STEPHEN WEBB INTERVIEW PART ONE - INTRO

Hello Ars Technica listeners. This is the latest serialization of an episode of the After On podcast. We're splitting this one into three segments starting today. And it considers one of my favorite topics to discuss after a couple of beers over dinner. Or before a couple of beers. Or over lunch, with no beer whatsoever. The topic is Fermi's paradox - or the question of why can't we detect any signs of intelligent alien life when we look to the skies. No signs of astro-engineering projects. No signatures of relativistic space travel. No obviously artificial electromagnetic waves, etc. Viewed through a certain lens this surprising due to three factors: the universe's immensity, its enormous age, and the speed with which life arose on our planet.

As you may know from previous episodes here on Ars, my podcast dives deep into complex issues in science, tech and society which are worth understanding a bit better. Each episode's built around an in-depth interview with a world-class expert in the relevant field**.** I do 20-30 hours of up-front research and preparation before sitting down with my guests. And I structure my interviews carefully, so that their information density hopefully feels a bit more like TED talk than a meandering long-form interview. Incidentally, because this is an early episode of mine, the quality level isn't quite up to what has since become my standards, so I apologize for the rather harsh S sounds.

Luckily, today's main subject isn't consonants, but Fermi's paradox. Which I could go on about for hours! But - as you're about to hear - I already have. With today's guest - British astronomer Stephen Webb - wrote the book on this subject. Literally. It's called *Where is Everybody?*

Rob Reid: I read it shortly after it came out in 2002 and it blew my mind because it taught me to respect the seemingly frivolous question that you might briefly bat around after seeing Star Wars or something. Where are all the aliens? Are they secretly among us? Studying us from afar or nonexistent? Stephen's book taught me that this is actually profoundly momentous and scientifically serious question.

Rob Reid: Now, on to our interview with Stephen Webb.

Rob Reid: Stephen Webb, thank you so much for making time for me across the Internet and across the time zones to talk about these fascinating topics.

Stephen Webb: It's a pleasure to talk with you, Rob.

Rob Reid: Before we get into Fermi's Paradox and the anthropic coincidences, which are going to be our topics, I thought we would talk briefly about your own personal background. One thing you told me previously in an earlier conversation, is that a very formative element of your background was a deep appreciation for science fiction when you were growing up and after growing up. Do you care to talk about that for a moment?

Stephen Webb: Sure. Well, I grew up in a science fictional world, Rob. When I was a kid, people were walking on the moon, I mean, how exciting is that? On television we had

Star Trek, so it was on television, it was in the culture, and I read lots of science fiction. Especially, Asimov, Heinlein, Clark, the big three, and Isaac Asimov in particular. Martin Reece, Lord Reece, he's one of the greatest living astrophysicists, he's fond of saying you can learn more from first rate science fiction than you can from third rate science. I think that's dead right. I went to Bristol University, I studied physics, had the privilege of being taught optics by Sir Michael Barry, real privilege, he's one of the great theoretical physicists.

Stephen Webb: I went on to do a PhD at Manchester in quantum chroma-dynamics, still reading science fiction, and that's actually where I first came across the Fermi Paradox.

Rob Reid: It was in a work of science fiction that you came across Fermi's Paradox?

Stephen Webb: It was in Asimov's science fiction magazine, which would have been in the mid-'80s, the magazine itself's still going strong, it's in its 40th anniversary year, I have all the issues. Mid-'80s, a couple articles appeared in back to back issues, it's primarily now a fiction outlet, it always has been, but those articles, they were science articles and the first argued that maybe there is something paradoxical about this idea that aliens, high civilizations, exist out there. The rebuttal article in the next issue was saying, "This is nonsense on stilts, of course we can't conclude anything."

Stephen Webb: Fermi himself, if I could just give you a little bit of background-

Rob Reid: Yes, please.

