Student questions: Jason Wright colloquium on "Artifact SETI and the Puzzle of (Tabby) Boyajian's Star"

10/4/17

Question 1: I noticed in your talk some data was presented at 3 sigma. Is it typical for statistics to be reported up to 3 sigma in this field of research?
Yes, 3-sigma is pretty standard for "statistical significance", although for upper limits one often sees 1-sigma.

Question 2: Some plots in your slides had Kepler days on the x-axis, what is a Kepler day?
NASA declared a certain moment to be day "0" of the *Kepler* mission. *Kepler* days simply measure time since that moment in units of 86,400s.

Question 1: How extensive would a civilization have to be to give off enough energy that we would be able to detect it?
It would take an energy supply around 1% that of the star or galaxy to make it very obvious; probably even less than that in cases where we can look very carefully. The trick is that there are lots of *other* reasons stars or galaxies give off infrared radiation, so then the main problem would be distinguishing the heat as due to civilization

Could a population of micro-organisms give off enough detectable energy or would only waste heat from intelligent life be detectable?
No, life itself is metabolizing energy that ultimately came from sunlight, so there is no waste heat to detect. This method detects the generation of energy, or collection of starlight that would not otherwise have struck any surface.

Question 2: Does the star brightness dip in any temporal pattern?
Not really; there do seem to be some patterns but they are not persistant or precise, and they may be random.

Question 1: Following the theory you laid out, it seems possible to identify extremely advanced civilizations using Artifact SETI. Would other civilizations be able to identify us, given that we haven't reached that level of technological advancement yet?
Not via waste heat yet; the effect is still far too small. They might detect our radio waves or atmospheric pollution, though.

Question 2: What was the red halo effect and why is it diagnostic?
I don't really know! This is what I was told by infrared astronomers familiar with the *WISE* data

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Question 1: Are there any hypothetical exoplanets where the energy available from the planet exceeds that from the star (K1/K2 outliers)?
Sorry, I don't really understand this question.

Question 2: If we get to a point where Tabby's star is more likely alien than natural, what is the next step?
Keep looking. Artifact SETI is hard pressed to ever prove it has found aliens; we would need to see something unambiguous, like radio emission.

Question 1: In the graphs that display Kepler day vs Relative Flux, I noticed that there are high-frequency "valley-like" noise features that are much smaller order of magnitude than the events that take place on days 215 and 260. What is the origin of this noise?

Not sure which noise features you mean. There is a quasi-periodic signal at 0.88 d that I think is the rotation period of the star as some sort of surface inhomogeneities are rotationally modulated. Most of the other features are real.

Question 2: What are the possible reasons for the assymmetry in the dips in the Kepler day vs Relative Flux graphs?
Unclear! If it is intervening material then it reflects variations in the column of material along the line of sight.

Question 1: Is heat (infrared) always the waste product? As in, can we imagine an advanced enough civilization that can utilize energy in a way that exports waste at longer than infrared wavelenegths or is this not possible for thermodynamic reasons.?
Thermodynamics makes this very hard. The surface area required goes as 1/T^2, so to get T a factor of 10 lower means a sphere 10,000 times as large in radius. But the free energy gain going from 300K to 3K from a 6000K star is just an additional 4% (from the Carnot efficiency). The optimum tradeoff between engineering difficulty and free energy use is not clear, but probably does not involve a 10,000 AU sphere.

Question 2: What are the political and social reasons for why SETI has not been funded to the same level, and in the same manner as other fields of exploration?
Some of it is a "giggle factor" from science fiction; some of it is that Congress used SETI as an example of frivolous spending in the 1980's and cut NASA's budget as a result, and I think NASA learned not to even go there again.

Question 1: About Dyson sphere you mentioned in your talk, I believe that if an extraterrestrial civilization is advanced enough to utilize all the energy of the star, they might as well have come up with better ideas to use it than simply creating Dyson sphere. How valid do you and researchers in SETI community think the hypothesis of Dyson sphere is?
A complete, solid sphere is not valid—it would not be gravitationally or mechanically stable. But a large energy supply requires a lot of radiation (for waste heat disposal), and no technology can overcome this thermodynamic necessity. There sphere is as much about heat disposal as it is about stellar energy collection. Also, most of the available free energy in a stellar system is the mass of the star itself (conveniently and sustainably converted to light by the star) so collecting starlight is the most natural route to a large energy supply, regardless of technology level.

Question 2: One of the most challenging facts about identifying extraterrestrial civilization is that we can never eliminate the possibility of observing natural phenomena we do not understand yet, and cannot guarantee if dimming of the star is caused by civilization or by unknown natural phenomena. What do you think would be the most promising way for Artifact SETI to eliminate such possibilities as much as possible?
Communication SETI

Question 1: How do you differentiate between point source stars and galaxies in the WISE observations?
So far its hard—one has to cross-correlate with catalogs. Gaia will provide distance measurements which will allow us to focus on nearby stars.

