It's a Wonderful, Complex, and Fine-Tuned Universe

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Announcer:

I expect you wouldn't be surprised if I told you that you were living in a finely tuned world. What, with humanities carefully crafted technical and logistical designs and all, indeed the existence of this fine-tuning is made all the more evident in recent times as disease and war disrupt the fragile balance in the world's supply chains and economies. But what does it mean for something to be fine-tuned? Does fine-tuning extend beyond our own manmade systems and into biology and the universe itself? And if so, what or who has done the tuning this week, we're joined by Dr. Daniel Diaz and Dr. Ola Hössjer to answer these questions and more on Mind Matters News.

Robert J. Marks:

Greetings. I'm your pronounced host, Robert J. Marks on this podcast of Mind Matters News. Today on Mind Matters News on the podcast, we're going to talk about fine-tuning. Scientists know the universe is finally tuned. For example, take pronounced atheist Sir Fred Hoyle. Hoyle was a great astronomer, maybe known best for his coining of the term Big Bang to describe the beginning of the universe. Hoyle did not at first believe the universe had a beginning and coined the term in a mocking way, mocking the theory of the beginning of the universe. He didn't like it, so he tried to make fun of it. But nevertheless Hoyle's term, his mocking term stuck and today we referred to the beginning of the universe as physicists talk about it as the Big Bang.

Robert J. Marks:

Hoyle was also convinced despite his beliefs that the science of the universe dictated that it had to be fine-tuned. In fact, most scientists knew that there's little controversy that the universe in terms of biology, chemistry, and the cosmos is fine-tuned. Hoyle said the following about fine-tuning, he said, "A common sense interpretation of the facts suggests that a super intellect has monkeyed with physics." I love that word, monkeyed with physics." A super intellect is monkeyed with physics as well as with chemistry and biology. This monkeying with physics, chemistry, and biology is the topic today on Mind Matters News. We have two guests who have published extensively in the literature about fine-tuning. Dr. Ola Hössjer is a mathematics professor or actually a mathematical statistics professor at Stockholm University in Sweden and he joins us from Sweden. Ola, welcome.

Ola Hössjer:

Well, thanks a lot, Rob, for inviting me to your podcast. Thanks a lot.

Robert J. Marks:

Oh, we're going to have fun. And our second guest is Dr. Daniel Diaz. He's a research assistant professor of biostatistics at the University of Miami. Daniel, welcome to you too.

Daniel Diaz:

Thank you, Rob. It's a pleasure to be here.

Robert J. Marks:

I tell you, what's incredible about this podcast is that currently, Ola is in Sweden and Daniel is in Columbia. He makes his living at the University of Miami, but his home country is in Columbia and he goes home there occasionally, so we're having this podcast across three different continents. That blows my mind. I'm an electrical engineer and every time I hear something like that I say, "All these electrical engineers, what incredible things that they can do." I have to warn the listeners that both of these guys are wickedly smart, so you better listen closely. So let's start in with the chat, with the dialogue.

Robert J. Marks:

Fred Hoyle has already defined tuning. He says the universe looks monkeyed with to allow life. Now, he's not the only one. Hoyle's one among many physicists who see fine-tuning in the cosmos. The famous physicist Freeman Dyson said, "The more I examined the universe and study the details of its architecture, the more evidence I find that the universe in some sense must have known we are coming."

Robert J. Marks:

Now, the interesting thing about the fine-tuning universe is there are different ways to measure the fine-tuning of the universe, to put numbers to it that make sense to us. And the three of us Ola, Daniel, and I kind of agreed on a list of different ways that fine-tuning can be measured. And we want to kind of go through these and discuss each one in turn. The first one is something called active information. Now, Daniel has published quite a bit in terms of active information. Daniel, could you give us a definition of active information and explain why it can be used as a measure of fine-tuning?

Daniel Diaz:

Okay. Yes, Rob. So let me start with how active information was born as a concept in the scientifically territory. And maybe too, that it is better to talk first about the no free lunch theorems. These are actually very famous results in evolutionary algorithms and in computer science machine learning. And this theorem, the no free lunch theorems say that in a big space, you can think of it as if you were shooting to some small target in a big wall. If you start looking at that target at random, then you're not going to do better than in a blind search. That is, you can have your target in different parts maybe of the big wall and when you are looking for it with any algorithm on average, you're not going to do better than a uniform search or a blind search. So active information was introduced in order to measure the amount of information that the algorithm is infusing in order to get to a target with the probability better than just that given by a blind search.

Robert J. Marks:

Yeah. The no free lunch theorem basically says, as I understand that you have no beforehand knowledge of any domain expertise of finding the target. So you have nothing that guides you, and if you have nothing that guides you, I would say the no free lunch theorem says that one technique can be used to find the target as well as any other technique, right?

Daniel Diaz:

Yep.

Robert J. Marks:

Okay, so that's a fair way to say it. One of the examples I think about is Formula 409. Ola, do you have Formula 409 in Sweden?

Daniel Diaz:

No, I haven't heard of it, actually. That sounds interesting.

Robert J. Marks:

It's interesting. It's kind of a bathroom cleaner in a spray bottle and the reason they call it Formula 409... It's very popular in the United States. And how about Columbia, do they have it down there?

Daniel Diaz:

Nope. I haven't heard about it.

Robert J. Marks:

Okay. The reason it's popular, it works really, really well, but it's called Formula 409 because it took 409 efforts to create Formula 409, 409 experiments before they got the final solution perfected at least to the point where they thought it was commercially viable. So the thing is that these trials were done by somebody with a background in chemistry. And so you had this domain expertise that went in. Now, imagine that you went in and you had no knowledge about what was happening. You didn't know anything about chemistry, you didn't know about anything. You know, vinegar might work as well as water and sulfuric acid in doing these things. If somebody came out with no domain expertise, no background in chemistry, we would be calling that formula 5,623,000 or something like that because the domain expertise simplifies things, but the no free lunch theorem as I understand it pre assumes that there's no a priori information. And that's a very important distinction. So, okay, Daniel. Okay, so that's good. How did I do?

Daniel Diaz:

Great. You did great. So let me compliment that because your question actually, well, it was the relation of active information to fine-tuning.

Robert J. Marks:

Yes.

Daniel Diaz:

And I want to compliment that point. You're saying that just as in this example of the big wall, let's call it, this big wall is going to be called formally a space and a small target is just similar to what is happening in cosmological fine-tuning. Cosmological fine-tuning says that actually the laws of nature and the constance in the standard models of physics must live in very small intervals such that life can exist. And those in intervals actually need to have small probability too. So the point here is that there is an easy analogy in mind that comes from the small target in the big wall to the small interval among all the set of possible numbers that the constant can take. So there is this relation between fine-tuning and search problems that look for targets in computational science, in computer science. And with that analogy in mind, we can use some tools of search problems, like active information in order to measure also fine-tuning.

Robert J. Marks:

And you get a number there. What's the number that you get out of active information? You get actually a numerical measure, right?

Daniel Diaz:

Yeah. Yes. We have some numerical measures, but I mean, those numbers are going to change in different settings and different strategies for different values that you're also considering.

Robert J. Marks:

Okay. I think that the units for active information is bits. Is that right?

Daniel Diaz:

Oh, oh, oh, so you're meaning the units in which it is measured. Yeah, it is measured usually in bits, just like we do usually for computation and too, we do the same in general for measuring active information in any setting, so the units are not important. You know, it is like measuring length in terms of kilometers or miles. You can make easy conversions from one to the other and you can for instance, change from bits to something that is called knots, which is a different way of measuring information. But in the end, the important thing is that from the beginning, you are clear on what is the measuring that you're using and keep it constant along the whole process.

Robert J. Marks:

Okay. One of the things that you mentioned, Daniel, is this idea of intervals, and I know that Ola and you and I have done work on not just talking about the interval of fine-tuning, but probability measure of fine-tuning and the difference between them and why one is the better. Ola, could you talk about that?

Ola Hössjer:

Yes. Yes. And that's a very good question because we have some process that generates outcomes and it could be the generation of generating the universe by some mechanism or it could be also in biology generating a protein by some evolutionary algorithm or something. And as you said, we have a target that could consist of a certain region or a certain interval within this overall space of possible outcomes. And as Daniel said, when we talk about the origin of the universe and look at a particular constant of nature, it's only a very small life permitting interval for that constant of nature that corresponds to universe that it meets life. So in that case, we could say that this small life permitting interval, as Daniel said, is the target of this process that generated our universe.

Ola Hössjer:

And then, so we have a small interval, and then we would say, "What is the probability that this process of generating this constant on nature? What is the probability that if we think of this process as random in some way, what is the probability that this constant of nature falls within the life permitting interval?" And then intuitively, we think that a smaller life permitting interval would correspond to a small probability of ending up there, whereas a large life permitting interval would correspond to a large probability of ending up there.

Robert J. Marks:

But you've shown that this isn't true, right?

Ola Hössjer:

Not necessarily, because it depends on the various possibilities of this random outcome of generating the universe. And that's called statistical distribution of that constant of nature that comes out from how the universe and in particular, this constant of nature, how it was generated. So in principle, it could be the case that the distribution is completely within this small life permitting interval. And then the probability would be one of ending up with a life permitting universe, at least when you talk about this particular constant on nature. And in the same way, it could be the case that we have a very large life permitting interval, but this distribution is completely outside of it and then still the probability's zero. But these are like exceptions, so in our paper we have a sort of general way of choosing this distribution of the value of the constant on nature, which is sort of outside of the universe.

Ola Hössjer:

So how it was constructed, we have very little knowledge about it. So we use maximum ignorance or maximum entropy. And so that sort of gave us a clue, which distribution to choose for this constant on nature. And then it's typically the case that a small interval gives a small probability and a large interval gives a large probability. And actually, we have some freedom of choice of choosing these distributions, so we actually, we are quite conservative, so we take the largest possible probability of ending up in this live permitting interval. And if it's still small, then we can say with more confidence that, "Yes, this universe is fine-tuned with respect to this constant of nature."

Robert J. Marks:

So a question is, you use the term maximum entropy. I think most people are familiar with the idea of maximum entropy associated with thermodynamics. And I think there's a relationship here, but as a statistician, you use the term maximum entropy in well, kind of a different context, in a more of a mathematical context. Is that right? Could you elaborate on that a little bit?

Ola Hössjer:

Yes, yes. That is correct because in this... And this is something called Bayesian statistics. So we have a certain parameter, the value of these constant of nature and we use a certain prior distribution for that constant on nature. And then there's something we observe, the life permitting interval or physicists have determined it. That's the likelier part. And then the question is in Bayesian statistics, how do we choose this prior information? And you could choose this in different ways. It could be chosen on subjective grounds, different people choose it differently.

Robert J. Marks:

Now, would this prior be something like the domain expertise that I talked about?

Ola Hössjer:

Yes. Yes. It could be. Yes. Then if you have prior knowledge, then you can use that. If you sort of have previous data, you could use that in order to choose the prior distribution. But if you don't have any prior knowledge or prior data whatsoever, then you can sort of let the prior be chosen in such a way that it corresponds to lack of knowledge. And that is maximizing epistemic uncertainty, so it's not like in thermal dynamics. When entropy means another thing, the degree of disorder. Here, it means the degree of lack of knowledge about the value of this in this case, the constant on nature. So we want to maximize our degree of uncertainty about the value of these constant on nature before we have observed anything and that means maximizing entropy. And that's a bit more tricky when the domain is unbounded. For a bounded domain, you're simply taking uniform distribution, but we have a way to circumvent that.

