Student questions: Alycia Weinberger colloquium on "Astronomical Constraints on Planet Formation"

1/16/19

Besides the Magellan telescope, what other telescopes are currently being designed in order to help us better see and identify other star systems? (For instance, are there any plans to launch another telescope into space etc.)
All telescopes that work at visual and infrared wavelengths are used to search for and study exoplanets and young stars. Radio, UV and X-ray telescopes further help us understand the stellar environments of exoplanets and the evolution of young stars. We are awaiting the launch of the next big infrared space telescope, the James Webb Space Telescope. We are also thinking about the next generation telescopes on the ground and in space such as the Giant Magellan Telescope on the ground and, further in the future, the Large UV/Optical/Infrared Surveyor in space. You can search for all these facilities online to read more about what science they want to do.

Are there any plans currently if we discover an exoplanet with a similar Earth like properties? (For instance, is there any plan to attempt to reach it or a craft to send to observe it like voyager 2).
Stars are frustratingly far away. The Voyagers have not even exited the solar system (they are well within the Oort cloud of comets) after 40 years. There is a lot we can do with light (more generally electromagnetic radiation) before we would embark on a craft. Bigger and more capable telescopes could tell us a lot, including whether such a planet has an atmosphere and whether gases like oxygen, methane, and ozone that could be the result of life, are in the atmosphere. That said, there is a project led by a Silicon Valley billionaire, called Breakthrough Starshot - https://breakthroughinitiatives.org/initiative/3, that is thinking of how we might send tiny space probes to the nearest Sun-like star, alpha Centauri or its companion star that does have a planet, proxima Centauri.

How do you know that the origin of the CO_2 on Jupiter is all from comets?
I based this on a paper that reported observations of CO_2 in Jupiter from the impact region of Comet Shoemaker Levy 9: "The Origin of Water Vapor and Carbon Dioxide in Jupiter's Stratosphere" by E. Lellouch et al. in the journal Icarus, volume 159, pages 112-131 (2002).

Why is there such a significant drop around 9.5 micrometers in the 2015 line of the Giant Collisions Change in Real Time plot from your slides?
Ozone in the Earth's atmosphere absorbs very strongly around 9.5-10 microns. That is a feature of our planet, and not something about the disk. We got very little light through the atmosphere there.

Is the reason why warmer dust declines faster with time, due to it being more active or is there another factor which explains it?
Warm dust is warm because it is quite close to the star, which means its orbital speed is higher than cold dust out at Kuiper-belt-like distances. So, collisions happen more frequently and more energetically, which breaks the dust down quickly to where radiation from the star removes it.

Is it possible to have a disk which shows two distinctive compositions, saying one wing is astroid based and the other is comet based?
Yes, that should absolutely happen and in fact is what happens in our own disk, where some of the dust comes from comets and some from asteroids, probably 70%/30% respectively in the solar system.

Why do the comet disks have so much carbon monoxide associated with them?
Comets are rich in ices that can only be trapped in them because they are so cold. For example, one of the bright comets that came to the inner solar system recently, Hale-Bopp, had a lot of CO. When objects get warm for a long time, all this CO ice is heated up and becomes CO gas and is released. So, asteroids, which are much warmer than comets, don't have a lot of CO (or water) left since they've been warm for a long time.

It was metioned that our planets seem to be the unusual case in the terrestrial planet formation process. The plot shown seems to agree with that. With this in consideration, a lot of effort historically is focused on finding "Earth-like" or similar planets. Is this the most appropriate focus, or should a shift of focus be made to search for and describe the more "common" terrestrial planets?
This is a matter of what motivates us. I agree that it is very interesting to study the most common types of planets to find out what they are like (How thick are their atmospheres? Can they have magnetic fields? All sorts of other questions). But we also have exactly one example of a planet (so far) where life arose, and that's Earth. So, if we think planets need to be Earth-like (in size of composition or both) to be habitable, and we want to know how common life is in the Galaxy, we want to study Earth-like planets.

Is BD+30 307 unique, or have we observed many other older stars that are still surrounded by debris disks?
We have observed many old stars with debris disks, but BD+20 307 is by far the dustiest of them all and really looks pretty special.

As planets form around stars, does the amount of raw material in the disks decrease?
Yes, absolutely. We still don't know how efficient planet formation is, so we don't yet know if most of the raw material winds up in planets or winds up falling onto the central star.

I was a little confused by the subject of Zodiacal Light, so the question may be worded wrong; could the absence of Zodiacal Light in another star be an indication of a yet to be detected planetary system?
We often argue by analogy with our solar system. We have a rich planetary system (giant planets and terrestrial planets) and very few leftover planetesimals (asteroids and comets). The asteroid belt and Kuiper belts are so empty that today, very few collisions occur, so these belts produce very little dust. The reason the belts are so empty is that the planets cleared them out. Jupiter probably cleared the asteroid belt and some combination of Neptune and the other giant planets cleared the Kuiper Belt. So, maybe having hardly any planetesimals left is a sign of a rich planetary system. But maybe it could also mean that the system didn't make anything interesting at all! We have to detect something (planets or planetesimals) to understand what's going on around a particular star. So far, there has been no correlation observed between the presence of planets and the presence of a disk, but those disks are much more massive than the Zodiacal light, so there could be a relationship between the presence of planets and weak disks. Other

systems could have retained a lot of planetesimals because they formed only small, not giant planets or because they started out more massive and formed more planetesimals or because their planets interacted in some particular way with the disk of planetesimals. We would like to tease out all these relationships using observations of both planets and disks around the same stars.

Do you receive more or less information from an edge-on disk than a face-on disk?
What information is lost from observing edge-on disks?
Edge-on disks are generally easier to detect, but harder to see rings in because the rings fall on top of each other.

In the velocity-distance diagram, we see that Keplerian motion alone doesn't explain the way the data looks. And I remember you had a comment on the slide which suggested possible coulomb braking. Is there a straightforward way of testing this observationally? I read in some paper that perhaps enhancement of Carbon is something that could be used as a tracer. Additionally, what other leading hypothesis do we have to explain the data if not for coulomb braking alone?
Very sophisticated question. Carbon could be responsible for coulomb braking because it is ionized by the central star, and so is charged, and because it doesn't absorb light at wavelengths where the star is bright, so it doesn't feel radiation pressure. We observed a lot of carbon in the disk around Beta Pictoris (Roberge et al. 2006), and this idea of coulomb braking was used to explain why that disk has atoms in it that should be blown away by radiation pressure – perhaps they stick around because of their coulomb interactions with the carbon (Fernandez, Brandeker and Wu 2006). It would be interesting to see if there is a lot of atomic carbon in the HD 32297 disk, and in fact, we did observations to look for it with ALMA last year. Now we have to interpret our atomic carbon detection and figure out if the coulomb braking works.

What is one main challenge when observing M stars (or cooler than F,G,K stars in general) such as AU Mic?
They are much lower luminosity, so they don't heat their dust as much, making the dust faint in infrared emission.

How would dust get closer to a star is there isn't any wind or gravity?
Dust reflects light very efficiently when the wavelength of the light is about the same scale as the size of the dust grain. So, the smaller the dust, the better it reflects blue light (this is why our sky is blue).

There is gravity in space! The star's gravity is important, but if a dust grain is in orbit around the star, it won't just fall in, just as the Earth doesn't fall in to the Sun. To get it to fall in, you have to remove energy and angular momentum from the dust grain. The interaction of the dust grain with the light of the star can do this.