Question 2: If Tabby's Star does have an alien civilization, what kind of processes/technologies could produce these strange variations in the light curve?
Very large structures, like solar panels or radiators.

Question 1: Is there a maximum distance for radio signals before they become indistinguishable from random noise in the signal?
This is a complicated question, and it depends on the strength and sort of radio signal one sends, and whether the receiver knows what to look for. But ultimately yes, any signal eventually becomes to weak to detect.

Question 2: We haven't seen “little green men” in our backyards, and if there are other vastly advanced civilizations out there, perhaps lighting the proverbial signal fire is a bad idea in the sense that something is killing off the civilizations that also signaled out; could doing this research actually be a bad thing for Earth in the long run?
I don’t think just looking is harmful because it is purely passive.

Question 1: What were some of the initial estimates for the probability of detecting intelligent extraterrestrial life?
I don't think this number can actually be quantified.

Question 2: How well do SETI scientists consider their own biases in thinking about extraterrestrial life and technology?
Not very well I would say: https://arxiv.org/abs/1708.05318

Question 1: You were talking about how there isn't a smooth distribution of infrared radiation across the galaxy; does this support the possibility of dyson spheres?
No, it's consistent with dust, which is clumpy, not stars, which have a smooth distribution.

Question 2: Are there other kinds of extraterrestrial artifacts besides dyson spheres that have been hypothesized based off the data we have so far?
Yes, lots. Arnold's solar panels are the ones I had in mind.

Question 1: How would you as a scientist approach delivering information to the general public if we were more confident that there is ETI?
I don't think I understand the question.

Question 2: Can the James Webb Telescope be a useful tool for ETI? If so, how?
It will be good for determining what the strong infrared sources are that we found in the G-HAT survey.

Question 1: What would our solar system look like as observed from far away using systems looking for infrared waste heat? Would we even be visable in terms of the systems we are using to look?
No, our energy supply is too low right now.

Question 2: Could the low thermal signature of a megastructure around tabby's star be the result of an attempt to direct waste heat?
No, because waste heat is high entropy, so can't be directed. It could be the result of using the energy in a low entropy way, though, like emitting communication signals.

Question 1: Can IR anomalies arise from something other than possible alien signatures (Dyson spheres)?
Yes, dust is the usual way IR anomalies arise.

Question 2: What if these 'alien civilisations' are not that advanced or 'intelligent' to effectively harness any energy?
We definitely won't detect them that way.

Question 1: Based on Kardashev scale, I would assume that Earth hasn't even reached Type I in which all of the planet's energy can be stored and used. On a scale of 1 to 10, how close is humanity from becoming a complete Type I civilization?
We're around a 0.7.

Question 2: If extraterrestrial intelligent life forms were to find us before we find them, would that imply that they are technologically more advanced than we are? How could we know for sure if we have been detected or not?
Yes, probably. We couldn't quite detect ourselves from the nearest star. We would not know that we had been detected.

Question 1: How was the wavelength for the IR waste heat detection determined?
I assumed somewhere hotter than about 100K.

Question 2: For Tabby's Star, you wanted to gather spectra during the transit events, what were you hoping to learn from the spectra?
We are hoping that the intervening material will leave its spectral fingerprint in the light so we can determine its composition.

Question 1: You mentioned that you consider SETI as a school similar to the Earth and Space Exploration or School of Sustainability. Similarly to how those school have specialized courses do you think that SETI should have courses taught at major universities?
I think of it as a field of study, not a school. But yes, I think SETI needs a curriculum and to be taught. I am starting a graduate SETI curriculum at Penn State as part of our astrobiology dual-title PhD program.

Question 2: Considering that even if it was found that there was an alien mega structure created, the chances of humanity encountering this alien species is so low due to the distance, why do you think that this is an important area of science to study?
The question of other intelligent life in the universe is one of the most profound we can ask. It's worth at least some of our collective time and effort.

Question 1: How would we be able to tell if what we find is a sign of extraterrestrial intelligence or just a natural phenomenon that we don't understand?
Communication SETI

Question 2: Where does human civilization rank on the Kardashev scale?
About 0.7

Question 1: Would you be able to see waste heat on a type 1 or 2 civilization, or only type 3?
Type 2 or 3.
Question 2: On the graphs that show the light dips, why are the top two so fuzzy, yet the bottom two smooth?
Different y-axis scalings

Question 1: What is your favorite SETI type star?
Tabby's Star and Prszybylski's Star.

Question 2: Do you plan on repeating this type of experiment of taking spectral readings of weird transits, or start from a different perspective for your next project?
Most of my work is on radial velocity detection of exoplanets.

Question 1: Michael Hart's argument was that we must be alone in the MW, because other have not already colonized the Solar System, what are some key factors that make life on Earth more special?
I don't understand the question. We don't know if Earth is special or not.

Question 2: Is it dangerous to expose the planets life to other alien planets, as scientist we always want to explore and grow knowledge about galaxy exploration, but what are some of problems we can encounter with other alien planets?
I don't think there is any prospect of exchanging material with any exoplanets. If you mean the Solar System planets, there is a danger we could contaminate the other Solar System bodies with Earth life, ruining our ability to detect any potential indigenous life there.