Robert J. Marks:

Yeah, that's one of the relationships between the mathematics, mathematical idea of maximum entropy and the thermodynamic. Usually, we think of thermodynamics as if you're in a room then maximum entropy corresponds to all of the velocities of the particles, the distribution being the same at every point in the room. And we can't have the situation where all the molecules accumulate in the upper right hand corner of the room, they have to be spread uniformly. And that is directly to the idea of maximum entropy that you're talking about in mathematical sense.

Robert J. Marks:

But also, the way that I relate to this is that maximum entropy is applicable elsewhere in unbounded domains one of which is the distribution of pressure on earth from the surface as you go to outer space. Now it isn't bounded like in a room, but as you go from the surface to outer space, you still have a maximum entropy distribution, but that turns out to be something called an exponential distribution, and that is maximum entropy with those boundary conditions. So those are the sort of things that you're talking about in terms of maximum entropy in different domains, bounded and unbounded. Is that fair?

Ola Hössjer:

Yeah. Yeah. Yeah. Yes, we talk about maximum entropy in terms of maximizing our degree of ignorance, our epistemic uncertain about the value of this constant. So even though when we talk about pressure and things like that, and we talk about a physical system in a slightly different way, it's still amazing that you get a distribution that maximizes entropy. And in this case, yes, as you say, we have an unbounded domain, but the exponential distribution, if we look at all the distributions on the positive realign or a distribution that puts all its probability mass on positive numbers, then the exponential distribution maximizes entropy subject to a constraint, the side constraint on the expected value of the distribution the first moment. So yeah, it's amazing that we can actually have maximum entropy distributions in nature in this way, even for unbounded domains. So yeah, that's amazing.

Robert J. Marks:

Yeah. It seems to be ubiquitous, doesn't it? You mentioned Bayes and Daniel, I'd like to ask you about this. One of the thing about Bayes is that it's criticized by its a posterior or after the fact probability. Let me illustrate. If you were to apply Bayesian analysis or after the fact analysis to the probability that the three of us would be here, one in Sweden, one in Columbia, one in Texas, and we'd be doing a podcast, I don't know if it makes a lot of sense to talk about the probability we would be here doing this, so what am I missing here?

Daniel Diaz:

Yeah. So before answering that question, Rob, let me just make another comment on a small interval has a small probability on fine-tuning.

Robert J. Marks:

Yes, please. Yes.

Daniel Diaz:

Because fine-tuning is usually taught in terms of the small interval, life permitting interval for the given constant of nature. But I think that what we have shown is that actually, it is more important, it is more probability for the small interval than the length of the interval itself. So that being said, the good definition for fine-tuning basically of an event is just that, that event has a very small probability. That is a better definition of fine-tuning than just having a small length interval. Maybe it is more appropriate to speak about the small probability of the interval. Because in that sense, it does not matter if the interval, as Ola was saying has a big length or a small length, what is important is the probability that is associated to it. And that's going to be a better definition of fine-tuning, a much more accurate definition of fine-tuning.

Robert J. Marks:

That makes a lot of sense to me. I've seen some fine-tuning videos and they say, "Okay, this constant whatever it is, maybe the speed of light, that if the universe is fine-tuned to allow for the existence of life... Let's say this is an inch. ...and we look at all the other possibilities, then that spacial interval extends from the surface of the earth, the surface of Jupiter or something like that. And the probability... Or not the probability, but the interval for life permitting is a small one." That's really not important as what you're saying is that, it isn't that interval is small. The question is what is the probability that you exist within that interval?

Daniel Diaz:

Yes, that's right. And there's something very interesting about it. I think Ola also mentioned a little bit about this too. And it is the fact that actually, this could lead to a reconfiguration of the fine-tuning problem in which sometimes even very, very large intervals, intervals of a very large length, even infinity could actually have small probability. And that happens sometimes in probability. You can have some intervals even of infinite length that have small a probability, but also in-

Robert J. Marks:

Wait, say that again. You can have intervals of infinite length, which have small probabilities.

Daniel Diaz:

Yeah.

Robert J. Marks:

That was an important statement. I just wanted to pause there and point out and let that sink in a little bit. Go ahead.

Daniel Diaz:

So let me just give... This is kind of a technical example, but imagine that there were spaces that whole real line and you know then that the distribution you are thinking of has a first finite moment. That's going to be the mean, and then it has also a second moment that is finite too, which is saying that it has a variance. Then you know that the maximum entropy distribution for that space is going to be a normal distribution with mean and that variance that you were thinking of. In that case, you can take for instance, the interval from minus infinity... I don't know. ...to minus 10 trillions, and that's going to be an interval of infinite length, but the probability is going to be very, very slow. It is going to be more close to zero than to any other thing basically, to put it informally.

Daniel Diaz:

The probability's still going to be positive, but it's going to be so, so small that it is negligible in most cases. So that's a good definition then for fine-tuning, it's the better definition to think of the small probability of the event that you are considering than the volume or the length of the event itself.

Robert J. Marks:

Okay. So I think the takeaway here is that intervals are an okay way to measure fine-tuning, but probabilities are much better.

Daniel Diaz:

Yes. Much more accurate.

Robert J. Marks:

It's better to talk about the probability.

Daniel Diaz:

Yeah. Yeah. Yeah. That's true. And now regarding your second question, or the question about what the importance of base theory, or as it is called in statistics in contrast to frequentist theory. You know this has been a long, long debated. It's very long debate in the history of statistics between these two positions, between frequentist and Bayesianist as you could think of. These are two different approaches to statistics. And the interesting thing is that as far as I'm concerned, I can see many cases in which one of the approaches is better than the other. And the opposite is also true in many cases in which the other approach is better than the previous one, so it depends on the problem that you are working on that you're going to have some ... problems for each of the approaches you're considering.

Robert J. Marks:

Okay. And in fact, both of them have applications as an engineer. I'm always interested in reduction to practice. And one of the things that Bayesian statistics is used for is something like spam filtering, where you gather a lot of emails and you figure out what is the probability that if a Nigerian prince is mentioned in the spam... We all remember the spam about the Nigerian prince trying to get you to give money to this Nigerian prince and it was a spam and a lot of people fell for it. But you can look at data that appeared in the past and the probability that the Nigerian prince given spam, and you can figure that out. You can look at all of the labeled emails and look at all of the ones that have been labeled spam and figure out how many that had Nigerian in prints in them were actually spam. And then Bayes' flips that around and your spam filter figures out the probability it was spam given that it mentioned the Nigerian prince.

Robert J. Marks:

And so therefore it's much more complicated than... Not more complicated, but... Well, the spam filter is much more complicated than this, but that's, that's a simple illustration and this works. And this is the reason we use Bayesian statistics. Now, if you look at an email that has Nigerian prince in it's either spam or it isn't, but your Bayesian statistics can say, what is the probability that this email already given, already sent, already received... What is the probability that it is spam? So it doesn't make sense to me. And as an engineer, I always say that reduction to practice is the proof of the validity of a theory. So I think that the criticisms of Bayesian statistics that I mentioned was totally inaccurate. It's not a good argument.

Daniel Diaz:

Yes, you're right. So it all depends on the context that you are talking of, so as you were mentioning for spam filtering, a Bayesian approach is very useful. It is also useful in some areas of medicine. I work in biostatistics, so I know that in many, many analysis of treatments, Bayesian results are very useful and more useful in some cases than the frequentist approach. But as I say, there are other approaches, there are other problems in which the frequentist approach works better. The important thing for our conversation is that actually the right way, I think, to approach our problem was using Bayesian patient theory and Bayes' theorem in order to determine what was the distribution of maximum entropy use. So for fine-tuning, in order to avoid certain problems that were there in the past, the right approach was to consider that this prior distribution was given in terms of the maximum entropy and that is also done with the help of the Bayes' theorem and Bayesian theory.

Ola Hössjer:

Yeah. Yes. I totally agree with that because we use Bayesian statistics and put a prior distribution on the possible values of a certain constant on nature. Because of the Bayesian statistic approach, not the frequentist approach, we are in fact able to talk about the probability of this interval, because we use a Bayesian approach. With a frequentist approach, that would not have been possible. We could only talk about how consistent each possible constant on nature is with data and so on.

Robert J. Marks:

Excellent. So the frequentist approach talks about probabilities events, which have been happened yet, whereas Bayesian talks about the probability of events that have already occurred by turning that around. I think that's an accurate depiction. Is that, is that fair?

Ola Hössjer:

Yeah. Yes. Because in Bayesian statistics, you have probabilities of the past, that is your prior, what you believe about a certain parameter, for instance, the constant of nature, and then what is going to happen. That is the date that you might have not have collected yet. Then you also have a distribution of that also in Bayesian statistics, whereas in frequentist statistic, you only impose a probability distribution on data for the future so to speak, not from the past. From the past, you regard each possible value of this parameter. Each possible value is constant on nature as a fixed constant. You don't put the distribution on it.

Robert J. Marks:

Excellent. Excellent. Well, I want to bring us back on track just to remind what we're doing. We're talking about fine-tuning and the ways that fine-tuning could be measured. We've gone through the method of active information, measuring of active information, measuring small intervals, and also probabilities of fine-tuning existing. The next one I want to ask Daniel about is specified complexity as a measure of the fine-tunedness. Is that right word? How well a process is fine-tuned? Daniel, what is specified complexity and how does it measure fine-tuning?

Daniel Diaz:

Okay. So let me talk about the specified complexity in the context of fine-tuning of our main topic here. So we can think of the life permitting interval as an interval that is satisfying a very special, or that is fulfilling a very special function. And it is that outside it life, as we know, it could have not existed in our universe. So in that sense, that small interval is fulfilling a very important function. It is satisfying a very important function. In that sense, just to put it in very simple terms, we could say that, that life permitting interval is specified. Now, in a specified complexity, there are basically two components, the specification and the complexity. So the specification is given by the function the interval is fulfilling.

Daniel Diaz:

As I said again, in the interval, inside the interval, if the constant is inside the interval, it is going to allow for a universe to have life. But if the constant is outside the interval, then no life could exist in the universe at least as we noted it. We are thinking of carbon based life here. And that is as much as we can say in very simple terms, or we can talk in very simple terms of the specification.

Daniel Diaz:

On the other side, complexity is more simple to understand. It is simply, you can think of complexity as very small probability. So in very simple terms, you can think of complexity as something that is improbable, so complexity is kind of inversely proportional to probability. The more probable an event is, the less complex it is. And also the less probable an event is, the more complex it is. So when we are thinking in terms of fine-tuning, then the life permitting interval is specified, so what we need to measure now is its complexity. We need to know if its probability is small and then that is how a specified complexity makes its way in the context of fine-tuning.

Robert J. Marks:

Okay, excellent. The last topic that we want to talk about, that measures fine-tuning is so called irreducible complexity and how does that measure fine-tuning. Ola, could you talk about that?

