EGSM 005: 10,000 Planets (Space)

Content Warnings

Explicit language
Innuendo & brief sexual references

Discussions of: death, alien life
Mentions of: food, extinctions

HELEN

Would it be possible to attach massive rockets to the Earth and shove it around?

PAUL

We do attach massive rockets to the Earth but then we let them go.

HELEN

Aww, we do. Fly free rockets.

[Show Theme - Intro]

HELEN

Hello friends and fans and welcome to Enthusigasm, the show where we talk about a few of our favourite things. I am your host, Helen Gould, one of the best Rusty Quillers and today we're talking about space and, I am delighted to be joined by Bryn, Josh, Marisa, and Paul. As always, we're gonna introduce ourselves alphabetically, so Bryn can you give me your pronouns and tell me who you are, what you do?

BRYN

Hi, I'm Bryn, pronouns he/him. I am part of Rusty Quill I guess. I have been for a long time now, like six and a half years or something. I appear mostly in Rusty Quill Gaming as Hamid but you might also know me from the Stellar Firma science episodes where I quiz our resident idiots, Ben and Tim, about their knowledge of science.

HELEN

(Laughing) Bryn!

BRYN

And here I'm going to be on the other side of that equation so we'll see how that goes. Many, many years ago I did study astrophysics and I hope that my knowledge is not horribly out of date.

HELEN

We'll find out.

(Bryn laughs)

Josh, can you give us your pronouns and tell us who you are.

JOSH

Hello, I am Josh Fox. My pronouns are he/him. I am a tabletop roleplaying game designer. The designer of such space games as Last Fleet and Flotsam: Adrift Amongst the Stars. And I really like space. I don't have an astrophysics degree, sorry about that.

(laughter)

HELEN

That is desirable but not essential.

(Group laughter)

I joke, I'm so happy to have you here. It's been a very long time since we last spoke. Alright, Marisa, can you give us your pronouns and tell us who you are and what you do?

MARISA

Yeah sure, my name's Marisa. My pronouns are she/her. I'm one of the Rusty Quill editors. You'll probably mostly hear me on Rusty Quill Gaming and also on Enthusigasm. I also don't have an astrophysics degree but I do like space a lot, so here I am.

HELEN

Wonderful. And last but absolutely not least, Paul. Can we get your pronouns and can you tell us who you are?

PAUL

Yeah I'm Dr Paul Sutter. Pronouns he/him. I don't have an astrophysics degree per se, but I do have a PhD in physics that I got from the University of

Illinois at Urbana-Champaign in 2011, and my astrophysics knowledge goes out of date every single day.

(Bryn laughs)

HELEN

Oh, bad news Bryn. Wonderful, ok. Let's start with a very easy and simple question then which is what do we all think is interesting about space? I'm sure that this is…

BRYN

Yeah, start small.

HELEN

Yeah, yeah we're going to start small. These are one word answers only.

(laughter)

For me, I like that it's big. Next person.

(laughter)

PAUL

Well that's why they call it space, because there's a lot of it.

HELEN

That is true. That is true. It's also very pretty or at least I think it is. I remember when we all went to Alex's wedding, we were out in the middle of Wales and there was no light pollution at all, and you looked up and you saw the whole Milky Way and it was all purple.

BRYN

I think it is very pretty, but yeah, as another Londoner it's so rare that we get to see any of it, it's sad.

PAUL

Yeah I live in New York City and I grew up in the midwestern part of the United States out in the middle of the cornfields and I enjoyed a lot of night skies and even though I don't live in New York there is so much light pollution near me from New York, from Hertford Connecticut, from Boston Massachusetts, every single horizon is bathed in glowing light and we can see some stars up here but it is not what I'm used to and I really do miss it.

HELEN

Aww. Genuinely what is it that draws people towards space, like what do you find interesting about it?

BRYN

I mean, you've said it's big, and I do think that's a big part of it. Like it's…it's so big that it boggles the mind and it's crazy impressive, and it, but also it contains therefore so many possibilities and you know, I know for me it's partly sci-fi stories but it's also, you know, for as long as I can remember I was always fascinated by black holes because you know they're so bloody weird apart

from anything else. And yeah like the weirdness, the difference to every day life, the bigness and yeah, therefore the possibilities it contains in that sense.

JOSH

You might think it's a long way down the shops, but that is just peanuts to space.

BRYN (simultaneously)

...peanuts to space.

HELEN

What is that?

JOSH

I was going to say the same thing. It's a…

PAUL AND BRYN

Hitchhikers Guide to the Galaxy.

HELEN

Oh! Oh, have we all read that?

MARISA

I haven't read it but I've watched the movie. I'll count that.

PAUL

I won't count that, I'm sorry.

JOSH

Actually I have to confess to not…I've, I'm just about to start reading it with my son. I've listened to the BBC Radio play which is…

BRYN

The definitive version.

JOSH

That surely counts.

