW: I was interested in science and math (and lots of other things like music) in high school. Studied physics in college, because it is the basis for so many other subjects. Took some astronomy courses, and realized I loved to apply physics to the study of the universe (hence, astrophysics!). I applied for graduate schools, and ended up studying Astronomy for a Ph.D. Once in graduate school, I found an astronomer advisor who was excellent in helping me learn, along with other students, how to do astronomical research, and advised us on what kinds of topics and projects would be good to get involved with. Financially, it is helpful to know that often graduate students in science (including astronomy) can get full financial support from their graduate departments (and/or fellowships those departments can recommend), if admitted. So at least in some science fields in the U.S., the graduate portion of education can be easier to fund than the undergraduate portion. Hope you consider joining this astronomical quest.

Because you all work on this field do you have any interesting opinions on the fermi paradox?

Thelimitless1

[DF]: Hi! This question was asked before - many people are interested in this! I think that there is a constraint on the number of space-faring civilizations from the Fermi paradox. It there was one for every solar system, we wouldn't be asking the question. But, it probably doesn't offer strong constraints on the existence intelligent or even technological life. So, I tend to avoid speculating, and instead race to do research that will hopefully advance the field!

Because you all work on this field do you have any interesting opinions on the fermi paradox?

Thelimitless1

AR: Have a look at this other comment.

https://www.reddit.com/r/science/comments/7y6ieg/hi_were_scientists_who_are_scouring_the_night_sky/duem2fh/

Thanks for doing this AMA! I'm a physics student specializing in astrophysics and this is the kind of stuff I want to do in a few years!

What kinds of methods do you use to determine the existence of exoplanets? In my astrophysics class we learned about the gravitational lensing method and the transit method but learned they are both very difficult to perform since the planets are so tiny compared to the stars.

Is there any method you like more than the others?

How do you know what stars to point at when looking for planets or is it just random?

Do you use mostly visible light or are there other wavelengths you look at systems with to determine if there are exoplanets?

Thanks for taking the time to do this!

TheOriginal28

JC: So, besides the transit method and the microlensing method, there is the Doppler technique, which observes the wobble in the star due to the tug of the planet (as the star is pulled towards us by the orbiting planet, its spectral lines get blue-shifted, and as the star is pulled away from us, they get red-shifted). There is also the direct imaging technique, where you block the light from the star and look for nearby points of light that could be accompanying exoplanets. There are also various ways of measuring timing changes - either changes in the arrival time of pulses from the star (the pulsar planets were found this way), or measuring the transit timing variations of one planet caused by the gravitational tug of a nearby planet. Finally, there is astrometry, which so far hasn't been very successful but is about to revolutionized by the ESA Gaia mission, in which you measure the position of the star on the sky incredibly precisely, and then watch to see if the star moves in such a way to indicate the presence of a planet.

We often here that life on earth would change if we ever discovered life outside of earth. In what way would it change? and shouldn't it have done so already when the chances of extraterrestrial life is pretty high considering the number of planets we can now see.

outlawbruce

JW: Hopefully discovering life beyond Earth (even simple life) would give us all an enhanced sense of appreciation for the rich diverse universe we live in, a stronger sense of unity as "Earth citizens", a curiosity to explore more, a better understanding of the history of Earth and life here, and a great sense of awe. Turns out people have been thinking about this question for centuries, and it has inspired great thinkers, philosophers, theologians, poets, and more, including, of course, scientists! The rapid detection of exoplanets in recent years has made this field into a prime focus of astronomy around the world, so this field is already making a big impact on the world.

Wow this is awesome. How have crowdsourced searches like Eve Online 's Project DiscoveryEve Online 's Project Discovery helped your cause?

Laventhros

JC: I work on a citizen science project called Exoplanet Explorers (exoplanetexplorers.org) and we have published one paper with a five planet system that was found by crowd-sourcing, and just yesterday announced another 94 candidates that we need to study more closely. Debra Fischer, another one of the AMA panelists, runs another project called Planet Hunters (planethunters.org), and they have published a dozen papers from crowd-sourced results!! So people are definitely helping us find exciting exoplanet systems.

Using the criteria you've developed, what is the habitable zone in our own solar system?

el_seano

AR: It's a bit fuzzy, actually. These days, most astronomers use the habitable zone calculations by Ravi Kopparapu and collaborators. You can use his calculator online here.