Ola Hössjer:

Yes. Yes. And this is a nice follow up of Daniel's nice explanation of specified complexity because irreducible complexity is a special case, I would say of specified complexity. As Daniel said, specified complexity, then something is complex, it has a small probability of occurring by chance and that is an independent specification. For instance, a universe that admits life, or in biology, a molecular machine that works and so on. And irreducible complexity is a special case when this complexity is like a machine that has many parts to it. And in order for this machine to be specified, in order for it to work, all the parts have to work. So if you remove one single part of all these many parts, the machine ceases to function. And that's typically makes this machine more complex because as Daniel was saying, complexity has an inverse relation to probability. The more parts-

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Ola Hössjer:

-we put to this machine, the less likely it is for it, this machine to have evolved by chance. So the summary is that irreducible complexity is a special case of specified complexity. When this structure consists of many parts that are all needed.

Robert J. Marks:

Ola, you coauthored a well received paper entitled "Using Statistical Methods to Model the Fine Tuning of Molecular Machines and Systems". We are going to put a reference to this paper, as well as some other papers in the podcast notes, for those that are interested in digging deeper. "Using Statistical Methods to Model the Fine Tuning of Molecular Machines and Systems".

Robert J. Marks:

I know little about fine tuning and biology. So you guys are really going to have to help me out. My car is not a molecular machine, but it's a machine and it has a gas cap that unscrews to give me access to the little pipe that goes to my gas tank. And it allows me to fill my car with gas and then replace I, so the gas doesn't get polluted. I suppose I could talk about fine tuning of the gas cap. You know, the threads for the screws have to be just right. The gas cap can't be too big in diameter because it won't fit in the little hole. To me that doesn't sound very compelling in so far as fine tuning, but I suspect, and I know from perusing your paper, that fine tuning in biology is much more sophisticated than that. Ola, what are some of the more sophisticated examples of fine tuning in biology?

Ola Hössjer:

Yes. Thanks Bob. In, in order to talk about fine tuning in biology, we have to go into the small things within the cell. And during the first episode, we sort of talked about different ways of quantifying or defining fine tuning. And it's closely related to specified complexity that Daniel talked about. And we can say that something is fine tuned if it's complex, if it's unlikely to occur by chance, and, secondly, if there is an independent description or specification of the thing that is fine tuned, and now there are a number of features within the cells that satisfy these two requirements. And the first thing are proteins. Most proteins are sort of all over the cell. And in order for the cell to manufacture proteins, there is an amino acid sequence written in a 20 letter alphabet of amino acids.

Robert J. Marks:

No, yeah. Amino acids. They're the components - I'll interrupt when I understand something, okay? So that I don't look too ignorant, but amino acids, these are the building blocks of DNA, right?

Ola Hössjer:

Well, well actually, yes. There is a correspondence between the nucleotides of DNA and amino acids through the genetic code. So we can say that from DNA, we have coding that corresponds to amino acid sequence. Yes. So that's correct. The amino acids form the building blocks of the protein. And in order for a protein to work, when these amino acids are manufactured in the ribosomes of the cell, this amino acid string has to be folded in a certain complicated three dimensional structure that is specific for each protein, and that is necessary for the protein to work. And this is a complex structure because if we look at all possible amino acid sequences of a certain length, it could be a few thousand amino acids that comprise a protein, what is a fraction of amino acids that give us a functioning three dimensional protein?

Ola Hössjer:

And it turns out that it's a very small fraction of amino acid sequences that give us a functioning protein. So that is the first definition of fine tuning. It's complex, it is unlikely to happen by chance to get a functioning protein. And the second part, we should have an independent specification. And in this case, a specification is that protein works. So, for that reason, a protein is an example of a fine tuned structure in biology. And then we could get up to the next hierarchical level and look at complexes of proteins, like molecular machines, the ribosome itself, the ribosome manufacturers proteins in the cell, that is itself a sort of a molecular machine that consists of many proteins that have to be arranged in a certain structure in order for it to do its work.

Ola Hössjer:

Another example is mitochondria in the cell plasma. These are the power stations of the cell that generate ATP. This is also an example of a molecular machine where all its parts have to be structured in a certain way in order for it to function. And so one could say, we talked about this during the first episode, a specific case or a special case of fine tuning are irreducible, complex systems. Something is not only complex, but it's complex due to the reason that it consists of many small parts and all parts must function in order for the whole system to work.

Robert J. Marks:

So if you remove one of the parts in the process, you're talking about the whole thing breaks down. Let me give you a guess, as an example, this is on the macroscopic level. Things such as our lungs, for example, have a bunch of individual cells. And one of these cells has no idea what the other cells are doing, but for some miraculous way, they all work together to allow us to breathe and put oxygen in our blood and other things. Would that be kind of a big example of what you're talking about?

Ola Hössjer:

Yes, yes. And another, you could view the whole cell as a cellular city. Like it has a network or roads or factories and power stations. You could view a larger part of the cell as a network, that consists of many molecular machines or protein complexes.

Robert J. Marks:

Yes. And, and these are things which display irreducible complexity: you take away one piece, the whole thing falls apart.

Ola Hössjer:

Yes. Because it's one layer above, it's one hierarchical level above, the protein complexes. And if the parts themselves are the protein complexes, the molecular machines that we talked about, are irreducible complex, then that will be the case also for on the next level, not by definition, but typically that is the case as well.

Robert J. Marks:

Oh, I see. Okay. Well, thank you that's, that's fascinating. Daniel, do you have any other examples of fine tuning and biology that you know of?

Daniel Diaz:

Yeah. There was a paper that we published, actually. [inaudible 00:41:33] and I published a paper last year on population genetics.

Robert J. Marks:

Well, let's talk about population genetics before we talk about it. Let's define it. What is population genetics?

Daniel Diaz:

Well, population genetics, try to study how populations evolve in time. Usually taking that evolution in terms of genetics. That's how it is. That's why it is called that name. So you're looking at some sequence of genes or some gene actually. And then you're looking how it is evolving in time and trying to infer some properties out of that process. That is basically a stochastic process.

Robert J. Marks:

Stochastic, by the way, I tell my students, if they want to impress people, they say stochastic, if they don't want to, they say random. So stochastic is a synonym for random. Okay. So it's a random process. Go ahead.

Daniel Diaz:

Yes. It's a synonym for random. That's the formal name that is given to that process in probability theory. So yes, it sounds quite impressive, but it just means that it's random over time, or that it has some randomness at least included over time. It's not necessarily just pure random, but it has some random added to it over time. So that's a way to think about it. In population genetics, actually something that could be studied in terms of fine tuning for instance, is the time to fixation of some allele, and allele is just a variation of a gene.

Robert J. Marks:

Could you say that was a mutation?

Daniel Diaz:

Yeah. It's possible to have a mu a mutation. And then what you're looking at is the possibility of that mutation to become fixed throughout all the pop the population. So once it happens, then you can, you can say that gene was fixed - that kind of a technical name again. So when it has a spread throughout all the population, and then you can think, and you can study the time that it takes for that mutation, for that allele to get fixed in all the population, again. That time can be just an example of fine tuning in biology. If the time for instance has more probability again. So we are coming back to the same concept, again. We have that now the time to fixation is going to be the specification, but that specification also has some probability of occurrence. If the probability is small, again, we can talk of fine tuning in biology and in particular in population genetics.

Daniel Diaz:

So that being said, I'm thinking here that we've been, we've been talking about specifications and we've been very informal, but just let me mention that, even though we are speaking about it here informally, there's a formal definition to it. And actually this is one of the great ideas all I had, and it is just defining it in very simple terms as a function, in mathematical function, I mean, with some interpretation, usually in reality, that is maximized. So even though we are talking here in very informal terms, I just wanted to mention that this specification can be formally defined in mathematical terms.

Robert J. Marks:

Okay. Yeah. I want to talk about that next. Ola, you came up with a general theory. We, we talk about in physics, for example, a theory of everything. It turns out the fine tuning is something ubiquitous in our universe. It occurs in biology, chemistry, and physics, and cosmology, the specific area of physics. And the question is there a general theory, a general way that we can look at fine tuning across all of these disciplines? And you've done that. And by something called, let's see, a specificity function, I believe. Could you explain a specificity function as at a high a level as you possibly can so that we can understand what's going on here about your general theory?

Ola Hössjer:

Yes, Bob, we introduced this idea in my joint paper with Steinar Thorvaldsen originally, and then I have an ongoing project now with Dania, where we sort of elaborate on this day, ID more, and we start with a sample space of all the possible outcomes of a certain algorithm. And this could be in cosmology. This could be the algorithm on generating the universe.

Robert J. Marks:

Okay. Now, an algorithm for generating the universe is kind of a... How would you describe that as a theory or a model of, by which the universe came into creation?

Ola Hössjer:

Yes, yes. So, in the previous episode, we talked about the possible values of a certain constant on nature. So this algorithm, if the universe was randomly generated, the different constants of nature could have different possible values with different probabilities. And the sample space is a collection of all possible outputs of the algorithm. So in cosmology, that would be the process of generating a universe. In biology that could be as Dian talked about population genetics, we, which is really describing small evolutionary changes. So then the outcome could be the outcome of a evolutionary process to generate a protein. We talked about proteins as being fine tuned, and it could also be in biology, the process of generating and that's more challenging, a whole protein complex or a molecular machine.

Ola Hössjer:

So that is the first part. We need to have a sample space of possible outcomes. And then we introduce now comes a specificity function to each possible outcome in this sample space, we assign value, which is how specified is this particular outcome. And if we go back to cosmology for each possible universe, we could look at a specific constant of nature. And then the value of the function will be binary: either this value of the constant of nature, the outcome corresponds to a universe that permits life, or not. Or when we talk about the protein, we have a certain amino acid sequence that folds to protein. So each amino acid sequence is a possible outcome. And that outcome either corresponds to a functioning protein or not. And in this case, the specificity function is binary as well. One, if something works, if the protein functions, and zero, if it does not.

Ola Hössjer:

But then we could also talk about a molecular machine, we could also say that the specificity function is whether it works or not, but we could also have more refined, like it could be the number of parts it consists of and so on. And, and if we talk about population genetics, if the purpose is to generate various organisms, not only a protein or a protein complex, but a whole organism, or population, or to generate a species with organisms, what is the biological fitness of each organism? That quantifies that organism's reproductive ability, how many offspring it is expected to have. And in this case, that's another example of a specificity function. So, that was the second part. The first part was the sample space of all possible outcomes. And the second thing was specificity function to each possible outcome. You assign a number that tells you how specified that particular outcome was. And then the third part, I call it a null distribution. And that is, if you think of this, an outcome being generated randomly by chance, you have a certain distribution on it.

Ola Hössjer:

And we talked about in cosmology, the distribution of a certain constant on nature, we could think of a randomly generated amino acid sequence. We could talk about a randomly, a random evolutionary process, the purpose of this, which is, or the target is a functioning protein or a molecular machine and so on. So, now we have these three components, the list of all possible outcomes, the sample space, we have a specificity function, and we have a null distribution that gives us the distribution of all these possible outcomes. And now we can define what is fine tuning using these three components. And, and the first is we need to, we talked about this in episode one, we need to have a target. And now the target consists of all the outcomes in this list of outcomes that are specified, that have a sufficiently high value of this specificity function above a certain level.

