Science & Faith: A Physicist's Perspective

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[0:00] Pastor Greg, and thank you. Thank you everyone for having me this morning. I'm really excited to be here. As Pastor Greg mentioned, today I'll be talking about my perspective in science and faith and kind of like how I think about the work that I do.

And the way that I've organized the presentation this morning is essentially to present a little bit of physics and then kind of give you some examples of some of the grounding. Oh, I realized that there's a microphone and I'm yelling.
I'll give you some of the examples of the grounding Bible verses that I use when I'm sort of thinking about it and some of the ones that inspire me, even if they don't necessarily map one-to-one to the things that I'm studying.
And then I also, I kind of, as I was praying about it, I kind of also wanted to end with some of the ways that you can pray for Christians who are also scientists. So that's going to be sort of the conclusion slide.
And then I welcome questions throughout and at the end as well. If anything is unclear or if you just have like spin-off questions, please let me know. So I begin with a picture of the Andromeda galaxy just as sort of a way to kind of demonstrate why I get really excited about science and physics.
[1:15] One of my favorite Bible verses in the whole Bible is the first portion, actually all of Psalm 19, but especially the first portion where it says, The heavens declare the glory of God, and the firmament showeth his handiwork.

Day unto day utters speech, and night unto night shows knowledge. There's no speech, there's no language, and his voice is not heard. And you can kind of just see both the, I like bright lights on dark backgrounds because it's sort of like the scintillating flash.
But just to keep it moving with a little bit, this is one of the galaxies that's fairly close to us. There's a lot that we don't know about it, but it kind of encompasses both the things we can see as well as a lot of the stuff that we're trying to figure out.
So one of the things I'll talk about is we think that there's a lot of missing mass in the universe. So this disk that you see here is apparently surrounded by a large halo of invisible matter, and we're trying to figure out what that is.
And a lot of the candidates for that come from the things that we study in particle physics, and we have to understand nuclear physics and a bunch of other things. And we're just basically pulling a lot of different areas of study together in order to understand the universe that God made.
[2:25] So I just wanted to sort of like recap a couple of things that Pastor Greg spoke about last week. And that is that the point of Genesis is really to tell us who God is and to outline the story of creation and redemption.

And so one of the main ways that I think about Genesis is I think that it's accurate, and I think that what the Bible says is true. I also think that in this overarching story where you kind of go from the vast to zooming in very quickly on a family and a person, Jesus, you skip a lot of details.
And that doesn't necessarily mean the details aren't important in this particular instance because we use them to learn things about the world that we are basically given to Stuart.
And so for this reason, I get really excited, and I think that this is worth studying. When used correctly, the work that we do in physics provides knowledge leading to goods and services that aid the flourishing of mankind, all of whom are made in God's image.
This is even true of things like cosmology and astrophysics and particle nuclear physics because a lot of the devices and things that we build and the techniques that we develop in trying to answer these very basic questions get used in other places, whether it's medicine or defense or just iPhones.

[3:40] all of these things, they benefit from each other. I'm not necessarily saying that understanding the Andromeda galaxy will lead to the next tech upgrade tomorrow, but a lot of these things do kind of learn from one another.

I also think that it provides insight into the nature of God, who is the creator, just in terms of glory and majesty and bigness, as well as attention to detail and looking at the very, very small, which the enormous and the tiny are really intimately connected in the fields that I study.
And so that's another thing that makes me sort of like just really excited as I think about it. And also, when you look at this and you kind of like begin to ask these questions and look out, you can really begin to, especially if you're a Christian, just marvel at the creativity and the power of God.
And I think that in a lot of cases, it has caused people who are not Christians to stop and rethink their perspective. And so I think that this is really, really interesting.
However, when used incorrectly, you know, you can have a lot of problems that arise from people using things that are developed to enslave, harm, damage other people in the earth that we're responsible for.
[4:59] It can lead to pride. It can lead people to worship the creature itself instead of the creator who made it. And so I think that part of our role as believers is to understand the development and the use of science and its practical applications and to be able to discuss these things and to act and use it responsibly and ethically.