BRYN

I have both read it and listened to the radio play and seen the movie and I think they are all valid versions. But I would say the BBC Radio one is…the radio play is the best version.

JOSH

I love it. So I was going to definitely say the bigness of space and I think there's something about the vastness of space that allows you and the emptiness, I mean, one supposes, to sort of project anything onto it and I think that's one of the things I like. There's so many different stories that you can tell about space, whether it's an empty universe or one that is teeming with other things or one that seems empty but really isn't, and I think that's what excites me about it.

HELEN

Cool. What about you Marisa?

MARISA

Yeah I think I would probably agree with most of everything that was said so far but I think one of my favourite things about space is how beautiful it is. I'm also from a very cornfield part of the US, and you know, that's the one thing that I miss about living there is being able to see space because especially like when you see the whole Milky Way galaxy it's just so beautiful, you could really just stare at it for hours.

PAUL

Yeah there's a reason that we have been telling stories around the constellations and the Milky Way and the…the new stars that occasionally appear. We've been telling these stories and recording these things for millennia, as far back as we can go. Some of our earliest writing is actually just astronomical records. And that tradition has continued all the way into the modern era and what really draws me to space and studying astronomy and astrophysics is a surprising connection that we have discovered over the past few hundred years between us and the larger cosmos and that connection is the fact that we can find physical laws that we can develop theories and hypotheses that are able to describe and encapsulate these forces that are unimaginable, these time and distance scales that are way beyond the human experience. We can write on a chalkboard an equation that describes the history of the universe over 13.8 billion years. That we can simulate on a computer the death of a star. That we can discover these physical laws that truly are universal. That we can, we can set up an experimental laboratory here on earth and understand how hydrogen behaves on the opposite side of

the Milky Way and it's that connection that…that universalism which really was the birth of modern science with Copernicus and Kepler and Galileo and Newton, they were discovering the universality of physics. And that is what gets me going in the morning.

HELEN

That's lovely.

BRYN

The connection between what's in the heavens and what's here on earth is such a good…such a good way to put it. Like, you know, there was definitely in earlier ages there may have been a disconnect as much as we were looking up and telling stories about the stars but, yeah, I love that idea of the connection between what's there and what's here. And you know I talk a lot about the abstract sense of space and, you know, astrophysics is a study of the universe as a whole but there's also…there's all the exciting things in the solar system too. Like, you know, if you can get a pretty ordinary telescope and look up and see another planet and that's an equally exciting way to enjoy space and you know, we live in an age where, you know, this has only been true for what 70 years? Where human beings have been to space, and human beings have walked on the moon. And I think that's really cool too. Like, you know, human beings have been around for what, 10,000 years, a bit more? 20,000 maybe? But the fact that you know, for a tiny fraction of that, we've...

PAUL

I think, if I remember right, anatomically…anatomically modern humans arose like around 40,000 years ago to 200,000 years ago. Somewhere around there. But yeah, like, this very brief amount of time where we have been physically exploring space, not just looking at it.

BRYN

And hopefully in the nearish future we'll go a bit further but I guess that's still to be determined.

JOSH

So one of the things I think is cool about space is the unknowns as well. I mean that's sort of relating to what you're saying, like what was there before there was space? What lies outside space, if anything? What would it be like to be inside a black hole? There's…you know, and this is just things that I as a foolish non-physicist can imagine. I can only assume that those of you who actually understand stuff can think of even weirder questions to ask.

HELEN

I mean if I remember correctly from one of those Stellar Firma science episodes, if you went inside a black hole you would spaghettify?

(Bryn laughs)

Is that an accurate way of describing it?

PAUL

Yeah, yeah I mean this is…and this is the cool thing about the, those unknowns. Like we do not know what happens at the centre of a black hole. We simply don't. We don't know what happens in the earliest moments of the universe. We simply don't. But around a black hole, surrounding a black hole, it is just gravity. It's just Einsteinian gravity. It's general relativity. It's gravity that we've understood for over a century and using that knowledge of what we do know, we can predict all these crazy things like spaghettification.

HELEN

I love also that that's the actual term. Like when I first heard it, I was like 'Oh Bryn's making up a funny word' but no that's actually what you call it.

BRYN

Yeah, no, that's what it's called.

PAUL

It's real science here folks!

HELEN

Hell yeah.

JOSH

I can actually help you out here because I've been into a black hole a couple of times. Yeah, both times there were extradimensional evil entities in there so I think, sample size of two, that pretty much says what's in there and we know now.

BRYN

The mathematical process of induction.

PAUL

The really annoying thing about black holes is not only once you cross the event horizon you can't come out. Once you cross the event horizon there is a finite time until you are obliterated at the singularity. You can end up…the amount of time is given by the mass of the black hole. For a super giant black hole millions of times more mass than the sun, it is a handful of seconds. And no matter what you do, no matter how you fire your rockets, no matter what you do, the singularity, the point of infinite density is always in your future. It's always right in front of you no matter where you turn around, and you will hit it in a finite amount of time. What happens at the singularity is beyond known science.