Stephen Webb: Enrico Fermi, he was an Italian theoretical physicist and experimentalist, he did a lot of his work in America, Nobel Prize winner. He was a great physicist, he's been called the father of the nuclear age. It's probably worth for your listeners to understand the time that he was working. He was born in 1901 and he died early, 1954. The reason I mention that is that when he was born, humanity was essentially a terrestrial species, by which I mean it was before the Wright brothers. I guess you could get off the ground, but it would have required a balloon or something. So, he was born into a world where we couldn't even fly in an airplane, and he died after humanity had just about touched space with the V2 Rockets, but it was clear that, that same technology would get us into orbit, into space.

Stephen Webb: Had he lived a long life, actually, admittedly, a centenarian, he'd have seen us just reach the edge of interstellar space with the Voyager One crafts, just getting to the edge of the solar system. I just want to put that into some sort of context, within one human lifespan, he would have seen huge technological progress.

Rob Reid: An interesting historical note, which is more geopolitical than scientific history, but he lived under Mussolini for a period of time and fled the fascist government in World War II, correct?

Stephen Webb: Indeed, indeed. Yes, he spent the last years of his career in America, having fled and obviously was influential in the Manhattan Project. His colleagues used to call him The Pope because he was infallible, so they said. I think he was the last physicist that was equally atone with experiments and theory. He made profound discoveries theoretically in nuclear physics, but also, he was capable of doing the experiments, and you don't get that anymore.

Rob Reid: He also asked this profound question, so let's talk about the question that he asked and what he meant by it.

Stephen Webb: Okay. Yeah, as far as we know, he didn't ... Well, I do know, he didn't publish anything on aliens or the lack thereof, which has lead some people to say, "Well, this isn't the paradox and it's not Fermi's," but we do know as a matter of record, in 1950, that he asked this question, "Where is everybody?" He was going to lunch in Los Alamos one day, a cartoon had made humorous reference to flying saucers, and they were discussing the possibility of these things being alien craft, and out of the blue he asks, "Where is everybody?"

Stephen Webb: I think we have to ask what did he mean and why actually is it, perhaps, a profound question? He didn't mean by that question that extraterrestrials don't exist. He'd have done a quick estimate and come up with a large number of extraterrestrial civilizations-

Rob Reid: That, in theory, should have existed in his mind, just knowing what he knew about the scope of the cosmos.

Stephen Webb: Indeed. That estimate that he'll have made, we now call it ... It now goes by the name of the Drake Equation, because Frank Drake, an American astronomer, he first wrote it down about 10 years later, 1960.

Rob Reid: He formalized it later, but when Fermi was asking it, we can assume that Fermi had his own solution to the Drake equation, which we'll discuss in detail in a moment, and the paradox was, "Gosh, there should be a lot of them, why on Earth have they not yet come here?"

Stephen Webb: Exactly.

Rob Reid: No pun intended with, "Why on Earth," yes.

Stephen Webb: Exactly, I think that's it. He'll have done, in his head, he'll have assigned variables to what we now call the Drake equation, and come up with a large number. The question then, "Where is everybody," is paradoxical because if you come up with this large number for putative extraterrestrial civilizations. You have to ask yourself, "Well, where are they? Why don't we see them?" The universe seems devoid of life, people have called it the great silence, so where are they? Where is everyone?

Rob Reid: There are so many fascinating, mutually inconsistent answers to that question, which we will dive into in a moment, but because the Drake equation has come up, it's probably worth giving it a quick overview because that starts to put the profound nature of this paradox into context.

Stephen Webb: Okay. So, the Drake equation, it's not an equation like Einstein's E=MC2 or Newton's F=MA, it's a tool for organizing our ignorance, really, it's a way of making an estimate for this number "n", which is the number of civilizations in our galaxy with whom communication might be possible.

Rob Reid: It's important to note that it's our galaxy, one of at least 100 billion that we can see.

Stephen Webb: Exactly, exactly. So, whatever answers we come up with for the galaxy, potentially you can multiply it by 100 billion or so for everything else that's out there.

Rob Reid: There's seven terms, right? I think.