Ola Hössjer:

And in the case of the universe, it's simply all the possible generated outcomes that permit life for, for a certain constant nature. So, that gives us the target, the function, or the subset of all highly specified outcomes. And then because we have, we have constructed distribution for randomly generated outcome. We can talk about the probability of ending up in that target of highly specified outcomes. And if that probability is small, then the system is finally tuned. We could apply that in cosmology. What is the probability of a certain constant on nature ending up in a... And then we called the target a life amid the interval. We could apply it to evolutionary processes for generating proteins. What is the probability of that process generating a protein that works or functions, or we could also talk about an evolutionary process. This is a chance with a certain null distribution. What is the probability of that evolutionary process generating a certain molecular machine, which is irreducibly complex. So, and if that probability is small, then the structure is fine tuned.

Robert J. Marks:

Excellent. Excellent. You know, one of the things I really like about your theory is including all possible successes. I've heard for example, that if you make a bowl of alphabet soup and the letters arrange themselves and say, "Good morning, Ola", that is specified. And you can talk about the probability of that happened by randomly selecting numbers. And that probability is very small. A more meaningful thing to do is to ask what is the probability of anything, which is meaningful coming up and floating in your soup. That's a more important thing. And it sounds like you've done that by looking at all of the possible solutions that are specified, you've looked at all the possible successes. Am I right in that interpretation?

Ola Hössjer:

Yeah. Yeah. And that's the sort of a, kind of a goal of this project, and I think that's the beauty of mathematics. You have some general abstract objects, and you could sort of model things from different areas of applications in a similar way. And I think that's an important part of the beauty of mathematics. That's seemingly unrelated features in cosmology, in biology and in algorithmic theory. And so on, they could be modeled in a very similar way using similar concepts.

Robert J. Marks:

Well, all of this, this looks like a landmark paper, and I hope it gets the attention it deserves. Do you per chance know, off the top of your head, the title of the paper, for people that want to dig deeper?

Ola Hössjer:

Yes. Yes. It's published in the "Journal of Theoretical Biology" by myself and Steinar Thorvaldson. And the title is "Using Statistical Methods to Model the Fine Tuning of Molecular Machines and Systems".

Robert J. Marks:

Okay, wonderful.

Ola Hössjer:

Yeah. And in this paper, we mostly talk about the biological application, but we also give an historical background because fine tuning was first mentioned in the context of physics and cosmology. So we also introduce some of these examples.

Robert J. Marks:

Okay. Well, excellent, excellent. I hope that the paper gets, gets the attention it needs. I'm in the world of artificial intelligence and I looked up artificial intelligence on Google with quotation marks around it and put 2020. And just to see how many hits I got, and it was in the millions. And it turns out to be like over two papers per minute, 24/7, there's no way that people can keep up with the literature. So there's lots of jewels in the mud of the literature that exists out here. And I certainly hope that your paper kind of floats to the surface as people realize the importance of it. I also know that sometimes papers lie dormant for a while, until somebody discovers them and begins championing it, and then it becomes more popular.

Robert J. Marks:

So anyway, I hope that I hope that indeed that happens.

Ola Hössjer:

Oh, thanks a lot, Bob.

Robert J. Marks:

Yeah. So really this is really a landmark result. I wanted to talk about the last topic, and this is kind of a general idea too. And, and it's a paper that Daniel Oland and I wrote, and it was about introducing the idea of probability to measure the degree of fine tuning. We talked about this a little in the prior podcast. If you want the background, you should go back and listen to that. It's really, really great. Daniel, could you talk about how we introduce the idea of probability to measure the degree of fine tuning? This looks also to be a universal model that can be applied to a number of different things in biology, chemistry, and cosmology, for example.

Daniel Diaz:

Yes, Bob you're right. It is generating a kind of universal setting to work in different areas. Some of the areas were mentioned actually by Ola, and as we have talked, cause fine tuning is started in cosmology. Now there has been some applications of it to biology as well. I was mentioning actually there are a couple of papers that appear this year in the literature talking about fine tuning, also in cell membranes.

So these are very specific things that are being done in biology. There is also fine tuning, as we mentioned in the first podcast on search problems in computer science that is machine learning. And there is also this very interesting area that has generated a lot of response, positive, negative among every possible different view about the simulation hypothesis and in the simulation hypothesis, there is also required that there is some fine tuning.

Daniel Diaz:

So it's very interesting. It is very interesting. And as we can see, fine tuning is kind of spreading throughout all the sciences. And there was an important realization that we had in our previous paper when we were finding a way to measure fine tuning, cosmological fine tuning, actually. And it was to notice that actually fine tuning problem, the fine tuning problem can be divided into two parts, two stages. The first stage is just finding what is the life permitting interval. And that is basically a physical problem. That is a problem pertaining to the science of physics. And the second problem is determining the size, determining the probability story of that life for meeting interval. And that is a mathematical problem. So when we realize that, then we could use all the mathematical power in order to find that probability. And that is the realization that I think allows to generalize the whole concept to all areas of science.

Daniel Diaz:

Because even though the first step is going to be determined by the particular area that is being looked at, so biology, physics, machine learning, whatever the second stage is going to be a general mathematical theory that can be applied throughout all the sciences. And that is what allows the concept to be generalized. That realization that the probability ... that finding the probability is basically a mathematical problem. The way that we do that we do it in our paper was then, as all I mentioned before, by using base theory and trying and looking for maximization of entropy, that is something that is maximizing our level of ignorance that is using all that we know, and then making as random as possible, all that we don't know so that we could circumvent previous criticisms that we're done to previous attempts also to measure that probability.

Robert J. Marks:

Let me ask you a question, Daniel, and this will probably come from some different people. And I think has been one of the obstacles for developing this general probabilistic theory. We have different cosmological constants, say, for example, the speed of light. But we have no idea the distribution. We have one statistic, which is currently the speed of light as it exists. How can you take one statistic and figure out, for example, in a model, how much it's spread out? Those with a background or a course in statistics, you know that it takes at least two numbers to figure out or estimate the variance. And usually that's pretty bad. So what do you do? How do you take one statistic and milk it for all this probabilistic information?

Daniel Diaz:

Yeah. So that's precisely what we did in this previous paper on cosmological fine tuning of how to measure cosmological, fine tuning, by the way, for the listeners that are in, who are interested, you can look for the paper. It is titled "Is Cosmological Tuning Fine, or Coarse?", and it is published in the "Journal of Cosmology and Astroparticle Physics". That's the name of the journal. And what we did in that paper then was realizing that there were some previous problems with the way that probably was considered for those, there is a famous paper that was written almost two decades ago, by some philosophers, Timothy McGrew and Bastrop. And this paper talks about how trying to use the uniform distribution, that is trying to constrain basically the life permitting interval to a finite space, to a finite set of possible outcomes, is not permissible for finding the probability of fine tuning.

Daniel Diaz:

So there was this big question that was kind of the origin of our quest for a way to measure this probability. So we realized that if we wanted to do that, we should replace that basic idea that was underlying the uniform distribution for this problem and generalize it to a more general situation. When we generalize it, or the way to generalize it was using, as all I mentioned before, the maximum entropic principle. And when we went into that direction and together considered a base theory, then we were able to actually use that life permitting interval in order to measure that probability without having those previous problems that previous attempts had when they were measuring the probability.

Robert J. Marks:

That's great. And I would suggest those of you who are sufficiently nerdy to understand the math, to go to the paper and the solution, which I believe was due to Ola is really ingenious how you can stretch this one statistic into a more general framework by assuming maximum entropy.

Daniel Diaz:

Yeah. So let me just mention here that two things that we achieved in the paper were first then to solve that previous criticism to the measuring of fine tuning, that is that criticism is usually called in the literature, the normalization objection. So our method overcome that criticism. And then all this idea also of base theory using it as background also overcame some criticism that is usually done to these measurements that is called the weak entropic principle in which is basically said that we are biased to see a universe as we are seeing because we are here to see it. And it sounds like a puzzle, but it has some weight. And then the combination of the maximum entropy and base theory solved the two problems in tandem. So we were able to solve the normalization objection and to find a way to go around the normalization objection, and to find a way through the base theory that Ola is so expert working with for the weak entropic principle.

Robert J. Marks:

So yeah, we recommend for those that are interested in digging deeper and getting more into the weeds of looking at these two papers, the one that Ola mentioned, and the one that Daniel mentioned also. We will post the citation and a link to the paper on the podcast notes so that you can have quick access.

Robert J. Marks:

Why is the speed of light, the speed of light? Why isn't it slower or faster? Why is the universal gravitational constant what it is. It turns out these and other constants of the cosmos are what they are so that the universe is habitable, so that you and I can live on planet earth.

Robert J. Marks:

There is very little controversy that the universe is fine tuned. Astronomer Robert Jastrow was head of NASA's theoretical division and the founding director of the Goddard Institute for Space Studies. He said, "It is my view that the universe was created for men to live in." And it's because it's very, very finely tuned by some of these constants that we're talking about. And we are talking about fine tuning of the cosmos today on Mind Matters News.

Robert J. Marks:

Ola, Daniel, I'm an engineer when I design something, I want robustness. If I use a resistor of 10 ohms in some sort of circuit and the resistant changes to say, I don't know, 10 and a half ohms I want my circuit to still work, but there has to be some wiggle room for small changes in parameters, such as the ohmage, but eventually the circle will break. If the resistance changes to something like a million ohms, my circuit might no longer work.

Robert J. Marks:

Now the universe might example of a resistor in the universe isn't applicable because I don't think we're talking about resistance here, but there's lots of other parameters in the universe as it exists. And that's what we want to talk about. And they have to, they are fine tuned, just like my 10-ohm resistor, to work well. And there isn't, in some cases, a lot of wiggle room. So Daniel, let's start with you. What are some of the constants in cosmology we can look for, for fine tuning? And what would the impact be on the universe if these constants vary too much?

Daniel Diaz:

Yeah. Thank you, Bob, again. So just let me first mention that. That's a very interesting case that I had not considered before. The one that you were mentioning for the resistor for fine tuning. It's a very cool example. And basically I think a more general way to define it is also fine tuning. You can look at fine tuning for any system to work.

Robert J. Marks:

Yes.

Daniel Diaz:

For any system to produce the desired outcome. You can just measure the probability, and then you say if it is fine tuned or coarsely tuned, whatever it is. So that's a very nice example in particular, for your question on, on the cosmological fine tuning, we look at different things when we are consuming cosmological fine tuning. We look first at the loss of nature. Loss of nature, like the most well known case, the gravitational law. So gravitation has to be in some very small interval, so the life can be produced. Now it is really kind of shooting like a rocket own life. It is more appropriate even to the consequence would be that life exists or does not exist. It's more appropriate even to say that if there is a big fluctuation of gravity, stars would not exist for instance of [crosstalk 01:06:45]

Robert J. Marks:

But let me ask you, what is the gravitational constant?

Daniel Diaz:

The gravitational constant is just a number that is attached to Newton's gravitational law. Now that constant was more formally developed after Einstein's general theory of relativity, but it is a nice way just to think about it in terms of what Newton did that is more familiar to all our minds, to all that we know. The basic idea is that there is a constant attached to the gravitational law. And in that gravitational law, that constant is producing some effect. That is the effect that if the constant, were the constant too small, then stars could not be formed. And it happens, as it happens, it is in stars that carbon is also formed. So if carbon is not formed... See if the stars are not formed, carbon does not come into existence. And if carbon does not come into existence, we living beings, we in biology are based on carbon in order to exist, then could have not existed. That very small number in the gravitational constant would have produced that stars could not formed.