HELEN

Wow! And sorry I'm…I'll say it, I'm getting starry eyed now because there's nothing I like more than hearing someone explain stuff. I do want to go back to something that we were just touching on earlier which is science fiction to do with space. And I'd be interested to know if, if we all enjoy that or if, or if there are…how shall I put it, what our standards are in terms of what we regard as good science fiction about space

(Bryn laughs)

Marisa, do you have any opinions on science fiction and space?

MARISA

Yeah so in terms of science fiction, I think that's actually what got me into space in the first place, not the other way around. I would say that I'm very forgiving in the science fiction that I watch. I really love some of the old Star Trek TV shows, that you're like this is definitely outlandish but space is also sort of outlandish to the average person, so who knows, maybe there are space whales and all of these ridiculous entities. I don't know! But I would say in terms of science fiction there's really nothing that I would say this is ridiculous, because, like I think Bryn was saying earlier that space really has these infinite possibilities so...y'know, maybe it's possible somewhere. I don't know.

HELEN

Josh, you write games about space.

JOSH

Yeah, totes.

(Helen laughs)

BRYN

I assume you strive for intense scientific accuracy at all times Josh.

(laughter)

JOSH

I, I strive mostly for the opposite I would have to say, as much…because I don't know enough about space science as has now been remarked numerous times to really do a good job of that but, I mean, I think…I like any kind of space based fiction that knows what it wants to be, right? So I like the hard super duper realistic, it's just three people in a pod on the outside of Europa trying to survive for five minutes. I like the weird and wacky stuff like Star Trek or Ninefox Gambit or Star Wars for that matter. I like stuff that has planets teeming with weird aliens and I like stuff that has no aliens at all. I just think if it knows what it wants to be and it's got something really strong to say then…and that's the great thing, like I say, you can project anything onto a space based story, right, because it could be anything out there.

BRYN

I absolutely adore sci-fi and I absolutely…I am a pernickety nerd, but I don't really demand scientific accuracy from my sci-fi. Star Trek is the thing I've been a fan of for as long as I can remember. Absolutely addicted to Deep Space Nine as a teenager. One of the things I love about the sort of Deep Space Nine, Voyager era of Star Trek is they did have a full time scientist on staff whose job was to edit every script. Not for scientific accuracy, but for what they would call scientific plausibility. And so actually I think Star Trek is pretty, you know, if you talk about the kind of scale of soft sci-fi down to hard sci-fi, Star Trek is closer to hard sci-fi than you might imagine a lot of the time because they do at least make an attempt or they did during that era, I can't speak if they have the same procedures in place in the modern era. Whereas, I mean, Star Wars is pure space fantasy as far as I'm concerned. And I still adore it and I don't mind. I do…my pernickety nerd side does come out, the thing that really grates with me is inconsistency. Like if you have a strong premise, if you set

your own rules and stick to them, totally on board, kind of, however accurate those rules are to what we might think of as reality. But if you start to break your own rules or if your rules start to like, just get thrown away again or, you know, rules that seemed to apply once just don't in another situation then I start to…that, basically I lose my immersion and I lose my, what's it called, you know when you buy into a premise and…

HELEN

Oh, your suspension of disbelief.

BRYN

Suspension of disbelief, yeah, if that goes then I find it really hard to keep engaging. So that's the thing for me that's a problem. It's not really realism but consistency in my sci-fi and, well even in my fantasy as well to be honest. But yeah.

HELEN

What do you think Paul? Is it difficult for you sometimes to watch silly space films?

PAUL

No, it's not difficult. I know it is for other astrophysicists and astronomers and scientists and lawyers and doctors and engineers, but it's not difficult for me because I…when I watch a movie or a TV show, I'm not interested in grading homework. I do enough of that. I just enjoy…it's a story, it's obviously not taking place in our universe. It's obviously not playing by our rules of the universe so why should I judge a movie or a TV show in the universe that they

are portraying by the physics that I know about our universe? It's not our universe. It's playing by a different set of rules. So as…like what Bryn said, as long as the movie or show stays consistent and it sets up the rules and tells a good story and I get to enjoy it, I could care less whether they're jumping into wormholes or shooting lasers. It doesn't matter. What matters…that's not the point. If I wanted accurate science, I would open up one of my textbooks because that's what it's designed to do. If I want to have a good time, I watch a movie or a TV show.

HELEN

Yeah. I have a very similar experience because part of my job is reading people's books and telling them, either for sensitivity checks or for editing checks and so now if I'm doing it for pleasure, it just…I turn all logic and rationality off, like, I can't approach anything with that same amount of rigour because it's tiring and I don't want it to feel like work.

MARISA

Yeah.

BRYN

Is everyone familiar with the possibly apocryphal tale that they…when people begin their career at NASA, one of the tasks they ask them to do is watch the film Armageddon and list as many mistakes as they possibly can. And the record is something like 250 something?

PAUL

Wow, I've never heard that before.