So I also wanted to point out and remind everyone from last week that there are varying viewpoints among Christians on the interpretation of the Genesis creation account and that these different viewpoints can coexist among faithful believers.
And so kind of where I fall tends to be in the old earth. I do believe there was a specific creation of Adam and Eve. I do believe that God made the universe. I also do think that the scientific data, I think that physics is credible and I think that we learn a lot and that what we have put together so far coming from a lot of different places is accurate and something that we're still thinking about but should not be dismissed.
So I kind of wanted to, this is a little bit hard to see unfortunately, give kind of a broad overview of just what the standard cosmological model is. At the end I have one that's kind of curtailed and might be a bit easier to see.
But what this is supposed to illustrate is a sort of time dependent going from my left to my right overview of the development of the universe from the beginning to today.
[6:30] So there was some sort of event about 14 billion years ago that led to some sort of creation and the appearance of matter and energy, space, and time all at once.

Everything expanded really rapidly after that. You, at some point, I'm going to skip a lot of details, somewhere you started to have things cool down enough so that you could form from like the super subatomic particles like quarks, you could start to form nucleons, so things like protons and neutrons.
And you also have things continuing to cool down fast enough. You also have elementary particles like electrons. Eventually things cool down enough so that the electrons can be captured by these sort of early low mass nuclei.
And once you have that, light stops scattering back and forth off of everything because now it's neutral. So now light is able to free stream and you, for the first time, basically start to have atoms in light.
Then everything, and so then you have sort of a, so about 300,000 years after the Big Bang, roughly speaking, you have sort of this production of just a wash of light.
[7:42] We call this the cosmic microwave background. And then at some point, you start to, well, and so that's the surface of the last scattering. You continue to have things move forward.

At some point, stars begin to form. They all heat up again. And then things start to cool down again. You form actual stars and galaxies. And then things continue to, the whole time things are spreading out.
Time is continuing. And then you eventually begin to have planetary clusters. There's a lot of details that I skipped. There's a lot of physics that people are still trying to understand and figure out.
You know, well, maybe we'll get into some of that. A lot of this is actually not my field. I will talk about my field in a minute. And so I kind of try to just give a picture because you can kind of see the progression here.

So in studying that, a lot of times what you're trying to do is, in putting the picture together, understand very specific questions along the way.
[8:48] And so two of the questions that I'm actually studying deal with the nature and origin of matter and mass. And they also deal with these sort of origins questions.

But they're more specific than just, you know, things started, things spread out, things heated up, things cooled down. And they're starting to ask questions like, well, okay, in particle physics, if you produce a particle, you also produce as any particle.
And they get produced in equal numbers. And so if that's the case, they should see each other, annihilate, you get energy, and then everything, you shouldn't really have any structure. We shouldn't really be standing here because everything that we see is made out of mass.
So why is it that most of the observable matter in the universe is actually matter? Where did all the antimatter go? It turns out there was this slight imbalance. And so we're trying to understand where that asymmetry came from.
And so one of the ways you can get at that is perhaps addressed by one of the experiments that I work for. Another question is, as I mentioned, when you look out at the sky, a lot of times you, well, there have been repeatable.
[9:52] And there's a lot of cumulative and very strong evidence that I'll describe in a minute that indicates that we actually aren't measuring all the mass that there is. And I'll give specific examples of those in a second.