Stephen Webb: As Drake initially wrote it down, yes. So, n, which is this number that we're after, it's equal to R, which is the average rate of star formation per galaxy. Then you multiply that by the fraction of stars with planets. You multiply that by the average number of planets that could potentially have a an environment that would support life per star. You multiply that by the fraction that is going to support life. You multiply that by the fraction that can go on to support intelligent life. You multiply that by the fraction of civilizations that develop a technology that potentially we could detect from space. Then you multiply that by L, which is the length of time that these civilizations would choose to release signals into space. So, there's seven terms there, you mash them all together, you make your best estimate of each of these terms, you mash them all together, and that gives you "n", which is the number of civilizations.

Stephen Webb: I think the interesting thing is that when Fermi was thinking of these things in about 1950, he really would have had to have estimated all of those terms, he wouldn't really have known much about any of them.

Rob Reid: Even the number of stars in the galaxy was somewhat mysterious at that point.

Stephen Webb: Perhaps less well known than we know it now.

Rob Reid: Than now, yeah.

Stephen Webb: He would have given a really, really good estimate and his attitude was, "Well, sometimes you overestimate things, sometimes you underestimate things," it all comes out in the wash when you mash all these things together and you multiply them together, but those first three terms, average rate of star formation, fraction of stars with planets, average number of planets that could

potentially support life, astronomy's come on hugely in the years since 1950, it's massive progression. The far terms on the right, your guess is as good as mine, that final term, L, the length of time that civilizations are doing this activity, that's potentially chilling because we have a reason, just right there, why we might not expect to see them if L is small.

Rob Reid: So, to just go through the terms real quick, it is interesting that when Mr. Drake and Mr. Fermi were first considering this, all seven were shots in the dark. We now really have a good sense of the number of stars and how fast they're formed, and as you said, really in the last 15 or 20 years, or even in the last particularly 10-ish years, we've gotten a much, much, much greater data on the number of planets that a typical star has, because of the Kepler Probe and other things, and we're starting to identify how common it is for a planet to be in the so-called habitable zone, and these numbers, both of these terms, are probably quite a bit higher than either Fermi or Drake would have estimated decades ago, is that correct?

Stephen Webb: That's right. When Fermi was around, it would have been possible, I think, to argue that planetary formation was actually quite rare. Some people, some astronomers, were still arguing, I believe back then, that planets came into existence when two stars underwent a close encounter, a collision, if you like, and then that collision would rip material off that could create then planets. Now, we know that basically if you have a star, you've got planets.

Stephen Webb: You mentioned Kepler, that's a space telescope that's basically staring at about 145,000 stars unblinkingly, and it's just looking for periodic dimming in those stars. The periodic dimming represents just a slight occultation, a little eclipse if you'd like, as a planet goes in front of the star, just blocks a little bit of the light out. We're at that level of technology where we can, from that tiny, tiny dimming, deduce the presence of exoplanet and exo-planetary systems. We know that stars now, pretty much, have planets, so we can't say that the reason for this question, "Where is everybody," lies in the fact that there's no planets. Probably there'll be, I don't know, a trillion or so planets in the galaxy, that's a huge number. When you try and whittle away that trillion via these other factors in the Drake equation, you still tend to end up with a number that's quite large.

Stephen Webb: Whenever I go through this with students or with members of the public in talks, typically, people come up with a number that's a few thousand, 5,000, 10,000 or so, I don't know what Frank Drake would say, but that's typically what people come up with for this number of civilizations.

Rob Reid: I actually do know what Frank Drake would say. I have a funny story, I've met Frank Drake a couple of times. Some years ago, the TED Conference had, they still have, something called the TED Wish, it's also sometimes called the TED Prize, it's basically the TED community rallies around one or two interesting public figures and "grants" them a wish. The TED community and its members and its resources, and their resources and assets, and Rolodex's, try to grant a

wish for somebody who has an interesting idea or problem that they'd like to solve. One year, it was Jill Tartar, who started SETI, the Search for Extraterrestrial Intelligence, which we'll talk about in a moment, and she was famously the person that the movie Contact was based upon.