BRYN

I have no idea if it's true. It's the kind of thing that could just be a lie made up by the internet but I think it, I really hope it's true!

JOSH

If you can do that, like pull it off, name all 250, do they have to let you be an astronaut?

(laughter)

BRYN

Who knows? Maybe!

JOSH

Because I will give that a try.

PAUL

If you do that and 50 push ups you're an astronaut.

(laughter)

JOSH

I'm in. I'm in.

BRYN

I mean I think it feels too easy. If you can…if there are 250 mistakes, they should get a more accurate film and see, you know, raise the difficulty level.

JOSH

Are you going to have a physics Enthusigasm, because I definitely think you should.

BRYN

I think this is it, really, more or less.

HELEN

This basically…this is…

PAUL

If you want to talk about space you've got to talk about physics.

HELEN

Yeah!

MARISA

That's true.

HELEN

And I am terrible at physics. It's one of the few subjects I got a D in at one point. I ended up with an A but only because I was getting extra tuition at home, like two hours every day. So while I'm on the subject of thinking about

physics at school...I was taught that Pluto was a planet. Can anyone remember why they said it wasn't a planet, afterwards, and then is it a planet again now?

BRYN

No.

HELEN

No...

MARISA

So if I remember correctly from my astronomy camp as a young child...

HELEN

You went to astronomy camp?

MARISA

Yeah I would be happy to talk about astronomy camp because it's one of the things that got me into space.

HELEN

Oh my god!

MARISA

But I remember that we talked about Pluto shares more characteristics with an asteroid than with a planet if I remember correctly. I remember that we talked about that it seemed more like a asteroid that could be found kind of near the area where Pluto is? Like the asteroid belt up there, instead of an actual

planet, and I think now it's classified as a dwarf planet. Is that right? That's my extremely, you know, I think I was in like eighth grade when I took that class so…

JOSH

Can I give my answer, because I want to say it before someone who actually, you know, one of the physicists is able to correct me...

HELEN

Go for it Josh, I'm all ears.

JOSH

It's more fun to let the ignorant people go first. So I think the reason it's a dwarf planet is because it hasn't cleared its immediate vicinity of objects. I think there's something about, like, to be a planet you have to have cleared your, I'm going to say region of space, that's probably not the right word, of other objects by drawing them…presumably they fall into your gravitational well.

HELEN

So you're saying Pluto is too close to the closest planet to it.

JOSH

Something else I guess, yeah. I mean obviously it can't be completely true can it because we've got the moon around us, but either it has to either be…have crashed into you, or be in orbit around you. I think that's…that's what I heard. Now you can hand over to the people who are gonna tell me I'm wrong.

BRYN

Well it's my turn next because I will then get corrected in my turn.

(group laughter)

So basically, I mean, you know this is classification in science and as Paul said earlier we get to make the rules. And so we've made some rules about what makes a planet. You know, it's certain criteria a thing has to meet to be a planet. And the problem is, if you want Pluto to be a planet, then there's like three or four other objects in the solar system which would also fall under the same definition. Like, if your list of criteria is you must be a, b, c, d well it turns out there's actually something like 13 objects in the Solar System that fit that criteria, and...some of them are just obviously not planets. They don't look like planets. They don't look like what we think of when we say this thing is a planet. And so you add in two more criteria. You add in criteria e and criteria f, and when you do that, well it turns out that Pluto is no longer in the list of things that meet all those rules. So basically that's more or less the situation but I'm happy to, again, have even more knowledge thrown my way in my turn.

JOSH

So because some cranky scientist didn't want there to be 13 planets, that's what I'm hearing.

PAUL

I mean basically this happened in…this definition came in 2006…

BRYN

Yeah.

HELEN

Ok.

MARISA

Mmhmm.

PAUL

…as a part of a vote of the International Astronomical Union. They were meeting in Hawaii that year because we pick very, very good places to have our conferences.

HELEN

Yeah!

BRYN

Absolutely. But there's also a couple of really big, good telescopes in Hawaii, aren't there?

PAUL

Yes, yes up on Mauna Kea, but that had nothing to do with the conference.

MARISA

You just wanted to go to Hawaii?

PAUL

It was just…the conference was in Waikiki and yeah, it…prior to 2006 there had been no strict definition of a planet. Basically if it orbits the sun, it might be a planet, it might be an asteroid, and we had generally decided that the stuff in the asteroid belt was asteroids and everything else is a planet. And Pluto was included as planet in that definition, but in the late 1990s and early 2000s we started to find more and more objects in the outer solar system alongside Pluto. There's Haumea, there's Makemake, there's Eris. There's all these cool objects. And we started to wonder, should we call these planets? And we suspect that there's a lot more objects out there that we simply haven't detected yet. That we might be facing a situation where we have somewhere around 10,000 planets…

BRYN

Oh wow!

MARISA

What?