But I should emphasize that the astronomer's "habitable zone" is a very limited concept. It's really the zone around a star where we don't know that an Earth-like planet **can't** have liquid water on its surface.

The concept is really designed to guide astronomers' search for **Earth-like** planets, since Earth is a) the only planet we know has life and b) has life so abundant it's changing the planet's atmosphere in a way that could be detected from interstellar distances.

Thanks for the AMA! Here's a couple of questions:

- I understand that our little system isn't necessarily indicative of the bulk of systems in the universe, but can you tell me why so many of the systems with exoplanets seem to have huge Jupiter-sized planets orbiting their stars in 25 days (as an example). This seems incredibly counterintuitive to me. I know the systems are typically dwarf stars, and that pushes orbital radii in, but still, 25 days?
- Are there any examples that we've found where the orbits were not such a rapid fire staccato?
- Understanding that we look for "wobbles" in the light from the host star, and waiting 11 years for plutoid-type bodies isn't feasible, are there any things that we can do to start gathering more accurate data on this to find systems that are more like ours?

ScabusaurusRex

JC: We have found so many of those hot Jupiters because they are the easiest thing to find!! In fact, when we look at the whole population of planets we've found and correct for how easy or hard they are to find, we believe that further out planets are in fact much more common, and that hot Jupiters are relatively rare (orbiting 0.1% of stars or so).

There are many examples of systems that only have further out planets, typically found by radial velocity. If you go to the NASA Exoplanet Archive table of confirmed planets (https://exoplanetarchive.ipac.caltech.edu/cgi-bin/TblView/nph-tblView?app=ExoTbls&config=planets), you can sort the period column in descending order and have a look at all the long period things we know of!

There are other techniques that are actually sensitive to further out planets. One of them is direct imaging, where you block the light from the central star and look for any remaining nearby points of light that could be exoplanets - in that case the further away they are, the easier they are to see!

Thanks for the AMA! Here's a couple of questions:

- I understand that our little system isn't necessarily indicative of the bulk of systems in the universe, but can you tell me why so many of the systems with exoplanets seem to have huge Jupiter-sized planets orbiting their stars in 25 days (as an example). This seems incredibly counterintuitive to me. I know the systems are typically dwarf stars, and that pushes orbital radii in, but still, 25 days?
- Are there any examples that we've found where the orbits were not such a rapid fire staccato?
- Understanding that we look for "wobbles" in the light from the host star, and waiting 11 years for plutoid-type bodies isn't feasible, are there any things that we can do to start gathering more accurate data on this to find systems that are more like ours?

ScabusaurusRex

[DF]: Great question! This sure surprised us. The answer almost certainly is that there are many close-in Jupiter-like planets because those are the easiest to detect. It's a selection bias. Even though only ~1% of stars have these planets, it's all we could find at first. As you note, the orbit of Jupiter is 12 years. There are 2 problems detecting these planets: (1) the reflex stellar velocity gets weaker and weaker and we have to collect data for at least one orbital period - 12 years or more. Other methods (direct imaging, microlensing) are helping with the more distant (longer period) planets!

First of all great work! You all are doing something that most of us wish we could do. With that in mind:

Is there any way for the general public to help with these efforts?

Mojavi-Viper

[DF]: I hope everyone here gives a comment. Thanks so much for your interest. The main thing is to promote science. You do that by electing people who believe in science. But, even more exciting is to join in on the fantastic Citizen Science projects that are springing up. I started one in 2010 ("Planet Hunters") and there is now a new "Exoplanet Explorer" program. These are not "public outreach" or "education" program - you will be contributing to science. With Planet Hunters, we had a dozen publications, all with the public "lay" volunteers who made the discoveries as co-authors.

Are there any exoplanets that are very toxic or acidic to humans but possible for other lifeforms to thrive there?

IHopeYouODandDie

JC: HD 189733 is so hot and has such a high concentration of silicates in its atmosphere that it is probably raining liquid glass - sideways! That seems pretty toxic to me :) I don't believe we've measured the acidity of any planet atmospheres yet - maybe one of my other AMA panelists will correct me.

I just have a simple question. At this rate, how possible is it that we will find life outside of earth in our lifetime?

SauceeCode

AR: I have every hope. We have the information now to design a good experiment to find dozens of habitable planet candidates and then probe them for signs of life. The technology to execute this experiment (a large space telescope with starlight suppression instruments) can be developed within a decade or so.