Question 1: You were talking about one of your sources being a Be star that you think had a nebula around it (which is not normal for these types of stars that generally have disks). Have you considered it might be something like a Wolf-Rayet star that has the same emission lines but are known to be at the center of planetary nebulae? Or are you seeing something like outbursts that make it most definitely a Be star?
It is definitely a Be star, not a giant or very massive star.

Question 2: If this star did have an alien megastructure that was not a full dyson sphere and you were able to get spectra of the star, do you think we currently have the ability to see a emission/reflected spectra from the object(s)?
No, reflected light is much, much harder to spot than the infrared emission.

Question 1: Could you expand on your reservations that the dimming could be the result of exocomets?
This hypothesis invokes a novel phenomenon we have no other evidence for, and requires us to have just caught this star during a very rare part of its life.

Question 2: Is there any technology on the horizon, ie. computer processing, telescopes, satellites, that will provide additional insight into the anomaly?
The recent dips of the star observed from the ground will help. The James Webb Space Telescope would make a firm measurement of its infrared emission.

Question 1: How is it possible for the dust to escape the EB star that you suggest is a potential dust source?
The Be (spectral type B, 'e' for emission) star has an excretion disk because it spins so rapidly. It also has a powerful stellar wind that will blow material away, and this material can later condense into dust.

Question 2: Is there a galaxy type that is hypothesized to offer better results for K3 life due to these intrinsic galaxy mixing properties you mentioned?
No, they all mix pretty well, but elliptical galaxies experience fewer supernovae and can have shorter star-star distances.

Question 1: Without any evidence of civilizations outside of our own, and without any indication of what those civilizations might be capable of, why is this hypothesis more convincing than the transit of families of bodies?
I don't think its more convincing, but I don't really know how to rank it. Comets like this were not in advance; civilizations were.

Question 2: Is the long-term, reduced brightness of Tabby's star after some transits due to a body disintegrating during transit, leaving a relatively long-lasting dust cloud?
We don't think so—the dust would have to be very cold to have escaped notice.

Question 1: Can you still do radio SETI of some sort with civilizations that no longer rely on radio waves for communications?
If they use radio for other purposes. For instance, there is an optimization of the interstellar spaceflight problem that involves beamed radiation that would show up as microwaves.

Question 2: What is the probability that the dips seen in Tabby's star is caused by an intelligent civilization?
I don't know. I presume they are very small.

Question 1: How does the new 500m Chinese radio telescope influence the work being done at SETI?
SETI is a field, not a place. The Breakthrough Listen project hopes to work with FAST to conduct radio SETI searches with it.

Question 2: What spectral features would you expect to see in the intensity dips that indicate potential signs of life?
If the absorbers are perfectly opaque, like structures.

Question 1: When you take these measurements that show a possible earth like planet orbiting a sun, how can you take these measurements when Earth is rotating itself, are there multiple places around the world that can also take these measurements?
I'm not sure what you mean. If you are asking about *Kepler,* it is not on Earth, but the Earth's rotation is not a big issue in any planet-hunting program.

Question 2: How do we know that the planets orbiting the sun are Earth like? Is this based on their size?
Which sun? If you mean the planets found by *Kepler*, right now most of the conclusions that planets could be "Earth-like" are based on the planets' sizes, yes.

Question 1: If Tabby's Star turned out to be the flicker of an advanced civilization, what would SETI's next step be? Would there be some sort of effort to contact them or would monitoring simply continue?
I don't know. I would want to study the star in every possible way to try to find other signs of their technology and understand what we are seeing.

Question 2: Other than infrared and radio telescope, is there any other method used to search for extra terrestrial intelligence?
Yes, laser NIR/optical SETI is the other major method.

Question 1: Were a civilization similar to our own within the Milky Way, transmitting radio broadcasts in the attempt to contact another potential civilization i.e. us, does the SETI Institute have the capability to detect the signal and/or resolve the transmission?
No, but Arecibo and Green Bank would have the capability to detect our own interplanetary radar—if we knew exactly when to look, where to look, and it was coming from the very nearest stars.

Question 2: Removing the limiting factor of funding, how close is humanity to having the technology capable of producing a Dyson swarm (a cluster of smaller solar arrays that orbit the sun rather than a large mega-structure)?
I imagine we are thousands of years away—such a swarm requires a large amount of mass, so we would have to disassemble entire planets.

Question 1: What about the possibility of the pseudo transit paths being generated by objects which are the remnants of a nearby supernova, and have been pulled into an orbital path by 'Tabby's Stars' gravitational field?
There is no nearby supernova, and supernova remnants generally do not produce "objects", just gas and dust.

Question 2: While the emphasis is on the search for 'GHAT dipping' (?) outside of our galactic system, has there been an attempt to test our own solar system using this, so we have something to compare against?
I'm not sure what this question is asking.