PAUL

…because if it's not an asteroid and it's orbiting the sun, it's a planet. So, this decision, which was controversial at the time and is still controversial even in the astronomical community, finally defined a planet and picked a definition of planet specifically designed to exclude Pluto. Because our choices were eight planets, or like 10,000, and we went with the definition that gave us eight planets. And the criteria is exactly what Josh mentioned, is that in order to be

a planet you have to orbit the sun, you have to be big enough to be round, and then you have to clear your orbit of any other junk. And Pluto has a massive moon compared to it, Charon, it's like half its mass or something; and there's a bunch of other junk in that general vicinity. If that definition sounds arbitrary, it's because it is. It was arbitrarily chosen so that Pluto would flunk. It's like a teacher designing a test with questions that they know that you are not going to get right so that you get your D in physics. And since then the arguments have gone back and forth. Pluto is now classified as a kind of planet, a dwarf planet. Just like Ceres in the asteroid belt is no longer an asteroid, it is a dwarf planet, and there's like a dozen other known dwarf planets. In practice, if you actually open up astronomical journals, astronomers refer to Pluto as a planet because it's easy and convenient, so by…even though by legalistic standards Pluto is not a planet, a lot of people argue it does look like a planet. It has interesting surface features. It has a source of heat on the inside. It has nitrogen glaciers that are currently sloshing around. It's raining water ice, it's raining nitrogen and snow on Pluto right now. If you look at a picture of Pluto it looks like a very interesting active world, and you might be tempted to call it a planet but...I'm not in charge. I think Pluto should be a planet. I think we should have 10,000 planets in our solar system. I think clearing the orbit is not a property of the object itself, it's a product of its environment. The argument is like if you were to take Earth and move it to the orbit of Pluto, we would get demoted to dwarf planet because there's too much stuff out there. And so that has nothing to do with Pluto itself but there are arguments for this line of thinking being coherent and consistent, and so who cares, call Pluto a planet if you want. IAU does not have a police arm to it. There are no IAU jails. You can do whatever you want.

HELEN

That is extremely encouraging.

BRYN

Yeah, that is really important too. Like scientific language and accuracy is not the same as everyday language.

HELEN

I think then, on the confirmation that the official stance of this podcast is that there are 10,000 planets...

BRYN

I'm, no I'm voting eight. I'm voting eight. I'm on the other side of this debate I'm afraid.

HELEN

Too bad! I'm directing this show!

BRYN

I'm happy to lose. I just want it on the record.

(group laughter)

HELEN

Well we'll be back in a minute while we hash out this debate.

And welcome back. So I have a really hefty topic to talk about next because…actually no, I want to check this first with Bryn because I think it's Bryn who I heard this from. As I recall time travel has something to do with gravity?

(Bryn laughs)

Don't laugh at me!

PAUL

What's so funny about that?

BRYN

I, that doesn't sound like something I'd say.

HELEN

That, ok that's not you verbatim! But you told Tim and Ben about time travel and it had something to do with something unexpected…it was like…

BRYN

I mean, gravity affects the flow of time.

HELEN

Yes! That was what you were talking about.

BRYN

So time...I might have been talking about time dilation. I mean, it's true that if time travel were to exist then probably it would have effects on gravity or gravity would have effects on it, but I think, I think, yeah, I think that may be talking about time dilation...

HELEN

Ahh, okay.

BRYN

...rather than time travel.

HELEN

So then how do time travel and space interact? Because surely there are some weird…like ok, yeah, I know time travel doesn't exist, just to be clear! But if it did...what would that do to like our conception of like, space time, I guess.

PAUL

Time travel does exist!

HELEN

We're going, ok, we're going forward in time.

PAUL

Yeah but that is travelling through time. You are moving, all of us are moving in the dimension of time, and that's important to remember.

HELEN

That's really inspiring actually Paul. We are all time travellers together.

PAUL

Yeah!

(group laughter)

JOSH

And we travel at different rates too. I mean that's like a cool thing that, I know about physics, yeah! That like if you're close to a black hole, then...or something heavy anyway, then time…I'm going to get this right, slows down for…time is moving faster for you than everyone else? Yeah, let's just say I'm right about that. I'm sure what I said made sense. And also, if you're travelling really fast, you know, same thing, right? So like in a real sense, time is not this simple kind of one way thing, right.

MARISA

Didn't something like that happen with the astronauts on the international space station where it seemed like they were ageing slightly less. Is that true?

HELEN

Ooh. Tell me more about that Marisa!

MARISA

I think...so I'm sure I'm going to botch this and then have to pass it to Paul, but I know that there have been, there's been a study on identical twins where one is an astronaut and one is not, and the effects that space has had but I'm not

sure if they actually studied time or ageing, or if it was just the effects of how being in space affected your body compared to staying on Earth.

PAUL

Yeah that was the point of the twin study. This is the Kelly twins, one stayed on Earth and one went to the space station for like a year, over a year. And then they came back and studied the effects of being in a microgravity environment it has on the human body. But you are right that astronauts in the space station experience time a little bit slower than us here on the surface, by something like a microsecond every year.