PART 2 OF 4 ENDS [01:08:04]

Daniel Diaz:

The gravitational constant would have produced that stars could not be formed and therefore we would not be here. On the other side, we're the constant too large then everything would have collapsed. Basically, the gravitational force would be too strong and then everything would be collapsing into one single thing, let's put it like that. I mean, in the most extreme case. So in that scenario also, life, as we know it, could have not exist because it's just... Stars could have not existed either. So that's one example in the loss of nature.

Robert J. Marks:

Okay. Here's an important question, if the gravitational constant increase and I went to my scales, would I weigh more? I think so, right?

Daniel Diaz:

[inaudible 01:08:47]. I mean, yeah. That would be given by the gravitational constant.

Robert J. Marks:

Yeah. If we increase the gravitational constant the stars would collapse into a singularity, but right now my immediate thing is whether I would weigh more or not, because I'm really sure.

Daniel Diaz:

That's a real [inaudible 01:09:03] preoccupation, you're right. And there are other examples, it is not only fine tuning the loss of nature, it also happens in the boundary conditions. For instance, it is assumed that entropy would have to be at a very low value at the beginning of the universe so that again life could exist as we know it right now. That is something that belongs to a category that is called boundary conditions.

Daniel Diaz:

And there is another set also of constants to look as fine tune, and it is the old parameters to look as fine tune, and those are the parameters that come in the standard models in physics. So there is a cosmological and there is a particle, the standard model, in physics. And those models, as any mathematical model, have constants, parameters, free parameters as they call it in physics. Then those parameters also in general have to be finely tuned in order for life to exist.

Robert J. Marks:

Okay. What are some of the other examples of universal constants that we can have interest in?

Daniel Diaz:

Okay. So other examples, for instance, are the cosmological constant that Einstein developed with his general theory of relativity.

Robert J. Marks:

Let me ask you about the cosmological constant. I know enough to know a little bit about the history that Einstein fudged the cosmological constant to get the results that he want and later regretted doing so. Do we have a way of measuring the cosmological constant a lot more accurately today?

Daniel Diaz:

Yeah. I mean, there is some discrepancy actually between what we are observing, and it's a big discrepancy actually, between what we are observing, but it was theoretically predicted. And that's one of the biggest questions in physics right now, one of the most interesting question in physics right now depends on that cosmological constant. But it is very interesting. And some people have pointed this out that even though that cosmological constant was introduced by Einstein in order to correct, quotation marks, correct, the theory that he was developing because it was implying a beginning.

Daniel Diaz:

And he realized that the beginning, I mean, when he realized that his theory of relativity was implying a beginning, he tried to correct that because the cosmo, the worldview at the time was that the universe has existed for an infinite time. Then actually he introduced this constant and he called it the biggest blunder in his life.

Robert J. Marks:

Yes.

Daniel Diaz:

But as some people have pointed out, even Einstein's mistakes ended up being useful. So that cosmological constant right now is a central topic of cosmology, a lot of research is happening trying to justify some discrepancies that, big discrepancies actually, that are observed in the cosmological constant.

Robert J. Marks:

Okay. So some other constants that we have to pay attention to?

Daniel Diaz:

Yeah. There is also the primordial fluctuations. This is basically a quantum event. There is something very interesting actually about it, it has usually been mentioned that these primordial fluctuations are finely tuned. One of the things that we found in our paper is that for this particular example, the probability is very large. So it might be that subject to a different set of conditions and restrictions it could end up being fine-tuned, but as we measured, it is not as fine-tuned as basically it was stored before. That's another example, at least of tuning, even if it is not fine but coarse according to our findings.

Robert J. Marks:

So in truth, there's a lot of fundamental constants. I've heard for example, the electric charge of an electron-

Daniel Diaz:

Oh, yeah.

Robert J. Marks:

...for example. The weak force, the strong force. Man, there looks to be tens maybe hundreds of different constants that we can look at. And we have to ask the question, like the speed of light, why is this constant equal to this constant and look at the consequences of what would happen if it varied? Is it a fine tune thing or is there a lot of wiggle room there?

Daniel Diaz:

Yeah, you're right. When you were mentioning the force, there are basically four fundamental forces. The electromagnetic force, the gravitational force, the weak and the strong force. Those are the four big forces and the unification of all those four forces is what is called a theory of everything in physics. That theory does not exist yet, basically because gravitation is very stubborn and it refuses to be placed in the same category as the others or in the same model, let's say, as the others in terms of unification.

Robert J. Marks:

Well, in fact, I think it was Steven Hawking that gave up pursuing the theory of everything. He didn't do it because of the unification of the different forces, but he appealed to girdle, and the fact that no matter what you did there were going to be stuff that was true in the universe that you still needed to prove.

Daniel Diaz:

Oh, that's very interesting. Hawking appearing to girdle. That's very interesting. So what we need in order to discover that the universe is fine-tuned... We don't even need that to measure and to see that all the constants are finely tuned. If only one of those is finely tuned then we can simply say that or deduce that the university is finely tuned.

Daniel Diaz:

That's very interesting because actually what is happening is that if those constants are independent of each other, and that's what is happening in the models, reigning physical models right now, is that they have to be assumed as independent. If they are not, then one could be reduced to the other and they could be discarded from the model. So if only one of those is finely tuned then we can say that the university is finely tuned too.

Robert J. Marks:

So are there numerous constants that are finely tuned?

Daniel Diaz:

That's our quest actually and that's what we want to observe. So what follows in our project is just now that we develop the theoretical way to measure those probabilities, is go and measuring those probabilities for the cosmological and particle model.

Robert J. Marks:

Excellent, excellent.

Daniel Diaz:

What we expect is to find that some of them, maybe most of them, are going to be fine-tuned, but again, if there is only one that is finely tuned, then that would be enough to say that the universe is finely tuned too.

Robert J. Marks:

Boy, that's interesting. But again, Stephen Hawking I think, speaking of Stephen Hawking, also said that, "Nothing is ever proved in physics, you just accumulate evidence." So if you have one that is not finely tuned, that's evidence. But boy, if you have a bunch of them that are required to be finely tuned, that's really a lot of evidence that something is going on. And as Fred Hoyle said, "Somebody has been monkeying with the universe." So very interesting.

Robert J. Marks:

Ola, we talk about fine tuning and these cosmological constants. And one of the terms that you use in your papers is an LPI. What's an LPI, what does it mean, and how do we measure it?

Ola Hössjer:

Yes. And we talked about this during the episodes one and two, and life LPI, that's a life-permitting interval for a certain constant of nature or a certain cosmological constant, and it could also be a life-permitting interval for a ratio between two constants of nature. And that means that this constant, or the ratio of these two constants, needs to fall within its life-permitting interval in order for the universe to harbor life.

Ola Hössjer:

And in episodes one and two we talked about the universe being fine-tuned it requires two things. First of all, we need to find this life-permitting interval, and that is physicists have done that. And that is the independent specification, that life-permitting interval. And then we need to find what would be the probability if the universe was generated by chance according to some distribution, what would be the probability that this constant of nature or the ratio between two constants of nature ended up within its life-permitting interval?

Ola Hössjer:

And if that probability is small, then we say that constant of nature or the ratio between these two constants of nature is fine-tuned. And as Daniel said, it's enough to find one constant of nature that is fine-tuned in order for the universe to be fine-tuned, because then it's also very unlikely that a universe was generated by chance, the one that harbor's life.

Robert J. Marks:

Excellent. We talked before about the difference between just looking at the intervals and looking at the probability an event was in that interval. Can you give me some examples of some of the constants of nature and the probability that the event as we see it lives within the life-permitting interval?

Ola Hössjer:

Yes. And in this joint paper of ours, Is Cosmological Tuning Fine or Coarse, in The Journal of Cosmology and Astroparticle Physics, then we give a couple of examples, and the first example that's really a ratio, or two constants of nature, it's a ratio of the constant on gravity that Daniel talked about and [Hubble's 01:18:48] constant squared. And Hubble's constant is related to a constant that explains how fast the universe is expanding.

Robert J. Marks:

Now, let me ask you this. Why do you take the ratio of constants as opposed to the constants? I mean, couldn't you kind of cook the books by looking at different ratios and seeing that they were fine-tuned? What's the reason behind taking these ratios?

Ola Hössjer:

Well, sometimes it could be the case that the ratio is more fine-tuned than each of the two constants themselves. It could be that they have to have a certain ratio in order for life to exist in that universe. We can think of it as a balance between different forces, the balance is more important than the actual strength of the two forces, so to speak.

Robert J. Marks:

I see. So maybe the life-permitting interval for one of these constants would not be as meaningful as with another one because there's an interplay between those two constants.

Ola Hössjer:

Yeah, exactly. So sometimes the life-permitting interval of the ratio could be smaller than the life-permitting intervals of each constants by themselves. And in this case, theoretical physicists have come up with an equation that relates the ratio between the constants of gravity and Hubble's constant squared with the critical density of the universe inverse when the universe was very young. So it's actually the case that critical density is highly fine-tuned.

Ola Hössjer:

And then there are some other constants as well, but this is sort of the important constant that comes up in that equation that says that the critical density of the universe is closely related to the ratio between the constant on gravity and Hubble's constant squared.

Robert J. Marks:

You know, I just thought of an example of this in my field, electrical engineering, there's something called a voltage divider, where the percent of a voltage that is bled off is just a function of the ratio between the two resistors.

Ola Hössjer:

Mm-hmm (affirmative).

Robert J. Marks:

And so therefore talking about the sensitivity of a single resistor doesn't make sense, you do have to talk about the ratio of two. So in talking with you, I just realized that these are problems in circuit design also, and I'm sure in other designs. Okay, continue with your example because we want some numbers here.

Ola Hössjer:

Yeah. And that example, which relates, the ratio between the constant of gravity and the squared Hubble constant, it relates that to the inverse of the critical density of the universe, that's called the Freedman equation. And Paul Davis, one known physicist, he has estimate that the relative, the life-permitting interval of that ratio between these two constants of nature has a relative size of 10 to minus 60. And that means this is the length of the interval divided by its midpoint. And it's more meaningful to talk about the relative size because it's dimensionless, it's not dependent on the unit we use to measure the constant of gravity or the Hubble's constant squared. So the relative size of the life-permitting interval is 10 to minus 60. We can think of 1% as 10 to minus two, or one per [inaudible 01:22:08] to as 10 to minus three. So it's extremely small.

Robert J. Marks:

Now that's the probability, is that right?

Ola Hössjer:

Oh, no. Well, it's actually the size of the-

Robert J. Marks:

The size?

Ola Hössjer:

Yeah, it's the size. And then we have a general way, we talked about that in during episode one and two, then the important thing is not the size per se, not even the relative size per se, even though it's dimensionless, it's actually the probability that we sign to-

Robert J. Marks:

Yes.

Ola Hössjer:

... this life-permitting interval. And then we have, and it actually... That probability depends a little bit on how we choose the normal distribution, the distribution of this the ratio between these two constants of nature. And it can be done in a few slightly different ways, but they all end up with probabilities that are like 74% of this relative size. So if this relative size was 10 to minus 60, the probability is zero point 74 times 10 to minus 60. And another approach is 50% instead of 74%. But the take home message is that the probability is very close, it's of the same order as the relative size of the life-permitting interval.