Rob Reid: Jill won one of the TED Wishes one year, and because I'm pretty heavily involved in the TED community, I ended up kind of helping her interface with TED because I was living pretty close to SETI's headquarters in those days. One day, I was in the office and Mr. Drake was there, and I asked him, I was like, "So, what's your solution to the Drake equation?" He went through those seven terms and of course, the first three terms, which had been educated guesses in the past, we know pretty well, but you get into those last four terms and it does start becoming questionable. We have a pretty good number of how many planets could bear life now, but how many planets did life actually emerge on, got to take an educated guess. How many of those planets yielded intelligent life, got to take an educated guess. Boom, boom, boom, go down the list. He came up with 10,000, so it's quite consistent with what you said folks out in the broader public, yeah.

Stephen Webb: So, wisdom of crowds, let's go with 10,000 extraterrestrial civilizations out there, but then that sets up the paradoxical element because the other big number in opposite to this is the age of the galaxy. We know the universe is 13.8 billion years old, so we can expect many civilizations to have come into existence long, long ago. The problem is, suppose you, to get some idea of what we're talking about, suppose you compress the age of the universe in to one year. Then on that scale, human civilization began about 20 seconds before the stroke of midnight on the 31st of December, so we're very, very late. Those other civilizations, they might have come into being in June or July.

Stephen Webb: I mentioned Fermi's own life, if you compressed the age of the universe into one year, well he lived about a tenth of a second on that scale.

Rob Reid: The last tenth of a second before midnight on New Year's Eve, in a sense.

Stephen Webb: Yeah. In that 0.1 of a second, the human species went from being terrestrial to space faring.

Rob Reid: That gulf of time is as big as the galaxy itself, when is the earliest we could imagine a civilization coming into existence over the 13-ish billion years? For many billions of years, there's no way an intelligent civilization would have arisen because at the very, very beginning there were no stars. For a period of time there were stars, but there weren't enough heavy elements. Starting when-ish, you said five or six billion years ago, is that about the time that we would expect, if life were abundant, life would have first started popping into existence?

Stephen Webb: Well, if you believe that it is ... There's almost this imperative, if it's possible, life's going to get going, then there's no reason, I don't think, that it couldn't have got going two billion years ago, three billion years ago. That's an awful long time when you consider that the time scale for colonizing the galaxy, if a civilization wanted to do such a thing, which you can measure on a scale of perhaps a million years or five million years, something like that. The time scale for colonization is much, much, much shorter than that, three billion years, say, during which civilizations could have come into being.

Rob Reid: When I first read your book, this is one of the things that really fascinated me was how quickly, once you get to a certain point of technology, which is that you can crawl your way to the nearest star, much faster than we could go today, but not impossibly fast, it is a remarkably short period of time before a civilization, moving at even a leisurely pace, would tend to fill the galaxy. You have some very rigorous equations in your book, and others have done them out in the broader, and it is just a few million years.

Stephen Webb: You have to make assumptions.

Rob Reid: Yes, of course.

Stephen Webb: It's possible to imagine, if we're talking about humanity or a technologically advanced species, lasting thousands of years, an immense level of technology, and hopefully, you would imagine, one of those civilizations, or humanity if we last that long, will crack this problem. Then if, again it's a big if, but if you chose as a civilization to go out and colonize the galaxy for whatever reason, there are search and exploration programs that you can imagine that would swamp the galaxy really on a very, very short time scale, even less than a million years, if you put your mind to it in your effort. So that when you ask this question, "Where is everybody," you could argue, under some assumptions at least, that this should actually already be here.

Rob Reid: Yeah. So, taking this 10,000 figure again, let's just assume that the most experienced mind in this question in the world, Frank Drake's, is roughly correct and there's 10,000-ish intelligent civilizations, if you make that assumption and if you say that life could have started here in the Milky Way some three billion years ago, that would tell us that there are civilizations that are billions of years older than ours, hundreds of millions, tens of millions, millions, and the fascinating thing is that when you look at the rate of technological change, as you indicated in talking about Fermi's life, look at how far we've come in 100 years, it's almost inconceivable to think of how advanced we'll be in merely another century, a thousand years hence. We'll be so unfathomably advanced. So then you say, there's 10,000 civilizations, they've arisen over a period of three billion years, let's say we're the youngsters because we're just getting to that point of awareness, yes, "Where is everybody," becomes a burning, burning question.