HELEN

Ohh!

BRYN

It's an absolutely tiny difference.

HELEN

It's still cool though.

PAUL

But measurable. We've, we've taken atomic clocks and put them in airplanes and measured the effects of time dilation.

BRYN

And it's the basis of GPS as well. You have to take it into account to get accurate GPS readings, the fact that the satellites that are sending the GPS

signals measure time differently to the receivers on the ground. If you didn't take that into account, your GPS would not work.

MARISA

Huh.

HELEN

I think that's what I'm remembering, and my brain translated that into satellites and time travelling! Or something!

(group laughter)

So now Bryn, you see Tim and Ben are not the worst at science.

BRYN

But they laugh at me and mock me while they do it Helen.

(Helen laughs)

HELEN

I will never laugh at you.

(Bryn laughs)

JOSH

Has everyone seen the Wandering Earth?

HELEN

No. Tell us about it Josh!

JOSH

Well, first thing, go and fucking see the Wandering Earth because it's amazingly cool. So it's, it's by Cixin Liu of the Three Body Problem and other such kinda Chinese physics books…physics fiction books, so every one of his books, as far as I can tell, I've only read two of them so, you know, sorry Cixin if I got that wrong! Um, like they're all about some sort of weird premise in physics, and then spinning a story around that. And in this case, it's about, for some reason we need to move the Earth to a different orbit around a different sun or something, I guess the sun must be dying or something like that. So they fit these giant rocket boosters to the Earth and use it as a spaceship, and like fly the Earth through space and…

HELEN

Yeah that basically happens in Mass Effect at one point! But it's an asteroid...

(group laughter)

MARISA

Oh, yeah yeah!

HELEN

...and you have to stop the asteroid from crashing into Earth because they wanted to put the asteroid into orbit, so they could mine it properly.

JOSH

Everything has been done in Mass Effect, and obviously, you know, I wasn't to know that.

HELEN

Hell yeah, everything's been done in Mass…sorry I won't, I won't make alien sex jokes.

(group laughter)

JOSH

There is a whole…there's a whole physics thing that happens, I think some…like a moon or something gets too close to the Earth, and all of the atmosphere gets…starts getting siphoned off and I remember looking at that and thinking, god to be a physicist watching this you'd be kind of like either, 'wow this is amazing I can't believe how well they've done this' or really angry. I don't know which.

HELEN

So the moon steals the atmosphere from the Earth?

JOSH

I don't remember whether it's the moon or they like, fly too close to another planet or something, but yeah, there's a whole kind of atmosphere stealing thing going on and they need to stop that from happening otherwise everyone's going to die. I'm not spoiling too much of the plot here because I

can't really remember very much about what happens. I have a crap memory for stories so, don't worry, I've probably got it all wrong.

HELEN

Huh.

JOSH

But it's on Netflix, so you can go and watch it. And it's, I think it's in Chinese with subtitles or something so I love that kind of international science fiction stuff that is getting more and more of that kind of thing. It's really good.

HELEN

Would it be possible to attach massive rockets to the Earth and shove it around?

PAUL

We do attach massive rockets to the Earth, but then we let them go.

HELEN

Aww, we do. Fly free rockets.

BRYN

I mean to generate enough thrust to affect the momentum of the Earth would require consuming so much of the energy present on the Earth that it's impossible for that reason in that sense, would be my take on it. Like the actual energy required would be just astronomical in…I guess in the literal sense. And yeah, so that feels like the major barrier. I mean you'd also, you

know, could you construct something large enough to create the thrust even, I don't know.

HELEN

Hmm.

JOSH

But you only did your astrophysics degree like years ago, Bryn, so you're probably wrong aren't you.

BRYN

And I mostly studied black holes so…

PAUL

Yeah, to give you a sense, the kinetic energy of the Earth is around 2 times 10 to the 29 joules. To put that into context, that is the entire…all the energy consumed by humans every year for about a billion years...

HELEN AND MARISA

Oh....

PAUL

...is the kinetic energy of the Earth in orbit around the sun.

HELEN

That sounds like a lot.

MARISA

Yeah.

(Helen laughs)

PAUL

It sounds like a lot because it is a lot.

BRYN

And if you somehow manage to change the kinetic energy of the Earth, the most likely effect would be you'd either start flying away from the sun or you'd start flying into the sun, because you'd mess with the orbit basically…

HELEN

Oh yeah because the Earth is spinning!

MARISA

Yeah.

HELEN

Yeah, I forgot that the Earth is move, is spinning…

JOSH

I think you want to fly away from the sun, that must be the idea, so...could you just nudge it a little bit so that it's still got its same kinetic energy but pointed in a slightly different direction?

PAUL

What you can do, like let's say you were to sap some of the energy out of the Earth, what would happen is it would move down towards the sun, it would come to a closer orbit and the act of moving closer gains speed and so you'd be in a closer orbit moving faster with overall less energy. That's it.