Debra and I are working on a mission concept that could find Earth-like life on nearby worlds ... or tell us if such life is rare. It's called LUVOIR - a working title. Another concept is called HabEx.

The Kepler space telescope has been extremely successful yet only studied a small swath of the night sky. Why not build a fleet of Kepler's to study more of the sky? Seems like we could make them increasingly more efficient and also save a bunch of money by continuing to improve on the design rather than scrapping everything and starting over with a brand new telescope.

BeerPizzaTacosWings

JW: Hi -- You're right that Kepler observed a small swath of the sky; it was aimed at a region with a lot of stars so that it could stare at something like 100,000 stars for a long period of time, looking for those that "dim" periodically because of transiting planets. This mission has been extremely successful, letting us know how common and diverse exoplanet systems are! But astronomers are eager to now advance this field with different kinds of telescopes and techniques to broaden our understanding, in ways the Kepler telescope was not designed to address. The TESS mission, for example (Transiting Exoplanet Survey Satellite), launching this spring, will survey nearby, bright stars over most of the sky, to look for more exoplanets -- those that will be easier for us to follow up with detailed study with larger telescopes. So we need all of these different kinds of tools to advance our understanding of exoplanetary systems.

The Kepler space telescope has been extremely successful yet only studied a small swath of the night sky. Why not build a fleet of Kepler's to study more of the sky? Seems like we could make them increasingly more efficient and also save a bunch of money by continuing to improve on the design rather than scrapping everything and starting over with a brand new telescope.

BeerPizzaTacosWings

(PB) Well we are just about to launch the follow-on to Kepler, called the Transiting Exoplanet Survey Satellite (TESS). TESS will do a two-year near all sky survey to find exoplanets around stars closer and brighter than the typical Kepler star.

We are unfortunately constrained by budget realities. The astronomical community has many and varied research interests, from gravitational waves to supermassive black holes to stellar evolution to exoplanets. Funding agencies try hard to spread the resources equitably. But we would all love to operate many more telescopes if we could. We really have only scratched the surface of the observable universe with what we've built and launched so far.

This AMA has been live for 2 hours yet there are no answers posted, are you replying via PM?

julius_sphincter

AR: Sorry for the confusion. We only just started replying at 3 PM central time.

Do you think it's plausible that life could be based on silicon and/or various other compounds unknown to us?

If so, do we have ways to detect life in that manner?

prawnsandthelike

JC: Yes! It could definitely be possible. It's hard to predict what we would see for those types of life though, so when we are designing experiments for detecting biosignatures we are thinking about the things we *know* are indicative of life, at least our kind of life. As Aki said elsewhere in the AMA, it's likely we will see signs of life without recognising it if it's very unlike ours.

When looking for "habitable planets," do you distinguish between planets where only a small region on the surface might be habitable vs the whole planet?

Based on the physics of planet formation and the limits of current and upcoming telescopes, which will be more common among early high-confidence discoveries?

OptimallyOptimistic

JC: At the moment we have limited information, both in terms of the properties of the planets we find (temperature, average density), and the properties of the types of life we might find and therefore what 'habitable' means. So when we say that we're looking for habitable planets currently, we are typically meaning rocky planets which are the right temperature for liquid water on the surface. We aren't distinguishing specific regions on a planet as habitable or unhabitable. The closest I can think is there are some tidally-locked planets (where the same half of the planet is always facing its star and the other half of the planet is always facing away) where one side is too hot and the other side is too cold, but at the 'terminator', the twilight area between night and day, it could be the right temperature.

Thank you for the AMA!

Habitability zones around smaller stars (i.e. M-dwarfs) are necessarily much closer to the star meaning stellar processes in the host star can have a much greater affect on the orbiting exoplanets. My question is how do you account for these stellar processes that may have an impact on habitable zones? What kind of processes do you model for and how do you determine the parameters for these models?

hipskillybumbum

JC: That's a great question! And that is a really active area of research right now. There is an effort that is starting with the launch of the TESS satellite in the next couple months, where TESS will monitor the optical output of M-dwarfs, and at the same time they will be monitored in the X-ray (with the SWIFT satellite) and in the radio (with the VLA) to really start to characterise the output of these M-dwarfs across the whole electromagnetic spectrum during the 'flare' events that happen much more commonly on M-dwarfs, and would likely be damaging for life like our life.