And then the question is, well, where is all this mass? And what is it made out of? And why haven't we actually been able to interact with it before? And so and it actually also plays a role in the development of the early universe. And so trying to answer these two questions gives you key insights into how this picture fits together better.
And then we kind of go back and forth from there. And so you zoom in very quickly from thinking about these big picture questions to trying to answer one thing.
And you build a lot of really high tech and elaborate equipment and collaborations in order to do so. But a lot of times, again, it's not just bearing on this. It gives us a better understanding of the world that we live in and that we deal with every day.
So among the first questions, so the first question about the matter, antimatter asymmetry of the universe, one of the ways that we're trying to get at it is understanding a particle called the neutrino. We've seen neutrinos. We've seen a lot of experiments in the last couple of decades that I don't, unfortunately, have time to get into.
[11:15] You can ask me afterwards. But those experiments are able to demonstrate that they have mass, and they've been able to demonstrate that they have mass splitting. But they don't really tell us what the absolute scale of the mass is, and they don't really tell us whether the neutrino might actually be its own antiparticle.

It actually has a special role in the standard model because it's neutral, and it's a particle called a fermion. And if it is its own antiparticle, then that could give us a clue into, like, maybe how matter antimatter asymmetry could have started, maybe some other symmetries that are in place that we haven't really developed before.
So the way that we actually chose to look for this in the experiments that I work for is usually there's an experiment called two-neutrino double beta decay, where this nucleus that is specifically able to decay a particular way usually gives off two electrons when it decays and two neutrinos.
If the neutrino is its own antiparticle, you won't see the two neutrinos. And instead of seeing, if you think about how much energy you measure by watching these detectors over time and given some certain amount, you expect to see a certain number of particles at every energy.
So we generally, like, just plot this out. If two neutrino double, we have seen two neutrino double beta decay in a lot of different elements, a lot being kind of a relative number.
[12:40] But if neutrino less double beta decay exists, what we'd end up seeing is, like, all the energy going to the electrons, and it would give a little peek at the end point of the sort of spectrum that we draw out.

And the issue is that this is a pretty big background. No one's seen this yet. And so we have to really understand this, which we actually think we do pretty well, and then have a really huge detector and wait a rather long time to see if this peak develops.

So far, no one has seen anything. The experiment that I work for is actually located in Italy underground. And it's basically an array of crystals of that particular type of element located in this huge dill fridge that gets cold to about ten thousandths of a degree above absolute zero.
And so we're currently running and still working on this, but this is an example of one of the things that we're doing to kind of look for that particular question. Another one that I actually have spent quite some time on in a couple of different experiments is this search for dark matter.
So this slide is kind of intended to give an overview picture of why we really, over a long time, people ignored even the idea of dark matter. And it came back up about 30 years after someone first started, like, trying to get people to pay attention to it.
[13:57] And then it kind of became unavoidable because the issue is that when you compare astronomical observations to basically some of the calculations from two different types of observations, they don't match.

One of the first places that came up was if you basically measure the amount of light that you can see from a galaxy in a telescope or, you know, telescope basically, and you kind of plot that out as a function of, like, the distance from the center of the galaxy.
And then if you kind of predict what you would expect to see based on general relativity, which has been tested over and over and over again and works as well as anything that we've had been able to develop, the mass that you see when you're dealing with general relativity should just kind of fall off.
But when we measure the amount of mass, oh, sorry, actually, I should have explained a little bit more, the amount of light that you see, but then you also measure the speed of the stars going, so the amount of light that you see from the whole galaxy and then the speed of the stars that you measure as you go out from the center of the galaxy should match.
And you should be able to predict what that curve looks like as you go out, and that's the one that should flatten out. And if you measure how much mass is in the galaxy and you measure the speed of the stars moving at the edge of the galaxy, apparently there's not enough mass to keep the stars on the edge of the galaxy bound together.
[15:24] And so this is something that's been seen over and over again. Again, people ignored it, and it's been seen not just in galaxies but in clusters of galaxies. And, again, what you end up seeing is that the amount of mass that we can actually visibly measure is just not large enough to hold the things on the very edge of these systems to the system.