JOSH

What if you had a bag of negative mass…

(group laughter)

PAUL

Negative matter, and you kicked it...well if the Earth was made out of negative matter, then if you tried to pull energy from it, it would move further away from the sun.

HELEN

You got a serious answer to that question Josh, so er...

JOSH

I'm happy with that yeah. I think we've solved the problem.

HELEN

I want to go a little bit more spacey now instead of…although I love these hypotheticals, I love just asking Paul more and more absurd things. I'm so sorry, I can't get rid of the idea that you thought you were going to come on and debate like intense scientific theories.

PAUL

No, no, no. This is way more fun.

HELEN

I want to touch on aliens. Again, that's not meant to be an innuendo but like I want to…

(group laughter)

…I want to like talk about whether we think that there is sentient life out there apart from us because Alex told me a really depressing paradox. He said that either all the aliens before died a long time ago or they will only exist a long time from now, or we're the only ones that will ever exist. That is a very, very terrible summary, but that, and I was extremely depressed after he told me that. What do we think? Do we think…because I feel like, I feel like space is so big that there must be other sentient life. I feel like just the sheer probability of it, there must be something else out there that can think. I don't know how the rest of you feel. What do you think Marisa, you went to astronomy camp, you were looking at planets.

MARISA

Well, so I have a couple of opinions about aliens. Originally I was like there's no way that there could be aliens, but then I went to, of course, my astronomy camp and we started talking about the fact that some bacteria can survive in space. So I was like ok well maybe there can be life out there but it's not necessarily sentient like us, like it could be like bacteria and things like that.

And then I started thinking about it more and thought maybe it's possible for aliens to have evolved on other planets. But then I was like, you know what, I don't think I have the mental energy to deal with aliens so I'm just going to pretend that they don't exist and that's, that's basically my opinion now, like maybe they're out there but...I'm gonna hope that they're not, because I can't deal with aliens too.

HELEN

Oh fair. I think that's fair.

PAUL

That's a great line of thinking. Aliens probably don't exist because it would make me uncomfortable if they did.

MARISA

I mean, I think it's rock solid logic, but...

PAUL

Well I think there is the Arthur…I think it was Arthur C Clark who said either we're alone or we're not, and both possibilities are equally frightening.

(Bryn laughs)

BRYN

I love it.

MARISA

That's, I think that's going to be my new theory on aliens. I'm just going to adopt that.

HELEN

I don't think it's very frightening to think that we're not alone.

MARISA

Really?

HELEN

I'd find that kind of comforting.

BRYN

I mean, I think it's a really hard question to answer. There's the very famous Drake equation which tries to estimate the probability of there being alien life, which is like, ok what is the number of planets in the universe? What is the probability that on any random planet life begins to evolve? What is the probability that if life evolves, it becomes multi cellular? What is the probability that if multi cellular life evolves, it becomes sentient? Because it seems perfectly possible that, you know, you could have, you know single cellular life like bacteria without those other two things happening. It seems possible you could certainly have multi cellular life without sentience, like, you know, the dinosaurs existed on Earth for a long time and as far as we're aware they were, you know, mostly killed off slash, you know, changed by the change in circumstances on the planet rather than that they, they may or may not have ever have been…you know, have evolved towards sentience. We have no way of knowing. But, it's, you know we only have one case study. Which is our

planet. So it's really, really hard to know what these probabilities are. I think I agree with you Helen in that, you know, there's several hundred million stars in our galaxy or is it one or two billion? I've completely forgotten the latest estimates.

PAUL

It's a few hundred billion in our galaxy.

BRYN

Yeah.

HELEN

Wow!

BRYN

And there's the same number of galaxies in the universe as there are stars in ours, you know, and if you add all those together, you know, there's just…there's so many places in the universe, there's so many stars, and you know, I think a huge fraction of those stars must have planets, like we've discovered extra planets by the buttload in the last few years and I think no matter how tiny you say the probability of the various forms of life evolving are, the universe is big enough that sentient life almost certainly exists somewhere else in the universe. I also think that the laws of physics as we currently understand it mean that it is not and never will be possible for us to interact with that other life and I don't know if that is a depressing thought?

HELEN

Mmm.

BRYN

I'm afraid it might be, and is that any different from saying it doesn't exist? I don't know. But that's kind of, that's my own, you know, feelings on that question but there are still a lot of unknowns and fundamentally, you know, it's a hard question to answer, I think.

HELEN

Mmm. So I asked it at the end when we're all tired.

(group laughter)

I don't think that the idea that there is other sentient life out there but we'll never meet, that doesn't sadden me so much as to think that we're alone because to me, that means that in the future someone might come by and be like 'oh there were people here, that's kind of cool'. I like the idea of someone else discovering like, the mark that we've made, I guess. Now I'm thinking about all the theories around how to tell people not to touch radioactive waste which you would have to inform the aliens about.