Robert J. Marks:

So the probability you're saying is about one in a million. If I remember your...

Ola Hössjer:

Well, it's one to 10 to 60, so it's much smaller.

Robert J. Marks:

Oh my goodness.

Ola Hössjer:

Yes.

Robert J. Marks:

10 to the 60th. Now, putting that into perspective, I think I've heard that there are 10 to the 80th atoms in the universe. And so 10 to the 60th is really, really big. What is that? It's a million, you say a million times and you get 10 to the 60th. So it's a million million million million million million million million million million becomes a tongue twister after a while.

Ola Hössjer:

Oh, yeah.

Robert J. Marks:

So it's a really, really humongous number.

Ola Hössjer:

Yeah, it is. So it's really amazingly large. And then we have another closely related example that also gives a highly fine-tuned ratio. And then we still have the constant of gravity in the numerator of that ratio, but then we have something called Lambda vacuum that is a contribution from vacuum energy to the cosmological constant that Daniel talked about. And then physicists have come up with very small numbers for the relative size of the life-permitting interval of that ratio as well, the constant on gravity divided by Lambda vacuum, and then the relative size. Depending on the theory used some authors come up with a relative size of that life-permitting interval that is 10 to minus 50 or even 10 to minus a hundred.

Robert J. Marks:

Now that's the interval, not the probability.

Ola Hössjer:

Yeah. And then the probabilities of the same order as the relative size of the interval. And it's like half of the relative size, the probability, or it's 75% of the relative size of the life-permitting interval. Depending what approach we use for computing the property, we talked about this during episode one and two that we used maximum entropy for the... We chose the prior distribution of the ratio, these two constants, according to the maximum entropy principle, but we could do it in different ways. Either we could choose apply the prior to the ratio itself, between these two constants on nature, or we could apply prior to the enumerator and denominator specifically.

Ola Hössjer:

But at the end of the day, we come up with very similar numbers for the probability of ending up within this life-permitting interval, which is of the same order as the relative size of this life-permitting interval. Which is like in this second example, the constant of gravity divided by Lambda vacuum, which was the contribution from vacuum energy to the cosmological constant. And this relative size was 10 to minus

50 or 10 to minus a hundred. And that the probability of ending up in that interval is of the same order, regardless of which maximum entropy approach we use for calculating the prior.

Robert J. Marks:

That's fascinating stuff. You've pointed out all of some things, some parameters, that are very finely tuned. Daniel are there constants of the cosmos that are not finely tuned?

Daniel Diaz:

Well, just in our paper we find two cases, one of those very atypical, I think this was something that Ola was mentioning in one of the previous podcasts. Once we are measuring the ratio of two constants, it is possible for some settings to obtain that the ratio is not going to be that finely tuned, that particularly is going to happen when the average is inside the life-permitting interval. Then if we take into account that life-permitting interval is very small than general, we can find a prior distribution for that parameter, the average, the expected value, being inside that interval, life-permitting interval.

Robert J. Marks:

Yes.

Daniel Diaz:

And then, and depending on that it's possible, even though atypical, to find that in some cases that average is going to be inside that life-permitting interval. If it is happening, particularly when the two constants in question are living in the whole real line, so it's not taking only for instance positive values, but it could be positive values negative values and zero, then in that scenario it is possible not to have fine-tuning.

Robert J. Marks:

Do you have a specific example?

Daniel Diaz:

Yeah. So for the situations that Ola was mentioning, then it is possible just not to think of those constants are living in the positive interval and the positive real line. When we are considering the whole real line, then we could obtain those things. For instance, let me just mention something. I mean, because this is a theoretical example, or this is a theoretical consideration, a mathematical consideration, again, as we mentioned before. So gravity is assumed to be positive so that it is an attraction for us, but theoretically, if we are allowing for the constant of gravity to move outside the life-permitting interval, then it is also possible to think of a universe in which there's no attraction force, in which case the gravitational constant would be zero.

Robert J. Marks:

So if I went and weighed myself, I would really lose weight, right?

Daniel Diaz:

Oh, yeah. Your weight would be zero.

Robert J. Marks:

I'm obsessed with my weight. Please go ahead.

Daniel Diaz:

And it is even theoretically possible, once we are moving the value of that constant, which is again the essence of the fine tuning argument. It is also theoretically possible to think of gravity as being negative, in which case it would not be an attraction force but it would be a repulsion force. So in that case, then the gravitational constant would be living throughout the whole real line, it could take values throughout the whole real line. And then in that scenario, if again, the expected value, the average, is living inside the life-permitting interval, is found inside the life-permitting interval, is going to be very difficult to determine that there is fine tuning. So the tuning would be coarse in that case.

Robert J. Marks:

Excellent.

Daniel Diaz:

There is also another possible scenario that we studied, and these are part of the two examples that we consider in the paper. We were looking at the gravitational constant and the ratio to other constants in nature, but we also consider the amplitude of the primordial fluctuations. As I mentioned in the previous answer, with this amplitude of the primordial fluctuations we did not find that it was finely tuned. Actually, what we found is that it is coarsely tuned.

Robert J. Marks:

Okay. What was that example again? Could you be specific about the constants involved?

Daniel Diaz:

Yeah. The amplitude of the primordial fluctuation. So we are taking this constant standing alone, no ratio or anything. Is just we are looking at it.

Robert J. Marks:

I see. Okay.

Daniel Diaz:

And what we found is that actually the probability of its life-permitting interval is very large. If I remember well it's something like 0.3, but Ola can correct me if-

Robert J. Marks:

So that was 30%. That was the probability that that constant would be created by chance, right?

Daniel Diaz:

Yeah. It's actually not 0.3, it's actually close to 0.7.

Robert J. Marks:

Oh.

Ola Hössjer:

Yeah.

Daniel Diaz:

So it's very. Yeah, I'm looking here at the paper and I just can correct myself. So the point is that actually, what is happening with this primordial fluctuation is that the life meeting interval is spreading through several orders of magnitude, and that is producing that. When we are looking at probabilities in the way we measure them, then the probability is high. So it's not going to be that finely tuned.

Daniel Diaz:

That being said, it is important to notice that in our method what we are finding is a maximum for that probability. So to put it in some formal terms, whenever we are finding that one constant is finely tuned, then we can be sure that it is finely tuned, but because the actual probability is going to be either that maximum or smaller.

Robert J. Marks:

So the probabilities are the worst case, that's the worst possible case that it could be?

Daniel Diaz:

Yes. Because we are being highly conservative in order to avoid a false positives.

Robert J. Marks:

Understood.

Daniel Diaz:

So we are avoiding false positives but the method is not that good in avoiding false negatives, because it is a maximum again. So from that perspective, whenever we are finding a high probability with our method it does not mean that it is not finely tuned, it means that the method cannot say anything definite in the end.

Robert J. Marks:

I see. So it could be that the things that you found that were not fine-tuned could be fine-tuned, but from what we know, and in accordance to the model you're using, they're not fine-tuned.

Daniel Diaz:

Yes, exactly. Because as I said again, this is a maximum. So if the maximum is very small, then we know that the probability should be smaller than that maximum, and then it is fine-tuned. But if the maximum is too high then we don't know what is the real status.

Robert J. Marks:

We've been talking about fine-tuning in the universe that allows life. There is no doubt the universe is fine-tuned to allow life, to allow you and me to exist. Everybody agrees, the scientist, the biologist, and the chemist. Today, we talk about the cause of fine-tuning. Again, there's no controversy, but why is the universe finely tuned? You know, there are various theories of the cause of fine-tuning of the universe.

Many are prompted by one's ideology. So let's go down the list of the ones that I have, and I think of I've done a good exhaustive search of the theories for fine-tuning. And the first one, Daniel, I'd like you to talk about is panspermia, were fine tune because of Penn's Permia.

Daniel Diaz:

Okay. So panspermia is the idea that life was seeded on earth from the outer space. That's basically the idea. And then there is a particular particularization of that idea that is called directed panspermia. It was, if I'm not mistaken, proposed by Crick-

Robert J. Marks:

Yeah. Frances Crick. Yes.

Daniel Diaz:

Frances Crick, yeah. The co-discoverer of the structure of the DNA molecule.

Robert J. Marks:

And a winner of a Nobel prize. So he was no dummy.

Daniel Diaz:

Yeah, exactly. So he proposed this idea of directed panspermia in order to explain how life started here on earth. That is basically the idea. Panspermia is just the idea that life was seeded on earth from the outer space, and then directed panspermia, as Frances Crick proposed it, was that it was seated on earth by an extraterrestrial civilization.

Robert J. Marks:

That's really strange. What's the difference between directed and regular panspermia? I think one was done on purpose, the other was accidental. Is that right?

Daniel Diaz:

Yeah. So basically there was an extraterrestrial agent in directed panspermia seeding life here on earth. And on the other side, it could be simply accidental that life was seeded earth because it was coming from instant, from an asteroid, and the little unicellular form of life started to develop until we become to this point.

Robert J. Marks:

You know, another person that was into and believed about panspermia was Fred Hoyle, who we've quoted. And Fred Hoyle definitely believed in a fine-tuned universe. I think that there's very little controversy that the universe is fine-tuned. There's always controversy. But I think that the consensus is that the university was fine-tuned. Isn't the idea of panspermia just kicking the can down the road? Are you familiar with that colloquialism? It's just kind of displacing the problem of where we came from to where did this incredible civilization come from? The planted life here on earth?

Daniel Diaz:

Yeah. So let me just... Recently there was a debate, a conversation, between [inaudible 01:35:59], I think is the way to pronounce her last name. She's a very famous physicist with a well known channel on

YouTube, and Luke Barnes, who has done extensive research on fine-tuning. And they were having this debate, and it is very interesting that they coincide that explaining why there is fine-tuning is actually not a scientific question. So Luke Barnes said that basically science ends, saying that there is fine-tuning. On explaining why there is fine tuning, there might be different approaches and of course, then different world views are going to produce different explanations for that fine-tuning that we are observing in nature.

Robert J. Marks:

Interesting. Okay. So panspermia, I don't know. I think it just, again, kicks the can down the road, it leads the question as to the origin of this master or race or the master people that came here and planted life on earth. It's just strange. One of the other theories of the origin of life on earth is something I only heard recently, maybe about five or six years ago, and it's called the Sims theory of fine tuning. Daniel, could you talk about the Sims theory of fine-tuning?

Daniel Diaz:

Yeah, we talked about it also before in one of the previous podcast, I don't remember at this point which one, but the idea of the simulation theory is that we are all part of a simulation. So the way to think about it is that, well, the guy who developed this theory is Nick Bostrom, a philosopher at Oxford University in England. And when he came with this theory, he proposed that it is possible that we are living in a simulation. So this has to be thought just as in any computer problem, then there is an algorithm and there was a super advanced civilization in the future that finally made a computer simulation and we are all part of that simulation.

Daniel Diaz:

I'm not saying that I agree with that position, but it is there, it has generated a lot of controversy. I know that for instance, Elon Musk is convinced of that theory and he says that we all live in a simulation, but it also has received a lot of pushbacks from many well known physicists. And so it's very interesting development.