Rob Reid: One of the chilling elements of the answer to that is what you alluded to earlier, what is the length of a time that a civilization lasts after it gets to the point where it becomes detectable, where it starts spewing radio waves and TV waves and rocket ships out into the universe. If that number is essentially indefinite, we should be swarmed with aliens at this point because they're so far advanced. They ain't here. Therefore, either they all die off or one of 74 other possibilities come up.

Stephen Webb: They're not here, but it's more than that, we don't see any evidence of their grand projects.

Rob Reid: Right.

Stephen Webb: We don't see evidence for Dyson Spheres or anti-matter rockets, or these relativistic spacecraft, or the signals that we hope that they'd be sending each other or us. They don't seem to be disturbing the universe in ways that we can imagine them doing.

Rob Reid: Yep, and they've had plenty of time. They've had plenty of time and plenty of planets to grow up on, so something is weird.

Stephen Webb: So something's weird. I think it's now reaching the stage because of advances in astronomy and cosmology, where it's really becoming actually one of the pressing questions in science, where are they?

Rob Reid: Where are they, and to pitch your books because I just want to because I love them, you wrote your first book on this topic, late '90s, wasn't it? Or 2000?

Stephen Webb: Yeah. About 2000, yes.

Rob Reid: About 2000 and it is called Where Is Everybody? It has 50 solutions to this question, 50 possible solutions, and your follow-on book, just a couple years ago, was an update that has 75 possible solutions. I love the structure of the book, it's very elegant and it is a perfect structure for the rest of our conversation because you cluster the solutions into three broad categories. One set of solutions say they are here or they were here, we'll get into that, because those are fun, particularly for science fiction authors. The second set says they exist, they're out there, but we have yet to see or hear from them, and there's lots of possible explanations that revolve around that. The third is that they don't exist and we are simply alone, either in the galaxy or perhaps in the universe, and there's a bunch of answers surrounding that.

Rob Reid: There's no way we can go into all 75 obviously, but why don't we talk through each of these potential clusters of solutions, starting with, they are or were here, that would be UFOs and X-Files, do you want to talk about that a little bit?

Stephen Webb: It would indeed mean that and it's the most popular solution to the paradox. Science isn't a democratic activity, I think some people get confused about this, just because it's the popular solution doesn't mean to say that it is in any way accepted by science, but people do say, "Well, they are here," and they'll point as evidence to UFOs, to crop circles, pyramids. Now, UFOs, clearly they do exist, I've seen one myself, but the U in that acronym is unidentified. I think there's no reason to identify them by saying that they're alien craft. Clearly, there's UFO sightings, that undeniable and even after investigation, some of them remain unidentified. Murder remain unsolved, we don't know the identity of Jack the Ripper, we can't know the reason behind all UFOs. Personally, I don't think that, that hypothesis carries much weight.

Rob Reid: That is the overwhelming consensus, too, right? If you look at the community of scientifically informed people who have looked into this and have opined on it, the consensus is perhaps even greater than that, that surrounds climate change, if I'm not mistaken.

Stephen Webb: Absolutely.

Rob Reid: Yeah.

Stephen Webb: So, UFOs, they tend to come in, in one of two forms. There's the unidentified aerial phenomena that lots of people see, it's videoed, it's on camera. Fine, it's an unidentified phenomena. Then you have the really interesting ones that would actually prove the existence of aliens, UFO comes down, car lights go off, aliens get out of the craft, they abduct someone, do all the probing that always seems to go on in these stories, and then return the people. That would proof, except, of course, that's never captured on video, on camera, or with any other evidence to support the claim.

Rob Reid: Yeah.

Stephen Webb: If you're going to make this big claim that extraterrestrials are whizzing around and interfering with human life, I think it's reasonable to ask for a lot of evidence to back that up, your claim, and that evidence is never forthcoming. I don't think that can be taken seriously, but I do know scientists that take seriously the idea of, for instance, of the zoo hypothesis. Which is that aliens are perhaps observing us, as we would observe animals in a zoo. Perhaps, for this idea of the prime directive that used to come from Star Trek, perhaps they just don't want to interfere with us, they're trying to avoid contact with primitive civilizations.