And so the question is, well, how are they being bound? What's this extra mass? So a lot of people have chosen the path of either saying there must be more mass, or maybe we have to change the rules of physics.
Changing the rules of physics is a really big deal, and it has to work everywhere. And so far the people who have tried to go along that route haven't been able to demonstrate as strongly that that's the way to go.
And as I mentioned, the rules that they're trying to change have been tested over and over again.
And so the idea is, okay, well, we know we don't understand some stuff from particle physics. Maybe there's new particles that we haven't seen yet that are contributing to this amount of mass. How do we figure this out? How do we see them? And it's not just these curves. There's also things like if you measure the amount that light bends around huge masses. So this is called, like, X-ray measurements coming from faraway galaxies and faraway stars.
[16:38] And then you also measure sort of – so that's where you get – so this is a false color image that basically is showing sort of the concentration of where you would expect the mass to be.

But then you also have, like, a lot of heat coming from the center of this galaxy, which is where most of – so these are the false color images. These are the X-ray images, and they mismatch.
And these are basically what this illustrates is, like, two huge masses moving against each other. The sort of normal matter is rubbing against itself and heating up. And then you have this portion that just seems to be going through without even seeing itself.
And so this is another indication. Maybe this is some weird type of matter that doesn't interact with regular matter strongly. There's other ways that we kind of are also able to kind of pick these things out. There's – remember that causing microwave background that I mentioned?
You can look at the fluctuations that come from this and see sort of, like, at different length scales how much it fluctuates.

[17:41] And this tells you important things about how early you could have certain amounts of mass and what would probably have happened to the universe at that point. And this indicates the need for some extra component early in the universe so that regular matter could start clumping together early enough to form galaxies.

You also have things like measuring the abundances of light elements in the early universe and constraints that you can place on that from a completely different area of physics. And you can only tweak that so much.
And so a lot of these things kind of go into looking for this picture of the fact that dark matter can exist. And then, as I mentioned, you know, we know that we're missing something for particle physics. There are all these theories that say, well, maybe there's this other symmetry or maybe this other thing is true.
These are some particles that would arise from that that we would not have been able to see yet. But if we build a detector, maybe we could find them because we know what we're looking for now. So that's an example. So I'm kind of going to move forward kind of quickly at this point.
But a couple of the experiments that I've worked on that look for dark matter work in a couple of different ways. One of them is another set of really cold crystals where you're looking for a particle to come in and scatter from the nucleus and keep going.
[18:52] Also located deep underground. Another one counts in the fact that maybe the dark matter does interact with at least light. And you can get it to convert two photons in a really strong magnetic field.

And then we build a different type of detector to look for that. And that's one of the experiments that's actually located and running right now here at Yale. So again, these are small rather, well, not small. These are actually very large efforts.
But they're trying to answer very specific questions that then point out towards the bigger picture. So I had a couple of things that people might consider about scientists.
Often a lot of people are trying to work together. And some of them, even if they aren't believers, are actually dedicated to seeking the truth with the tools they have available. And put a lot of time, thought, and energy and study into what they do.
And so they are simple people in need of a savior. But they are real people with lives, family desires, fears, goals, motivations, and feelings, whether they're Christian or not.
[19:52] And so I think that if we pray for one another, even if they don't recognize it, even if we don't recognize it, a lot of times what we are getting to see is firsthand both the simultaneous simplicity and complexity of the God who created the universe.

So I'd like to focus on, going forward, is actually Bible passages that have influenced me in my approach to work in science. And among the first is Genesis.
So Genesis 1, And to me, this is like giving, again, that big picture, not so much detail, but very clear statement that the universe had a beginning.
It was created, and it was created by God. And so this is sort of a very important foundational thing. Even if I'm trying to figure out how he did it, this is a key aspect of my view and work in physics.
I also already mentioned Psalm 19. So this is something that I get really excited about, as I mentioned. And it's one of the ones that, for me, points towards the value and even necessity, at least for my part, of studying the world that he made.
[21:29] And the fact that amongst all people and nations, everyone can look up at the sky, and they can see that there's something out there that's much bigger than them, and someone made it.

