DoSER Dialogue on Science, Ethics, & Religion | AAAS

TRANSCRIPTS

SPACE AND EXPLORATION: HUMANS IN A VAST UNIVERSE

Dr. Jennifer Wiseman: We now have evidence from many directions that the universe is about 13.8 billion years old, beginning with an enormously spectacular burst of energy.

WE ARE FROM STARS

Dr. Jennifer Wiseman: And that energy transforming over time into a mix of matter and energy, and that matter becoming atoms, gas, stars, and galaxies. And then within these galaxies, generations of stars producing heavier elements, those heavier elements enabled the formation of planets around stars. And then on at least one planet, we have life.

We are very intimately connected with the rest of the universe in a very practical way. Our bodies actually do contain atoms that were forged in stars. In fact, most of the elements that we are familiar with, we don't know how to create them originally other than in stars. So, it's not us here and the universe out there. We are all part of the same wonderful physical entity.

Dr. David Charbonneau: Astronomy is an entirely observational science. What we do is we can listen to the universe, basically through our telescopes. We can gather light from distant objects. And through studying light, we're able to puzzle out the properties of objects that we can never go to directly. There are many astronomers who study light from 10 billion years ago, and basically we are allowed to look back in time through using our telescopes. So, telescopes are sort of like a time machine.

Dr. Jennifer Wiseman: Everything we look at we are looking at it as it was when the light began its journey to us. Astronomers use this wonderful time machine tool to help us understand how the universe has matured from a burst of energy to a place teeming with galaxies, stars, and planets.

ORIGINS OF THE UNIVERSE

Br. Guy Consolmagno: The early solar system was a very violent place where planets were being formed and broken up constantly. We know that the planets form from a cloud of gas and dust.

Dr. Jennifer Wiseman: Where does this dust and gas come from? So, stars themselves are little factories that start with mostly hydrogen collapsed into a dense clump of gas. And then that pressure creates a fusion reaction in the core of stars that can result in the production of heavier elements. Then when stars die, they actually release all of that material they've created into the

interstellar medium, and the next generation of stars incorporates some of that richer material. So you have generations of stars that create heavier and heavier elements. All of this has served over the 13.8 billion-year history of the universe to enrich galaxies with more and more varieties of elements that we now enjoy on places like planet Earth.

OUR EXPANDING UNIVERSE

Dr. David Charbonneau: The distances between things in our own solar system is tiny compared to the distances between different solar systems.

Br. Guy Consolmagno: If you go to a football field and you have a beach ball at the goal line, at about the 30 yard line, there will be a pebble. That's the earth. At the other goal line is maybe a golf ball, that's Jupiter. If you travel from there to the other side of the earth, from America to Russia, that distance would be one light year. And the nearest star is four and a half light years away. And that's our *nearest* star.

Dr. Jennifer Wiseman: We also see that the universe is still expanding.

Br. Guy Consolmagno: Space between galaxy clusters is growing. It's not that these galaxies are going out into empty space, but the space itself is actually expanding.

Dr. Jennifer Wiseman: So, we don't really know a crisp answer to how big the universe is. We know its age, and we know it's enormous. And we know the content of the universe is enormous. In the visible universe, there are something like 400 billion galaxies, and each galaxy can have hundreds of billions of stars. So, it's mindboggling.

EXOPLANETS AND LIFE BEYOND EARTH

Dr. Jennifer Wiseman: As we are realizing more and more the enormous size and scale of the universe and its enormously rich content, it begs the question of whether there could be life outside our own solar system.

Dr. David Charbonneau: If you had asked me 10 years ago how common are small, rocky planets like the Earth, I would have said we really had no idea. Humans have been asking that question for hundreds, arguably thousands of years. What's so exciting is that we are the first generation in human history that actually can answer that question. An exoplanet is a planet that orbits another star, and we really didn't know anything about exoplanets about 20 years ago and that situation has changed dramatically.

Br. Guy Consolmagno: In the last ten years, we had something called the Kepler Space Telescope which allowed us to focus on one particular part of the Milky Way. Very, very narrow field, but study it very intently.

Dr. David Charbonneau: At this point, astronomers have found about 5,000 planets orbiting many different stars throughout the galaxy.

Dr. Jennifer Wiseman: Because of all these planets, there's a lot of speculation that life might be common. Why should Earth be the only place where there's life? So, it certainly seems in some sense just by the statistics that life could be very common, at least simple life.

Dr. David Charbonneau: An active, current question is what is the minimum set of things you need to measure to really conclude that the only explanation is life? And it may be that there's other molecules, such as methane, directly seeing that there are liquid oceans, maybe seeing the green, the photosynthetic color. But is that enough? Will we ever be able to make a conclusive statement that we really know that there's life on another planet? I do think in the next even 10 years, it's possible we're going to answer that question.

Dr. Jennifer Wiseman: And of course, these are just the scientific questions. There are the bigger philosophical questions of why capital W, why is life existing and is there purpose in it? Those are the kinds of questions beyond the tools of our microscopes and telescopes, but this type of science does beg all these interesting types of questions.

Astronauts have commented on looking back at Earth from space. It gives them an entirely new perspective when they see all of humanity in one unified space. I think you can have a similar reorienting experience looking the other direction. Looking out in the larger cosmos and realizing that we are a tiny part of an extraordinary system.

Br. Guy Consolmagno: I had a little telescope I'd take up country and everybody in the village would come out and they'd look through the telescope and see the craters on the moon, or the rings of Saturn, and they'd go, "Ooh and ahh," just like my family and friends back in Michigan do. And it finally hit me - this is what makes us human, this ability to look at the sky with wonder.

A CLOSER LOOK: HOW WE DISCOVER EXOPLANETS

Dr. David Charbonneau: The first thing to know when you're thinking about how we study planets around other stars is that we never get to see the planets directly. The way that most planets have been found is we wait for the planet to pass in front of the star. When it passes in front of the star, it blocks some of the light from the star; we can see the star get a little bit fainter and a little bit brighter as it passes out from our point of view. Then, based on that we can infer, for example, the size of the planet. If it's a bigger planet, it will block more light. In terms of understanding the properties of the planets, what we really would like to measure are their sizes, their masses, and, if we put those two ideas together, therefore, their density and maybe what they're made of. Are they made of dense things like rock, like the Earth, or are they made of puffy things like gas, like Jupiter?

The way that astronomers learn about the mass of a planet is through the dance of the planet and star. Think about it as if you're watching two dance partners on the dance floor, but one dance partner was 10 or 20 or 100,000 times heavier than the other one, but that heavier dance partner would still do-si-do back and forth. We can study the light from the star, see that it's do-si-doing back and forth, and we call that the wobble method or the Doppler method. That allows

us to know that there's a planet there, even if we don't see the planet. It allows us to measure the mass of the planet because a heavier planet would cause the star to wobble more.

Furthermore, we like to figure out the temperature of the planet and, fortunately, that's very easy. The temperature really is set by the distance from the star, and we can infer the distance of the star by measuring how long it takes the planet to go around in its orbit. We've been able to measure the size and the mass and the temperature for thousands of worlds, and now we have a very good understanding of which of those planets are a little more like Earth, both in terms of being rocky and being temperate, and which are really not like the Earth, maybe because they have a lot of gas or maybe because they're much, much, much hotter or much colder.