Daniel Diaz:

Anyhow, the point with that simulation, if it is an algorithm whose outcome is that we are here, then again, it could be looked as fine-tuning in which there is this algorithm who target is this civilization as we know it, inside the simulation. And in that sense, then that target, it needs to be finely tuned. So fine-tuning has been started in that sense in the simulation hypothesis, more looked at from the perspective of the entropy principle.

Robert J. Marks:

You know, this also kind of kicks the can down the road in my opinion. We have to ask ourselves again, where did this super race come from? And certainly their ability to write simulations about us must come from some sort of fine-tuning. The other objection I have is, there's many things that people do that are non-algorithmic. In fact, this is one of the fundamental postures of the Bradley Center, that we are not algorithmic, that we have things which we do that you can't write a computer program to simulate. These include things like [inaudible 01:39:50], understanding, consciousness, creativity. And if we are indeed simulations, then whoever did this programming must know how to program non-algorithmic things into our being. And I just, man, I don't see how that can happen, at least from what I know, because all computers are limited and all simulations are limited to the algorithmic. Have you heard Elon Musk has hired some people to go around and look for some flaws in our simulation?

Daniel Diaz:

Yeah. Some people have look at those things, but let me just mention that I also do agree with your comments, what you're saying right now, but in just playing as the devils advocate here in terms of the simulation hypothesis, well the argument as it goes is that a post-human civilization is so technologically advanced that it is capable of simulating all that we are doing, even if it doesn't look algorithm in some sense. So that's the hypothesis. So, I mean, it has many, many, as I said, people who are detractors and many people who do not agree with the position that well that's how the argument goes anyhow.

Robert J. Marks:

It seems kind of silly to me if we talk about the sims from an advanced simulation that does simulations of us. There's a couple of movies that I'm reminded of with the Sims theory, one of course is the Matrix.

Daniel Diaz:

Yeah. That's the default.

Robert J. Marks:

Yeah. That's the default, that's where everybody goes to, where, gosh, Keanu Reeves.

Daniel Diaz:

Yeah. Keanu Reeves.

Robert J. Marks:

Yeah. Anyway, he wakes up in a big vat of primordial soup in which he has been basking and his entire life has been simulated. So that's one example of this Sims, I guess.

Daniel Diaz:

Yeah.

Robert J. Marks:

And Elon Musk looking around for little flaws in Sims really is strange. It reminds me of another movie called The Truman show-

Daniel Diaz:

Oh, yeah.

Robert J. Marks:

...starring Jim Carrey.

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Robert J. Marks:

where he came out one time and all of his life, all of his existence was programmed in order to make it seem like he was living in a real world. Then all of a sudden, this big lighting unit goes... right in front of his house. It came from the top where there was a simulation of a sky, and all of a sudden, Jim Carey had this idea that maybe the reality that he perceived wasn't true. This reminds me of Elon Musk's hiring of these people to go out and look for flaws in the Sims theory and see if he can find any evidence for it. So, anyway, it's an interesting theory, I suppose.

Robert J. Marks:

Well, let's move on to another theory. We've covered panspermia, the Sims theory. Another theory of the reason that we are here is the anthropic principle. Ola, could you educate us about the anthropic principle?

Ola Hössjer:

Yeah. The word anthropic, that has to do with humans, the meaning of the word, and it comes in two versions, the weak and strong anthropic principle. The strong anthropic principle was proposed by John Barrow and Frank Tipler in the late '80s. It holds that the universe is constructed for life to exist and for humans to live and thrive within the universe. So in that sense, the strong anthropic principle is closely related to that our universe is fine-tuned for life to exist and for humans to live with it. But it sort of also adds an interpretation of it. It was almost like a purpose.

Ola Hössjer:

But the other version, the weak anthropic principle, it also deals with the fact that the universe is fine-tuned for life to exist. But it says that as humans, we are biased because we live in a universe that harbors life, and for this reason we are biased. It's also called selection buyer. So it's a criticism of the strong anthropic principle, saying that, "Yes, if there was another universe without life, we would not be able to live in that universe and tell that it existed." So according to the weak anthropic principle, we should not be surprised to live in a universe that harbors life.

Ola Hössjer:

So these are two different kinds of interpretation of fine tuning of the universe or fine tuning of the universe for life to exist. But I should add that in our paper that we published recently and which we talked about during episodes one, two, and three, the paper is Cosmological Tuning Final Course that was published in The Journal of Cosmology and Astroparticle Physics. There we compute or give an upper bound for the probability of a randomly generated universe to have a certain constant on nature ending up within its life-permitting interval. Then we actually take the weak anthropic principle into account, and still we come up with small probabilities for certain constant of nature's or certain ratios or constants of nature. So I think that is interesting. So even though this weak anthropic principle, in a sense, criticizes the strong anthropic principle, we are able to come up with a small probability of ending up within the life-permitting interval and still not violating the weak anthropic principle.

Robert J. Marks:

Okay. One of the best counter examples of the anthropic principle, I heard from William Lane Craig. I don't think he was the originator of the idea. But it's very clear from the work that we've been talking about that the probability of our universe permitting life is very, very small. Craig gives the example of a man dressed and ready for a firing squad. He goes out; his hands are bound. His eyes are covered so he doesn't have to look at the firing squad. But in the firing squad, there are people which hate him. There are marksmen. There is one guy with a bazooka, and they're all ready to take him out in this firing squad. So a big explosion happens and there was a lot of smoke, but when the smoke clears, the guy was still standing there. His blindfold was gone; his hands weren't tied behind his back and everything was okay. He didn't have a scratch on him.

Robert J. Marks:

So the anthropic principle would correspond to the guy that was in front of the firing squad, shrugging his shoulders and saying, "You know what? It happened. I don't know why it happened. But it did happen. I don't have to worry about that because I'm here and that's proof that it happened." Whereas I think in reality, if we had a small probability event like this, if I was the guy in front of the firing squad, I might dedicate maybe a portion of my life to finding out why the heck I wasn't shot. Why did this low probability event happen? So I think it's intellectually bankrupt. The anthropic principle is intellectually bankrupt. I see that this is shared by a number of physicists, that they see this as an explanation that fits their ideology, but they're really not wild about the anthropic principle at all.

Ola Hössjer:

Yeah. Yeah. I totally agree with you. I think that's example with the firing squad is a very nice one. I think if we apply the weak anthropic principle to everyday life, we should not be surprised by anything because we simply say, "Well, given that it's happened, it happened. I cannot say anything about the probability for it to happen or anything." I think that's a philosophy of life that is difficult to adhere to for anyone.

Robert J. Marks:

Yeah. Could we talk about the difference between the weak and strong anthropic principles? We were talking about movies. There's one of the first X-Men movies where Dr. Xavier who heads the school for special mutants gives a homework assignment. He says your homework assignment is to go home and write an essay about the weak and strong anthropic principle. So the weak and strong anthropic principle has made it into the movies. What's the differentiation between the two? What makes the anthropic principle weak? What makes it strong?

Ola Hössjer:

Yeah. I think that if we start with a strong anthropic principle, then it's really saying that it's almost like the universe was constructed for a purpose, for humans to exist and thrive within it because the probability for it happening by chance is so small. Then the weak anthropic principle tries to weaken or explain away that first explanation by saying yes, but given that we exist here, we cannot say anything about any other possibilities. So we are bound to simply accept that we live here, and it's like we are not going to think about the reason for this happening at all.

Daniel Diaz:

Let me add one thing about it. It is related also to your previous questions about how did we measure the probability in our paper? Basically, that was the idea behind taking the maximum of the probabilities over all the restrictions we were considering. So we are not considering only our universe, but we are considering all the possible universe that could have existed under the restrictions that were assumed, and then once we are doing that, we remove the possibility of the weak anthropic principle to appear in our measurement because we are not just looking at our universe again; we are taking a general overlook over all of the possibilities.

Daniel Diaz:

Then once we are doing that, we select the maximum. That's why I mentioned before that we were going conservative in our approach. Then in that way, we avoid the weak anthropic principle. It has some strength in terms of the measurements because we don't want to fall in the category of the selection bias measurement. Again, that is pretty common in scientific developments. The way to avoid it then was just to consider all the possibilities and then taking the maximum probability. So that's how we approach it in our paper.

Robert J. Marks:

Okay. Okay. Well, Daniel, continue about another theory of why there is fine tuning. We've talked about panspermia, the Sims theory, the weak and strong anthropic principle, and the one I'm hoping you will comment on, Daniel, is the multiverse. That's another explanation for why we are experiencing fine tuning.

Daniel Diaz:

Okay. So yeah, the multiverse is this idea that there is not only one single universe, but that there are multiple universes. The theory, again, is highly controversial because nobody can measure what is happening outside our universe.

Robert J. Marks:

Yeah. That's a good question. I don't think, and correct me if I'm wrong, that there's any evidence at all for the existence of a multiverse.

Daniel Diaz:

No. It is only some theoretical developments that are based on the assumption. It's basically assuming that there has to be other universes. So we have the multiverse that produces that outcome and it is an assumption. So what I mean in the end is that it is an assumption that is done and it is not a conclusion of science. It is not a conclusion of physics. And it is very interesting because most of the talk about multiverses started to appear once it was realized that there was fine tuning in nature. So of course, as a metaphysical possibility, well, yeah, it is a possibility, but it is highly biased by the assumptions that people are making with respect to what is the cause of the fine tuning that we are observing.

Daniel Diaz:

The problem, if you think about it as I was saying before, is that we cannot know that there are external universes beyond ours. I mean, we cannot even look at our whole universe. We can only see our universe to the point where light has traveled yet. In our universe, that is what is called in physics the observable universe. So there is theoretically a portion of our universe that we cannot observe. So my point is that we cannot even look at our whole universe, let alone looking outside the universe. There's no way to do that. We could not even know how to measure that thing.

Robert J. Marks:

Excellent. I have to brag about one of my publications or one of my pieces of analysis about the universe. A lot of people say concerning the multiverse, I'm sorry, I said universe. Some people say regarding the multiverse that in some parallel universe that this podcast would end right now, and in another universe, it would say that Daniel was in Miami as opposed to Columbia. They use the multiverse to say that anything can happen. Now there's different versions of the multiverse. One is from quantum theory, which says every time there's a quantum collapse, that the universe is split. That's a weird interpretation. I'm kind of a Copenhagen man myself. But there's also other theories where these multiverses literally exist, and I visualize them as being side by side.

Robert J. Marks:

The theories for multiverses are many, but one of the most common one has about 10 to the 1000th universes in the multiverse. And that sounds like a lot. It does sound like there might be some place that this podcast ends right now, and there might be one where it doesn't end right now. But if you look at the simple math behind it, it can't happen. Following on that, there's a universe where I am bald. I still am not totally bald. It's getting thin up there, but I'm not totally bald. So how many universes would it require for me to be bald in one and not bald in the other? It would take two universes, right? Now, we talk about Ola. No offense, Ola, but in some universe you might be bald, too.

Ola Hössjer:

Yes. Yes, certainly. Yeah.

Robert J. Marks:

And so what happens and how many universes do we need for that? We need four, right?

Ola Hössjer:

Yes.

Robert J. Marks:

We need bald, bald, bald, not bald, not bald, bald, and then the fourth one. So we have four. Now let's put Daniel, who has a rich crop of beautiful hair, but in some universe, Daniel, you're bald. How many universes would we need then?