Simple question what is the closest exoplanet that could possibly be habitable

memeweenie

JC: Actually the closest star to the Sun, proxima Centauri, has a planet in its habitable zone! So, that's about 4 light years away.

Simple question what is the closest exoplanet that could possibly be habitable

memeweenie

AR: The planet orbiting Proxima Centauri, the star that is closest to the Sun!

Have you found the dipping in light, or the stellar wobble to be more effective at detecting Earth-like exoplanets?

Also, how common is it to be able to detect atmospheres?

Thanks for doing this AMA!

CounterSanity

[DF]: Ha! At this AMA table you have astronomers using both of those methods. I look for stellar wobbles (radial velocities) but also use transits (dips in light). In fact, we need *both* of those measurements to derive a density for the planet. For Earth-like planets, I have to say that space-based transits have won so far. But, my students are commissioning a new spectrograph "EXPRES" at this very minute - we start observing next Friday. EXPRES was designed for EXtreme PREcision - we're aiming for 10 cm/s so that we can detect analogs of Earth around the nearest stars. Then, the stellar wobble technique will get HUGE bonus points for detecting small rocky planets around our closest neighbors. Please send positive thoughts our way!

If future rockets like the 9-meter-diameter BFR successfully made it cheap to launch many large, heavy telescopes, what would your dream fleet of telescopes look like?

What kind of impact would that have on astronomy and your work?

OptimallyOptimistic

JC: Astronomers have had these kinds of fantasies - we all want bigger telescopes! One of the most exciting futuristic concepts is TPF (Terrestrial Planet Finder)/Darwin - which would be a precision formation flying fleet of telescopes which would use interferometry to image distant Earth planets in incredible details. *sighs wistfully*

Do you get to name any findings or will they just always be known by their catalogue number?

Dr_McKay

[DF]: as soon as the first exoplanets were discovered, we joked about naming them "Planet Your-Company" to help with research funds. Personally, this never appealed to me. But, a few years ago, one astronomer tried to do this and suddenly the International Astronomical Union launched a "planet naming" contest. Maybe I should just start naming them... Fischer-1, Fischer-2, Fischer-3.

What kind of salary could I expect if I had a job like yours? I'm seriously considering the field. You could PM me if you aren't comfortable sharing.

APossessedKeyboard

[DF]: I think that the salaries of professors are public (at public universities). Maybe starts at $60K? But, don't do this job for the money - do it for your love of the work because it is not a 9-5 job. When I go observing, I'm away from home for 2 weeks and working long days, sleeping little, missing birthdays...

What kind of salary could I expect if I had a job like yours? I'm seriously considering the field. You could PM me if you aren't comfortable sharing.

APossessedKeyboard

(PB) The American Physical Society compiles salary statistics for people graduating with a degree in physics (undergraduate and graduate). Some recent stats are here:

https://www.aps.org/publications/apsnews/200911/physicsmajors.cfm

Astronomer's salaries pretty much track physicists's. And graduate degrees command more than undergraduate. Bottom line: physicists are paid pretty well, a bit less than engineers.

Hi, and thanks for the AMA.

How many planets on average do you discover per month? How difficult is it to do so?

useful_person

JC: I'll answer this one, since I work at the NASA Exoplanet Archive and its our job to keep track of how many exoplanets there are. I would guess that the average is 10-20/month, irregularly punctuated by large catalogue releases that can be in the hundreds or even thousands. (Just Thursday there was an announcement of 95 new planets!)

How far away from having the tech to detect exoplanet atmospheres? Would we be able to detect person made chemicals then?

theothercoolfish

AR: We can actually detect exoplanet atmospheres now. The first detection of an exoplanet atmosphere (of a hot Jupiter called HD209458b) was done with the Hubble Space Telescope in 2007.

Currently, we can use the technique of transit spectroscopy to study the atmospheres of large planets (gas giants). The launch of the James Webb Space Telescope in 2019 will push this technique down to smaller planets. But atmospheres of Earth-like planets will remain out of reach until newer telescope concepts come to fruition (maybe in late 2030s).

I doubt we'd be able to detect chemicals produced by technology, though. Nothing we make is that noticeable in Earth's atmosphere, compared to the huge amounts of oxygen coming from plants or methane coming from bacteria.