PAUL

Yeah I think Bryn and Josh and Marisa all basically echo my own thoughts. It's impossible to know. We simply don't know. Until we actually discover it, things like the Drake equation are essentially useless because we don't know…we don't know any of these numbers. We don't know any of these probabilities. We're just spit balling, and so we might as well just spit ball

without…we can just skip over the Drake equation and just say we don't know. We are hunting for life out there in the universe. We are listening for radio signals. We haven't heard anything. We are actively searching for biosignatures on other planets. We're looking for oxygen in alien atmospheres, with tests with the James Webb Space Telescope. We are actively searching for life. We haven't found any yet. As far as we know, all available evidence indicates that we are totally alone. But like you said, Helen, there are just so many stars, so many galaxies. And even a tiny probability gets multiplied by that huge number, and you probably, maybe, I hope, end up with more than one intelligent civilisation operating in the universe at any one time. But the scales in time and distance between any intelligent species are so great, that even though I personally believe we are not alone in the universe but we are effectively alone.

BRYN

Yeah. Yeah.

JOSH

But only in the same way that it's like a really long way from Scotland to London, so like hardly anybody bothers to make the journey. That's a really bad example, but you know what I mean? It's like, we're alone in the sense of being a small village that's out in the Artic circle or something like that. We're not alone in the sense that we don't exist.

HELEN

Mmm.

JOSH

I was really interested in what you said about the…I think it is the Fermi paradox, Helen. It's sort of a troubling thought, the idea that if there is intelligent life in the universe it probably evolved like at a significantly different time from us. Like, it's very unlikely that it happened to pop up at the exact same time that we did. And that means it's probably had a really, really long time to develop its technology, and that probably means that it should have very, very advanced technology. So the fact that we haven't come across them indicates either that they wiped themselves out before they could get to that point or, that…yeah, some other reason why they haven't spread across the entire galaxy. They haven't reached the singularity which is what, kind of, we're all hoping we'll get to a point of post scarcity and being able to spread out amongst the stars and so on. No one else seems to have done that, otherwise we would've bumped into them. I kind of, I'm not sure I quite buy into that, because exactly for the reasons everybody's been saying, you know these vast distances in space and indeed other universes. You know, it could be that there is no other life in our galaxy, but that there is in some other galaxy, the vast distances of which would mean that even if they did have hugely advanced technology, they might not be able to reach us in the time available. So, yeah, I think that the Fermi paradox could be an argument against anyone ever reaching faster than light travel, I guess, but I don't think it's an argument against sentient life and I certainly…I cling to the, rather the opposite logic to Marisa's…I cling to the comforting thought that there are lots of cool lifeforms out there. But there's no way of knowing is there.

HELEN

I kind of like the idea that they're all having the same discussion.

(group laughter)

MARISA

There's an Enthusigasm in another galaxy.

(group laughter)

HELEN

Oh...

BRYN

Yeah I think it's interesting, you know, every sci-fi includes faster than light travel, basically; or at least faster than light communication, and you know, it's…I at least have not encountered a story where there is none and I think, you know, if humans were ever to expand beyond the borders of our solar system, I think the form that it's going to take is likely, you know, a sort of a generation ship style thing, you know, where you strap some engines to an asteroid and you take thousands of years to fly an asteroid from one solar system to another, and hope you can find a way to land at the other end basically. And you know and once you've done that, you've set...you know you've put a message or some people in a bottle, put it out to sea, and you'll never know what happened at the other end and you know, I don't think the sci-fi we imagine where there are kind of networks of connected solar systems, that to me seems probably impossible. But, it may be that one day there will be people, you know, who are for some definition humans that do live outside our solar system. I hope that is true. But the laws of physics, you know, do not

favour, kind of, as I understand them, don't favour, you know, that interstellar contact. You know, we might be able to have multiple humans living in different places in our solar system, but beyond that, I think that that may be more or less as far as our horizons will ever extend in that sense and that we will just have to hope that some of the people who left made it onto the other side in that sense.

HELEN

I really like the idea of just plopping everyone on an asteroid, putting a, putting an engine in it…

(group laughter)

PAUL

See you later!

HELEN

Yeah, vroom vroom! Bye! I'm sorry, I'm not usually this silly, but I think I have accepted that I don't know anything about this so I'm like, ok. No thoughts, head empty. Space.

BRYN

Well isn't that the message of Enthusigasm? You can still love something, be fascinated by something, want to know more about something even without having to know it or you know understand it on an academic level.

HELEN

Yeah, that is absolutely one of the central premises of the show, for sure. Yeah, I think we're going to have to end it there, though I could genuinely keep talking about this for a really, really long time because I love the idea of space, but for now it's goodbye from me. Goodbye. And it's goodbye from everyone else. Do you want to say goodbye everybody?

EVERYBODY

Goodbye!

[Show Theme - Outro]

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[Show Theme – Outro Ends]

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Editing by Marisa Ewing and Cathy Rinella

Music by Samuel D.F. Jones

Art by Anika Khan