Daniel Diaz:

Eight.

Robert J. Marks:

Yeah, we would need eight, right? So every time that we add a different contingency, we double the number of universes that are required.

Daniel Diaz:

At least.

Robert J. Marks:

Yeah. At least. Yes. We're only using binary counter distinctions here also. We could have one where you're bald, not bald, and then maybe partially bald. We could do three or four or five and we would multiply it instead of by two, we would multiply it by five, but let's just stick with two. So you take each added counter distinction and it doubles the number of universes. So you can work backwards by taking, if you're a nerd, you know that you take the log base two of the number of universes to get the number of counter distinctions. Anyway, if you go up to 10 to the 1000th, which is a common model, one of the models for the existence of the multiverse is that we have 10 to the 100, to the 500th, 10 to the 1000th. So I'm taking the worst case conditions. How many counter distinctions can you have?

Robert J. Marks:

Well, if you take the log based two of that, you find out less than 4,000. There can only be 4,000 different things in these universes. So even though 10 to the 1000th sounds like a heck of a lot, there's not a lot of things you can do with only 10 to the 1000th parallel universes. Then there's people that say, "Well, maybe we have an infinite number of universes." That is pure speculative metaphysics. There's nothing in our universe that is infinite. Everything is finite, everything.

Daniel Diaz:

So your point is that as we are adding contingencies, the number of multiverses is exponentially increasing.

Robert J. Marks:

Exactly. It increases exponentially, and 10 to the 1000th isn't enough to do anything.

Robert J. Marks:

So we've been covering different theories of the multiverse. I think the multiverse, in terms of probability, has been added for those that don't want to look to a creator as saying, well, if we have a multiverse, then anything could happen. I think that just careful analysis says that that isn't true. Also, the fact that there is no evidence that there exists parallel universes, absolutely zero.

Robert J. Marks:

So let's continue. We've been talking about the reasons for fine tuning: panspermia, the Sims theory, the anthropic principle. We've just covered the multiverse. And so let's now go to the deist creator interpretation, which I would say that is embraced by Christianity, Judaism, Muslim, and many other religions. What is the deist creator interpretation of the fine tuning of the universe?

Ola Hössjer:

I think previously we have defined that something is fine tuned if it's unlikely to occur by chance and if it has an independent characterization, and in terms of the universe, that is that the universe harbors life. If now it's very unlikely that, for instance, such a universe came to existence by chance, then it's very natural to think about other causes of the universe. Since we also have now for something to be fine tuned, it has to have an independent specification or characterization. Often it's a case that this characterization brings us or comes us to think about creative mind because in terms of the universe, it's that this universe should harbor life. When we talked about biology, is that a protein should function, or when we talked about molecular machines, it was the same thing: It should function. All this independent characterization that is part of the fine tuning brings us or tells us that probably there is a creative mind behind or that's a very good hypothesis.

Ola Hössjer:

It's like when we look at a painting and see features that we can recognize, just as when we look at life and see all the features of life, it's things that brings our thoughts towards a creative mind. For that reason, I would say that fine tuning naturally leads to a theistic interpretation. Earlier during this episode, we talked about fine tuning is something we observe and that's quite uncontroversial when it comes to cosmology. But now we talk about the interpretation of fine tuning, and then theistic interpretation is quite natural because of the way we define fine tuning.

Robert J. Marks:

So the creator of this is a creative mind. And so I think a lot of people would say, "Okay, you're talking about God." Which I think we are, right?

Ola Hössjer:

Yes, yes, certainly. Yes.

Robert J. Marks:

It's very interesting about how the fine tuning of the universe has brought people to a belief in God. One of them, which is kind of a poster boy, is Antony Flew who wrote in 1976 The Presumption of Atheism. Gosh, who was it? I think it was Walter Bradley was telling me, boy, he sure wishes that Antony Flew had become a deist before he became a deist. That would save him from reading a lot of Antony Flew's defense of atheism, but it didn't happen. So he had to read a lot of Antony Flew's work on the defense of atheism.

Robert J. Marks:

So I want to get now to the last topic that I want to talk about. I think panspermia is silly. I think Sims theory is silly. But for every one of these that I think is silly, there are people out there that would argue and debate me and say that they're not silly. Many times this comes down to a personal belief that everybody has. So we're going to put aside the physics and talk about what our personal beliefs are. And let's go ahead and start with Daniel. What do you think is the cause of all this fine tuning that we see in the universe?

Daniel Diaz:

Okay. So just trying to go a little technical in the philosophy here. Just let me make a differentiation between deist and theist.

Robert J. Marks:

Yes. Yes. Okay.

Daniel Diaz:

It's an important point to make because actually the deist believes that there is a God, but that the world is created in such a way that God is not interacting with it in any way.

Robert J. Marks:

Really. I always thought that theist was a subset of deist, but I'm being corrected here. Is that right?

Daniel Diaz:

So theism is the position that there is a God and he interacts with the universe he created. So there is a differentiation between the two. Deism was actually championed by Baruch Spinoza, and it influenced Einstein's thinking a lot, actually that's-

Robert J. Marks:

Who was it influenced by?

Daniel Diaz:

By Baruch Spinoza. He was a very famous philosopher in Europe in I think it was the 1800s, but I might be mistaken in the date. But the point is that he defended a universe. So this is very interesting. The guy was a believer in God. Of course, that's why he proposed that there was God. But he did not [inaudible 02:03:09]. But he created that he thought that God had created a world that was so perfect that did not need any intervention. So it is a very, very mechanistic way of thinking of the world.

Daniel Diaz:

That was something that Einstein observed a lot, and that is the reason for Einstein's to reject quantum physics with its Copenhagen interpretation. That's where the famous sentence of Einstein came about: "God does not play dice," because he was thinking that if God were playing dies, then he would be interacting with nature, with the world that got created. So for Einstein, that was unthinkable. Anyhow, that's the deist position.

Daniel Diaz:

The theist position is to believe that there is a God and that he interacts with the universe that he created. So I am a Christian and that's basically the position I suppose. That's what I think happened. That's according to my worldview, the best explanation for fine tuning. I think that there was a God and that there is a God actually who created the world and that we can see evidence of that in fine tuning.

Robert J. Marks:

Okay. Ola, what do you think?

Ola Hössjer:

Yes. Yes. I totally agree with Daniel and I'm also Christian. Therefore, for me, it's natural to associate or explain a fine tune structure such as the universe existing with life within it to interpret that as the universe was created by God, and that also he had a purpose for creating that universe, and that purpose was for humans to live in the universe and thrive within it and have a relationship with God. So I connect this interpretation with reading the Bible. The Bible also says that we as humans, we have a big responsibility in taking care of our planet, the Earth, and that naturally leads us to the strong anthropic principle that God created the world, the universe and our planet in a way that is optimized for us humans. That's simply, in my interpretation, that's because of his love for us.

Ola Hössjer:

I think that his love is most strongly revealed in his sending his only son Jesus Christ to die for our sins, so that anyone who believes in Jesus and commits his life to Jesus will have eternal life. Personally, I gave my life to Jesus when I was 22, 23 years old. That has been the best decision of my life. That is my interpretation of fine tuning. It's really God is a creator of everything for the purpose that he loves us and he wants to have a relationship with us, and he wants also to be surrounded by a nature and a cosmos that is functioning well and that is also aesthetically pleasing.

Robert J. Marks:

Excellent. Thank you, Ola. I am with you. I am also a follower of Christ. I would say even more fundamental. I'm kind of a John 3:16 kind of Christian and I became a Christian about the same age that you did, Ola. About I was 22 years old as a junior in college, and nothing made sense, and then I came to Christ and all of a sudden everything made sense, and it was just a beautiful, beautiful experience that's difficult to communicate to people. So, yep. I'm with you.

Robert J. Marks:

One of the things that happens is I think that people become Christians by their faith, but one of the things, especially people like us, we are intellectually gifted. That's been gifts that God has given to us. We are all three, if you'll excuse the expression, kind of nerds, if you will. The beautiful part about being a Christian is that all of these things that we look at are intellectually stimulating and provide evidence for the faith. I have always find that just to be wonderful. I've always looked at the Christian, well, kind of a version, which talks about God's creation and the purpose of God's creation in our existence. This is Romans 1:20. It says, "Since the creation of the world, God's invisible qualities, his eternal power and divine nature, have been clearly seen, being understood from what has been made so that people are without excuse."

Robert J. Marks:

Louis Pasteur famously said, "The more I look into science, the more I see God." That certainly is true with all of this fine tuning stuff that we've talked about. The more I look into it, the deeper I understand it, the more I see God's hand in it. It's just been wonderfully intellectually satisfying in our times and our discussions together. Great. Any final words?

Daniel Diaz:

Yeah. I just want to mention another thing, Bob, and it is that all the other, quotation, competing explanations to the deist interpretation that God is the source of the fine tuning are actually not totally opposed to it. So for instance, in the simulation of hypothesis, it is perfectly possible to think that the programmer was God.

Robert J. Marks:

Yeah. I've thought about that too. I've thought about that too. He kind of wrote us and created us with his word and he we're simulations of God in some sense. Is that what you're saying?

Daniel Diaz:

Yes, exactly. I'm not saying that that's my interpretation, but then that is a possibility if we are considering the simulation hypothesis. On the other side, for instance, with the weak anthropic principle, the fact that the observation is biased does not mean necessarily that it is incorrect. So that happens with the weak anthropic principle. With the strong anthropic principle that actually adds the interpretation and says that the universe was made so that it could host life, but it's basically kind of going into a deistic at least, or even a theistic interpretation. So none of those things in the end are necessarily opposed. It's just a particular version of those points that would be opposing to the theistic argument as the source of the fine tuning. So that's very interesting because not even the argument that have been placed in order to counter it necessarily counter the theistic interpretation of the fine tuning.

Robert J. Marks:

One of the things Stephen Hawking wonderfully said that nothing is proven in physics, that you only accumulate evidence. I think accumulation of evidence is also important for these interpretations of fine tuning. There is no evidence for panspermia, directed or otherwise. There's no evidence for Sims theory, although we've heard stories. I don't know if they're urban myths, but we have heard stories about Elon Musk looking for holes in the theory of fine tuning. There is no evidence of the strong and weak anthropic principle. It is totally philosophical. There is no evidence about the universe, but there is evidence accumulating that maybe God Almighty was the creator of the universe. With abductive reasoning, that kind of leads me to the biblical account of creation as the correct one. So it's the only one to me that makes sense.

Daniel Diaz:

Yeah. In the end, to me, it's the same thing.

Robert J. Marks:

Okay. This has been great. Look, we've been talking about fine tuning in our universe and not only in our universe, but in biology with Dr. Daniel Diaz from the University of Miami and Dr. Ola Hossjer from Stockholm University,.it has been a great chat. We've covered a lot of material and I've learned a lot. So I hope you've enjoyed it too. So until next time, be of good cheer.

Announcer:

This has been Mind Matters News with your host, Robert J. Marks. Explore more at mindmatters.ai. That's mindmatters.ai. Mind Matters News is directed and edited by Austin Egbert. The opinions expressed on this program are solely those of the speakers. Mind Matters News is produced and copyrighted by the Walter Bradley Center for Natural and Artificial Intelligence at Discovery Institute.

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