Hello, and thanks for the AMA! I have a question regarding the Hubble / upcoming Webb telescopes. With so few orbiting telescopes, how is 'telescope time' allotted for research? Similarly, what is the process like for choosing a particular area of space to study for exoplanets? I assume data from ground based observatories is used to choose candidate coordinates, but is there a list of places that might harbor plants / life that have yet to be examined based simply on limited resources?

I_am_Searching

JW: Hello! Telescope time is highly valued, so astronomers submit detailed proposals to observatories for the kinds of observations they would like to do, and why a particular telescope would help them answer important astronomical questions. For the Hubble Space Telescope, these proposals are evaluated by panels of experts, and about 20% of them are actually selected each year for observation time. The data sets from the observations, however, go into an archive, and in a year (or less) the data become available for anyone to use. So, many astronomical papers are published based on data retrieved from this rich archive.

As for choosing an area of space to look for exoplanets, astronomers look at stars or star systems that, based on previous studies of those stars, are interesting candidates for planetary systems, and are best observable with current telescopes. Some of these planetary systems are orbiting their star in a plane along our line of sight, so for those systems, their geometry allows us to most easily look for the radial-velocity "wobble" of the parent star, or for periodic dimming of the star when the planet transits in front of it. These allow for certain kinds of study. Other kinds of "face-on" geometry planetary systems are good candidates for coronagraphic imaging of the system. Future telescopes will push the technique of coronagraphy even farther, allowing planets in more of these systems to be imaged and to be studied through spectroscopy to understand their atmospheric compositions.

A bit of a morbid question, if the unthinkable happens, after so many years and so much cost, and the JWST or its launch fails in some regard, how severely set back will the exoplanet field be in terms of both the scientific opportunities lost and possible ensuing funding qualms for future missions?

Dyaus_Pitar

(PB) This is truly a terrible thing to think about. Everyone who works on mission development is extremely focused on safely launching the payload. However the worst does happen from time to time. We all have colleagues who have experienced the total loss of their missions on, or shortly after, launch. This is a devastating outcome for a team that has worked night and day to see launch day finally arrive. Space is risky, and we are all aware that the worst can sometimes (rarely) happen. It is very important to stress though, that everyone involved in the mission and its launch works, tests, questions, analyzes data, etc, to do everything in their power to insure a safe launch. The actual launch is actually the most dangerous part of the entire mission. Once successfully launched, many missions go on to exceed their mission expectations. They were made so durable to withstand launch, and that has led in some cases to missions that can survive even better than expected the rough space environment too.

What are the issues faced when finding planets orbiting binary stars? Does it increase the habitable zone or decrease? What about more stars?

dingogordy

JC: Ooooooh good question! Most of the planets orbiting binary stars where the two stars are close together and the planet is far away orbiting both of them (as if they were a single central star), are found by eye looking at the dips in the light curves, because the dips, which are usually found by software looking for exactly periodic dips, aren't exactly periodic! For planets orbiting a single star nearby which happens to have a stellar companion very far away, we usually find them by finding the planet signal (either by dips or the Doppler wobble) and then looking more closely and realising there's another star nearby.

For those second kinds of planets, there isn't an effect on the habitable zone, since the second star is so distant as to provide negligible radiation. For the first kind, it's a complicated dance of temperature versus stability - you need to be close enough to be warm enough for liquid water, but not so close that the binary stars make the orbit unstable. So it depends on a case by case basis.

Well here's the obvious question: how many have you found?

MarkToasty

JC: The NASA Exoplanet Archive (where I work!) keeps track of this - as of today the answer is 3700 exactly!

I know I'm probably too late to expect a reply but here goes - my 12 year old daughter has decided she'd like to work towards working in this field. She has the potential, just needs to put in the work. Can you please give me a brief idea of what path she should follow during high school and university to be well placed in 10 or so years time.

Thank you.

Oz_ghoti

AR: Fantastic! She'll want a good foundation in mathematics. I'll note, however, that while I love science, I don't really love math. For me, it's a tool, but a necessary one. Obviously, take as many science classes as possible.

And for sure, get some hands-on experience in science. There are summer internships (for example, at NASA) available for high schoolers and undergrads.

Finally, believe it or not, I urge her not to neglect the humanities. The further I get in my career, the more writing I do. And reading is a joy that no one should miss.

I know I'm probably too late to expect a reply but here goes - my 12 year old daughter has decided she'd like to work towards working in this field. She has the potential, just needs to put in the work. Can you please give me a brief idea of what path she should follow during high school and university to be well placed in 10 or so years time.