I also really enjoy Psalm 100. This one is not necessarily so creation-specific, but it is a reminder that God made us, and we belong to him, and that we have a responsibility to him.
But also it's a psalm that's full of joy and full of excitement just at the fact of living. And so it's one of the ones that kind of reminds me of the lightness and creativity of the world that he made.
Another one that actually does inspire me, there are a number of psalms that either have sort of very poetic descriptions of just the natural universe, which I also enjoy. And then there are some that really speak of the constancy and the structured nature and law of God.
And then there are some psalms that talk about the fact that God is the one who gives wisdom, and that, you know, as you seek him and ask him things, sometimes he will give you insights. And along those lines, one of my favorite verses from Proverbs is, it's the glory of God to conceal a thing, but the honor of kings is to search out a matter.

[22:47] And so it seems like a fun and royal challenge that we get to embark on to kind of study this out and try to dig deep and understand the structure and the nature of the universe.

Along the lines of how I approach my work are Proverbs 3, 5, and 6. Trust in the Lord with all your heart. Do not depend on your own understanding. In all your ways acknowledge him, and he will make straight your paths.
And this both goes to humility in terms of holding things kind of loosely when you need to, but also trusting him in terms of just career and in terms of life in broad perspective.
He is very generous in his provision and in the way that he allows us to, like, pursue the things that interest us. But he needs to be the one who's directing your work, your study, your time, your energy, your focus.
And then Proverbs 16, 3, Commit thy works unto the Lord, and thy thoughts shall be established.
And so one of the primary things that needs to be happening is that when you're doing all of these things, you really need to do them as unto him and to his glory and not just building your own kingdom.
[24:04] Another major set of scriptures, and I picked one out here that really inspires me, is the book of Daniel, especially the first three chapters and the description in chapter 6 and some of the other portions, but where it really describes Daniel, Hananiah, Mishael, and Azariah, or Shadrach, Meshach, and Abednego, as we know them commonly, being captured and going into Babylon, but then being selected from amongst their peers as people who were able to be taught the language and the tongue of the Chaldeans and who understand science.

And basically they were brought from their homeland into captivity, but then basically sent into the middle of this very intense, high-profile academic, but also political atmosphere where they had to perform.
And they couldn't really do it in their own strength. And if you read the first chapter, you see that they were determined to honor God in their actions and in their life and in their lifestyle.
And it's not so much the things that they did, it's their heart towards him, and he was the one who basically established their promotion in the kingdom. And so that was too much to put on the slide, but one of my favorite things comes from the second chapter, where basically they've learned all this, they've kind of established, he's established their reputations, they've gotten set up, but now the king has had this crazy dream.
Sorry, I heard a timer. The king has had this crazy dream. He doesn't really know what it means, but he's not telling his wise men what the dream was, either because he forgot it or because he doesn't want, well, the Bible specifically says he's not telling them because he needs them to tell him so that he knows they're not just making something up.
[25:51] But who's going to be able to tell you what you dreamed? So everyone's been sentenced to death. They get woken up in the middle of the night. The guy's banging on their door. Daniel's like, hold on a second. Give us, you know, however, a short amount of time.

We'll figure it out. Don't kill everyone. Just wait. So he and Shadrach, Meshach, and Mennigo go and pray. And the Lord actually shows him the dream and the interpretation.
And this is Daniel's, like, praise. Daniel answered and said, Blessed be the name of God forever and ever, to whom belong wisdom and might. He changes times and seasons. He removes kings and sets up kings.
He gives wisdom to the wise and knowledge to those who have understanding. He reveals deep and hidden things. He knows what's in the darkness, and the light dwells with him. So just the fact that all of this mystery and all of this stuff that we're trying to figure out, God already knows what's there.
And just that imagery of the fact that the light dwells with him and the amount of attention that's being given these days to the nature and behavior of light and its interaction with matter is something that's really interesting to me.
[26:53] But also the picture that, you know, even if we're trying to, like, figure all of this out, the light dwells with God. And there's a lot behind that statement to me in terms of, like, things that it reminds me of for physics.