Rob Reid: Or maybe like a safari when you try to observe and take only pictures and leave only footprints, because you don't want to interfere with the lions and other critters in their natural habitat.

Stephen Webb: Absolutely. A couple of things I find difficult about that idea. You just advanced a very civilized way of looking at going on safari, and of course, some human cultures would go on safari and shoot animals.

Rob Reid: Yes.

Stephen Webb: So, there isn't even cultural homogeneity here on Earth, it's difficult to imagine every alien species would have this idea of a prime directive and this idea of leaving civilizations unhindered.

Rob Reid: You'd need a uniform consensus because if, again, let's take our informed guess number of 10,000 civilizations, not merely would one of them need to have the scruples of the Enterprise, but all 10,000 of them would have to basically be adhering to the same rules of, "Let's not mess with these primitive societies," and that seems less likely when we consider the vast diversity that we would imagine intelligent aliens societies to have.

Stephen Webb: Absolutely. That, I think, encapsulates my feeling perfectly. Of course, the other difficulty that suppose they do come to this agreement and they want to classify Earth as being out of bounds, that's fine, but could they really hide all traces of their activity? Remember that we don't see any signs of their ships, their astro-engineering projects, their relativistic craft, their communications. Would they be able to hide all traces? Actually, presumably, if they're sufficiently advanced, yeah, probably they could, but then you've got zero chance of taking this idea forward because the continued lack of evidence you can always just explain away and just say, "Well, they've got this superior tech that means they can always hide from us."

Rob Reid: Yeah, and then it just becomes a faith based statement, really. You say that the absence of evidence is further proof. That, to me, is sort of like, "If my wife we were having a surprise party for me, she might tee things up in the apartment in such a way that I'd have no idea that 30 of my friends were hiding around the next corner," but she wouldn't take over the entire city of New York and somehow scrub that of evidence. If we imagine a prime directive civilization, it would be one thing to say, "Hands off, nobody gets to go to Earth," but to say, "Okay, we're not going to build Dyson Spheres, we're not going to do any kind of visible astro-engineering, we're going to make the entire universe seem uninhabited, so that these primitives can come to their own moral conclusions and create their own great art," that starts seeming like a pretty hefty price for them to pay in terms of living their own lives with their own technology, in order to maintain the surprise party for us.

Stephen Webb: Precisely.

Rob Reid: Something that fascinated me as a child was Erich von Däniken wrote this book Chariots of the Gods, it was a monster best seller I think back in the '70s, and he posited that no way could primitive people have built the pyramids, or dug

these tunnels in Peru, or build this temple or that temple, or if you look at this thing from the air, it looks like a hawk, but if you look at it from the ground, it doesn't look like anything, therefore, there had to be somebody with an airplane, and so it was ancient astronauts. That one just fascinated me because for some reason, it fascinated my very level headed father, he was so intrigued by that set of solutions, so I heard about it a lot when I was a kid, but that's basically they are or were here. Fun, great storytelling to be had around it, but very few, if any, credible experts put a whole lot of stock into that.

END INTERVIEW ELEMENT OF PART ONE

Hello again, Ars Technica listeners. In tomorrow's segment, Stephen and I will open by talking about the second large set of plausible solutions to the paradox, which cluster around the notion that intelligent aliens ARE out there - but we just haven't been able to detect them yet. An amazingly diverse set solutions radiates out of this possibility, and we'll discuss several of them.

If you can't wait to hear the rest of it – or, if you'd like to browse my other 30-ish episodes, you can just head on over to my site, at after-on.com. Or, type the words After On into your favorite podcast player. This interview originally ran on September 26th of last year. You'll also find lots of stuff about life sciences - above all, genomics and synthetic biology. Conversations about robotics, privacy and government hacking, cryptocurrency, astrophysics, drones, and a whole lot more.

If you like what I do, I hope you'll consider subscribing to my podcast and listening to some of the episodes in archive - all of which were designed to have long shelf lives, and none of which have gone stale yet.

And of course you can join me here tomorrow on Ars, when we'll continue with Part Two of this interview.