Thank you.

Oz_ghoti

JC: She would be well served by doing maths, physics and probably computer science subjects in high school, whichever are available! Then, depending on the college, majoring in astronomy or if that's not available, physics and/or maths.

That's the 'traditional' route, but honestly there are many other paths too. She will work hardest on the things she's interested in, so she needs to find those! I loved physics and maths because I love solving problems!!

We love in a truly amazing time and probably the greatest time to have ever lived on this planet. One thing I hope for myself is that we find alien life of any sort (single celled organism --> intelligent life) before I die.

What are your opinions on the chances of us discovering this in let's say the next 50-60 years?

CrazySwayze82

[DF]: 50-60 years? I think you're good! There is a very high probability that we'll have exoplanet spectra in the next 20-30 years. Those spectra will allow us to search for biosignatures. The first detections are going to be tentative and super exciting. In the same way that people were skeptical about whether the first exoplanets were real, there will be lots of debates about the first biosignatures. But, we'll learn and move forward.

We love in a truly amazing time and probably the greatest time to have ever lived on this planet. One thing I hope for myself is that we find alien life of any sort (single celled organism --> intelligent life) before I die.

What are your opinions on the chances of us discovering this in let's say the next 50-60 years?

CrazySwayze82

(PB) I have always hoped for this myself. Until recently it seemed like such an elusive goal, more like a dream really. However now that we see how many planets are out there (they're everywhere!), and how much water is on other bodies in our own solar system, like the icy moons, and how life has found a way in such extreme environments on our own planet, I now believe that we will make such a discovery in this century. It may even be in our own solar system, which would mean that we could study it in great detail.

First, somewhat tangentially, how much say to the primary investigators/scientists have over the selection of the actual rocket launch for a given payload? For instance, was there skepticism in the TESS team when SpaceX was awarded the contract?

More specifically to TESS, how did the team come up with the relatively novel lunar resonant orbit for science use? What advantages does it offer over other, more standard orbits? (Even the JWST, at Earth-Sun L2, could be considered to use a more conventional orbit than a 2:1 lunar resonant one :)

Bunslow

Here's a great article about TESS's really cool 2:1 lunar resonant orbit. It will be remarkably stable.

https://www.nasa.gov/content/goddard/new-explorer-mission-chooses-the-just-right-orbit

Do you ever think that you're wasting your time doing this?

eyerenicus

JC: Not when I do public outreach like this. So many people so excited by our discoveries! It's an honour to get to do it and I consider myself extremely lucky. NASA discoveries inspire each new generation of kids to become scientists and engineers and discoverers and it's wonderful to be part of that.

Could a planet extremely distant from its host star be supplied with energy to make it 'habitable' with a radioactive core? I watched something on TV today that mentioned Pluto's surface being supplied with heat from the latent heat released by the freezing of a probable liquid ocean core. Are there other uncommon methods of providing heat to a planet besides solar radiation or giant impacts slamming into the surface?

OoglieBooglie93

JC: Great question. There is also tidal heating, which is for instance what keeps the interior of Europa liquid water. It's the gravitational pull of nearby Jupiter being so strong that it actually stresses the interior of the planet and keeps it warm.

If an exoplanet were in orbit around a binary star system, how would that affect the habitable zone? Also, would the detection methods in this case differ significantly from single star systems?

al-why

(PB) Kepler actually discovered a couple dozen planets orbiting binary stars. These are called circumbinary planets. The energy received at these planets' surfaces would vary with time depending on the orientation and temperatures of the two stars, which could lead to quite different habitable conditions than those we're accustomed to thinking about in our own solar system.

Doctors...

Numerous contributions in astronomy are still made by amateurs. Do you foresee a growth in technology where amateurs working with low cost instrument budgets (>20K) are able to make contributions in exoplanet astronomy?

patb2015

JC: Yes!! The NASA TESS mission will launch in the next couple of months, and we are going to be swamped by potential planet signals. They will all need following up, and we are currently assembling an army of amateur observers with ground-based instruments to help us. There is more information here: https://tess.mit.edu/followup/

Whenever I hear about new exoplanets, they usually seem to be gas giants really close to their star. Is this just because the methods are better at detecting these planets or is our system probably unusual with how its planets are placed? How has this changed as detection methods improved?