But I think that even just in the context of this verse, you can kind of see in this short package the fact that he knows everything, and he deserves all the honor.

So there's more. I have focused on physics because I am a physicist. But there's, throughout the Bible, things that just kind of talk about nature as a whole, and in particular the type that has, like, life and movement and color and all of the interplay and people.
And the book of Job has some descriptions. Colossians talks about whatever you do, do it as I actually have written on my computer. Work at it with all your heart.
It's working for the Lord, not for men. 1 Corinthians and a lot of other epistles talk about the wisdom of God, the fact that, you know, you have the simple that confounds the wise. You have, you know, we're spending time and energy and effort to understand the very basic constituents of the universe, and we're every day walking on the complicated results of those interactions.
[28:07] And it's just amazing. And his transcendence above his creation. Oops. So, as I wrap up and leave time for questions, I would like to leave this slide about things you might consider praying for Christian believers who are scientists.

I think probably all of these apply to people in any field, and I would welcome people who have additional things to recommend. But boldness, both in their faith and in their work, and to be able to enjoy it and to be able to, like, have confidence in what they're doing and presenting and move with decision, excuse me, humility, that, you know, that they, even as they go out boldly, there's a God that they're submitted to, and there's a lot they don't know.
So, that's two things right there that are encouraging to humility. Encouragement, because a lot of times that day-to-day grind gets hard. We talk about the big picture, and we think about these big questions, but really what tends to happen is you're dealing with paperwork and travel reimbursements and purchase orders and computer codes that won't compile or are doing the wrong thing, or broken experiments, lots of stuff, or funding, you know, whatever reason, or things that might even be happening outside of the lab.
Again, people are not there 24-7, even though there's pressure to do so in some places. Rest, going right into that.
Creativity, integrity, because, again, with the pressures, a lot of times people will succumb to doing things that just, minor or major, you know, it's not right.
[29:53] So, integrity, fearlessness, wisdom, understanding, and knowledge, much as God gave Daniel and Daniel and Shadrach, Meshach, and Abednego. Love for their fellow believers and fellow scientists and colleagues.

I think this is a really big point because both when you're interacting within the body, and when you're interacting with people outside of the body, there is sometimes a tendency to stridency, which isn't helpful.
And so, I think that, you know, the Bible talks about how they will know us by our love. And so, how we treat each other is a really important thing, even if you have differing opinions on important issues.
And how you treat people outside of the church will also be their impression in your witness. And so, being careful about both of those things will be helpful. a desire for God's glory because all of this that we are doing should not be just so that we get remembered maybe 50 years from now. Right? And a lot of times it's really easy to kind of get caught up in the moment and kind of get caught up with people need to know who I am. I need to get this right. I need people to come to me for the answers.
[31:02] And that's ultimately not what it's supposed to be about. Opportunities to witness faithfully to their colleagues can be tricky in professional settings, especially when there are different things in place.

So just building relationships and opportunities to do that so that people do hear about Jesus. And because we all live forever, right?
But where we do, you have to, you have to tell people. But a lot of times the opportune time is just as important as kind of like throwing it in their face and doing it poorly and God can use stuff but it's better to wait for His Holy Spirit and use wisdom.
Protection. I think that this is in a lot of different areas for the same reasons as I was talking about for encouragement before. And to find their identity in Christ, again, for a lot of those other reasons, it's really easy to kind of get caught up and feeling like if you don't do this next thing then it's, you know, it's rough.
And so, related to that is balance, discernment about choosing the stuff that they do and to be led by the Holy Spirit in this as well as in other areas of their life. And so, I, with that, will yield the floor

and thank you for listening.
[32:19] Thank you. Thank you. Thank you.