DrunkenAsparagus

[DF]: exactly right. I'm trying to change this with EXPRES - an instrument that my team designed, built, and is commissioning right now at the 4-m Discovery Channel Telescope at Lowell Observatory. We are going for Earth analogs around nearby stars. Wish us luck!

What color planets are usually habitable when looked at from far away with a spectrometer?

ThunderClown456

AR: Well, we don't really know. We want to look and see. But we can make a couple of guesses based on the Earth.

Today's Earth: Blue because of rayleigh scattering.

Archean Earth (4 - 2.5 billion years ago): Maybe orange, from an organic haze created by chemical reactions of methane coming from bacteria.

I could also imagine a very cloudy habitable planet that was basically white. So really, there's a whole range of plausible colors.

I never found this answer around. Given the more promising planets in the habitable zone, from their point of view, which of them can see the Earth transits in front of sun and theoretically study our own atmosphere?

Thanks

zulured

(PB) Fun question! there was a study done of this question, published last year in the Monthly Notices of the Royal Astronomical Society. There are currently 68 known exoplanets that could see Earth transit the Sun. See a nice write-up at:

https://newatlas.com/exoplanets-spot-earth-transit/51275/

Aren't these planets so distant from our own that it would be virtually impossible to ever actually reach them for colonization purposes? Short of some sci-fi generations long voyages?

mmbls

JC: The closest habitable planet we know if is actually around our closest star - proxima Centauri! Which, admittedly, is still four light years away. Given our current technology even that short a trip is still out of reach in fewer than hundreds of years. So, generation ships is a good prospect (IMO).

Not meaning to be mean, but isn't AI better at scanning the skies in search of potentially habitable planets?

Altitude_Adjustment

[DF]: I'm happy to partner with AI! Right now, we need humans to lay the groundwork so they can train the AI. We do use AI in some of our data analysis algorithms and we automate telescopes to scan the sky (the days of the lone astronomer at the observatory are fading away).

Do different types/sizes of stars have different habitable zones

avidlistener

(PB) Yes, the distance from the star of the Habitable Zone is a function of the temperature of the star. the HZ is farther out from stars hotter than the Sun and closer in for the abundant cool stars. See a nice graphic overview of this at:

https://www.nasa.gov/ames/kepler/habitable-zones-of-different-stars

Have you considered looking for post biological intelligence. Especially for life beyond our intelligence?

TransPlanetInjection

[DF]: SO COOL! We're often stuck with what we know and that makes it tough. I tend to think that looking for nanobots is the right thing to do (since that's probably how we'll first explore the galaxy) but the signature is so small and hard to detect. We do watch for things we don't understand and publish those papers, too, trying to uncover the unknown and the unexpected!

Have you considered looking for post biological intelligence. Especially for life beyond our intelligence?

TransPlanetInjection

AR: How would we know what to look for?

What is the launch date for the James Webb Telescope and what are you hoping it finds?

Nightman67

JW: The James Webb Space Telescope (JWST) will launch in 2019 -- and we are so excited! It will provide infrared-light observations of distant galaxies, circumstellar regions around stars, solar system objects, and much more. Two of the (many) science goals for the observatory are to help us understand better the planet formation zones (disks) around young stars, and, much farther away, the early proto-galaxies forming in the early universe more than 13 billion years ago. Since the Hubble Space Telescope should also be operating for quite a few more years, observing in ultraviolet, visible, and near-infrared wavelengths of light, the combination of Hubble, JWST, and the Chandra X-ray space observatories (as well as many other excellent observatories on the ground and in space) will provide astronomers with a fantastic suite of tools for studying the universe. check out nasa.gov/jwst

What is the launch date for the James Webb Telescope and what are you hoping it finds?

Nightman67

JC: At the moment it is scheduled to launch in spring 2019, and *I* am hoping that it helps us characterise the atmospheres of exoplanets in detail we've never been able to see before. To find more molecules, to probe more structure, so examine variability (space weather!!!).

No questions, just wanted to say thanks for your hard and important work!!!

givemecookies456996

JW: Thank you! And our work wouldn't be possible without public enthusiasm, support, and involvement -- so we're all in this exciting quest together!

Could there be a planet that is not orbiting a star, but rather traveling between stars?

xHomicide24x

JC: Yes! We have found quite a number of them! We call them rogue stars. We theorise that they either formed themselves out of a gas cloud that was too small to form a star, or formed within a solar system like our own and got kicked out by a gravitational interaction with another planet or star in the system and ejected into interstellar space! (Like the interstellar asteroid that came through our solar system late last year!).

Could there be a planet that is not orbiting a star, but rather traveling between stars?

xHomicide24x

[DF]: Yes! These "rogue" planets have been found. We think they formed in disks around stars and then were booted out!

If you have to pick a destination for an exploration probe, where would you send it?

The-Grim-Sleeper

[DF]: alpha Centauri because it is the closest star system! But, I'd make sure that it has planets before launching!

If you have to pick a destination for an exploration probe, where would you send it?

The-Grim-Sleeper

JC: Right now? Probably to our nearest star, proxima Centauri, which has a planet in its habitable zone and is only 4 light years away!

What is the most reasonable prediction of where we'll be living in a few years?

ExpertGamerJohn

JC: Earth.

I know there are two basic forms of looking for exoplanets: doppler shift and [whatever the term is for looking for dimming of the stellar disk] -- in both cases these seem to be dependent on the extra-solar solar system being more or less on the same plane as our line toward that star.

(1) Do I have that right, even on Dopplershift detection? I realize the relative accelerating might just be shifted.

(2) Where it is the case with occulation, how many systems would we expect to actually be lined closely enough with the plane of observation so as to be detectible.

CardboardSoyuz

JC: (1) You can detect off-plane systems with the Doppler method, but the more inclined they are the harder they are to detect. We're most sensitive to things close to the plane. There are a couple of methods (direct imaging, microlensing) that don't rely on that kind of alignment, which is good. (2) The probability that a given planet will transit depends on the size of the planet (big planets more likely to transit), and how far from the star they are (close-in planets more likely to transit). So it depends on each system individually, but for something like the Earth-Sun system, the probability is about 1 in 200 that it will transit. So we would need to look at ~200 stars like the Sun with planets like the Earth to catch one which transited.

Do you publish the raw data so that someone like me could write their own algorithms or do our own searches? I think it would be fascinating.

lucuma

(PB) Yes! The Kepler/K2 mission has been putting the raw data from recent campaigns into the archive and teams are using their algorithms to quickly find planets and study stellar variability. See for example:

https://keplerscience.arc.nasa.gov/raw-data-for-k2-campaign-12-and-trappist-1-now-available.html

All NASA missions archive their data, so if you're interested in trying your own algorithms out on the data, you can go to the archive where it is located, download the "Level 0" data, and have fun!

Planets seem to orbit in the same or similar plane. I assume this is because the sun is rotating causing some force similar to a bicycle. It seems likely that the orbit of the planets isn't on the exact plane that you are observing it from so there are a high percentage of stars that you won't be able to observe planets on because of our vantage point using this method. Do you think we will ever make telescopes powerful enough to see the planets themselves even if they aren't in front of their stars.

IverTheLumberjack

[DF]: Ah! Great observation - certainly true for our solar system. Stars and planets form together in a collapsing cloud that ends up as a disk (thus, planar orbits). The dust and gas drain to the center of the disk, forming the star, and the planets form in the left-over debris. Collisions in the disk tend to result in planets that are traveling in the same direction - this is also the direction that the star is spinning. In fact, we've found a number of planets that are not in co-planar orbits, and even some planets that orbit in the opposite direction of their host star. We determine this by measuring something called the Rossiter-McLaughlin effect.

Have you (or anyone else) done simulations of solar system formations to estimate the probability of finding such a planet based on properties a star that we can use to focus on likely candidates?

mc8675309

JC: We now have enough exoplanets that we're starting to study how the occurrence rate of planets depends on the types of stars they orbit. If we find some positive evidence that there are stellar properties (such as metallicity) that indicate higher rates of planet formation for the planets we're interested in, then we will certainly use that to inform our search! At the moment we have measured that gas giant planets like Jupiter seem to occur more often around stars with higher amounts of heavy elements (heavier than Helium is what that means to an astronomer :P).

When the James Web telescope is finally launched what are the first things you'll be looking at? And what are you most excited for with the launch of the telescope?

LordGRant97

JW: I'm excited about the Early Release science observations planned for the James Webb Space

Telescope (JWST), studying galaxies, stars, exoplanets, and the solar system: https://jwst.stsci.edu/news-events/news/News%20items/selections-made-for-the-jwst-directors-discretionary-early-release-science-program