Blueshift - Episode 4a

John Mather (long interview)

Kim: I'm here with John Mather. John, I'm thrilled to have you here with us today, and John is one of my colleagues at Goddard Space Flight Center. John, in October 2006 you received the Nobel Prize for Physics for your work with the Cosmic Background Explorer, also called COBE. What was the discovery that was made by COBE that gave you this Nobel Prize?

John: Well, okay, there were two major discoveries that we made with this satellite. One was to measure the spectrum of the cosmic background radiation, which is the heat radiation from the Big Bang itself. And our measurements showed that it exactly matches the theoretical prediction that it would have if it were really the residue from the Big Bang. So, this basically is the strongest proof we now have for the Big Bang theory, and that it was hot at the beginning. The second discovery of the mission was that the Big Bang radiation is not the same brightness in every direction. It's almost exactly the same, but not quite. And so, these little hot and cold spots are considered to be the seeds that would eventually grow into the structures of the Universe that we see now today, with galaxies spread out in gigantic patterns hundreds of millions of lightyears across. And that is all traceable back to the Big Bang and its hot and cold spots.

Kim: That's amazing. How did you feel the first time you saw the temperature data that told you that you had made the discovery that COBE made?

John: Well, I didn't realize yet at that time how important it was, because it was exactly what I expected. And I thought I knew what the right answer was. But it certainly turned out to be more important than that, because there had been decades of wrong answers and good theoretical explanations for wrong answers that really did cast doubt on the whole idea of the Big Bang as the story of the Universe.

Kim: But you never doubted that you would make this discovery, you knew that this was coming?

John: I certainly thought so. About the hot and cold spots, we didn't know that at the beginning. But by the time that COBE was launched, the theorists were very strong that we had to find them or else something was really bad.

Kim: So COBE not only confirmed one of the ideas that you believed in strongly, but also that you had this whole new field open up, which was understanding the cosmology more in terms of the hot and cold spots.

John: Yes, when we conceived the COBE satellite in 1974, there was no expectation that we would see all of this rich set of phenomena. We only knew this was the one thing that we had to go measure, and it would probably be interesting. By the time we actually flew the mission, it was very clear that it was going to be a very exciting subject if we could ever pull it off.

Kim: Absolutely. Well, I want to ask you a question about the Nobel Prize, just a little bit. Most scientists, even myself, think about what it would be like to win a Nobel Prize. What was it about the ceremony in Stockholm, and the experience of the whole thing, that was just as you expected it would be?

John: Goodness, well, they did explain to us in advance what it would be like, and the nobelprize.org website is very good about explaining what the great banquets and the great ceremonies will be like, and what it will be like to meet the King and to have dinner with the Queen of Sweden. All of those things, they did try to tell us what it would be like. But the feeling of being there, it's not possible to convey you in information. And the feeling is much more like you really did something important. Your name is up there with Albert Einstein and a lot of other very famous people that you read about in books and you studied what they did. And the idea that our project and our names are on there, too, is just sort of hard to absorb.

Kim: Yeah, so the ceremony really gives you a feeling for how important that discovery is that you made.

John: It really does.

Kim: That's excellent. What about the experience really surprised you?

John: I think the big surprise was enjoying the great party that the students throw at the very end. I was inducted into the Order of the Ever-Smiling and Jumping Green Frog, which is a student organization. And it was so much fun.

Kim: So what's the Jumping Green Frog mean?

John: Well, this is a traditional story, and I now have a small pendant of metal that I can wear on my neck as a member of this little student organization. So they have a good time. This is a fun party they do.

Kim: That's great.

John: This was one of many, many parties and speeches that we had. We were there for ten days, I think, and every day there were parties, interviews, and speeches. And it just begins to get to you in the end that what you did was important.

Kim: Excellent. Well, of course, you have been very busy. I assume you've been enormously busy this year. What has your year been like so far?

John: Well, every day I get yet another invitation to go do something. To speak to some group, or travel to some interesting place, and I have to say no to most of them. But there are many wonderful things to do. Also, this year I've taken on a new part-time position at NASA Headquarters as the Chief Scientist for the Science Mission Directorate. So this is to help this perspective of long-time at NASA to help guide us toward the best possible future we can make for science at NASA.

Kim: So you're there to give advice for the future?

John: Primarily.

Kim: And in NASA's future direction in science?

John: Right, so ideas about how to do more with less, what the mostpromising areas are to work on, how to structure the programs so that we do the best things, that's all up and we're working on it. We have a new manager, called the Associate Administrator for the Science Mission Directorate, that's Alan Stern, and I work directly with him to help think about what should be done.

Kim: That's excellent. So I'm interested in knowing a bit about your childhood. You were born in Virginia, and grew up in New Jersey. When did you become interested in astronomy?

John: I think I was about 7 or 8 years old, and my parents took me down to the Museum of Natural History in New York City, where there's a wonderful planetarium show. And in those days there was a model of the Solar System, you could watch the planets go around. Also, Mars was extremely close to the Earth that year, and everybody was hoping that we'd be able to see the canals on Mars, that people still thought might exist. So they didn't turn up. But my father bought a little telescope from Sears-Roebuck, and we brought it home and we tried to see the canals on Mars, and, anyway, it was a very exciting time. It was before there was space travel in peoples' minds.

Kim: So when specifically did you become interested in the more specific aspect of cosmology and the early Universe?

John: Well, I think that happened when I was in graduate school. I knew the basic idea of the Big Bang story, it was already pretty well known when I was a college kid. And I'd even read already some stories in popular books by George Gamow, who had explained it all and worked on it himself. But my thesis topic turned up when I was just wandering around looking for what am I going to do to get a PhD. And I could have worked on a variety of different things, but this topic was something that was in

progress by the professors at the university and so I thought, “Well, that sounds pretty cool, let me try that.”

Kim: So this was an outgrowth of your thesis project?

John: Yes, in fact the COBE satellite is basically my thesis project on steroids.

Kim: Excellent. So you were in your 30s, then, when you became the Lead Scientist for COBE, right?

John: Yes. Actually, I was 28 when we submitted the proposal. I was only a few months out of graduate school.

Kim: Wow.

John: And so that was one of those great surprises in life. I was not expecting to ever do cosmology again, because my thesis project seemed very difficult. I thought, “I’ll do something else.”

Kim: Sure.

John: But then, NASA had this announcement of opportunity, and it seemed like the obvious thing to do, to pursue this. The big reason the thesis project was difficult was the interference from the Earth’s atmosphere. And if we could get an instrument out into outer space, it would be so much better. So it was pretty obvious that we should try this if we could. I didn’t expect that we would be chosen.

Kim: So that was my next question - how long did it take for them to approve it? Was it approved the first time?

John: Oh, not at all! In fact, in 1974, it turns out there were three proposals, related proposals on the cosmic background radiation, and none of them were chosen. But in 1976, just two years later, NASA chose a team of six people that included members from all of those three groups, including the one that I had organized. So then we started off in earnest, we had a set of engineers and managers assigned to us to work with at NASA Goddard Space Flight Center, and we actually made a much more detailed plan. And that then survived all challenges. We finally were approved to start construction in 1982. So, took quite a while to get the plan mature, and also for resources to become available. So that’s how that one got started.

Kim: Excellent. Well, how important is it to have these sort of training grounds, similar to COBE, the small missions for scientists today, for young scientists today? Do you think those are very important?

John: It seems to me critically important that for us to carry off the grand missions we now are tackling, like the James Webb Space Telescope,

we have to have a reserve of many people who've cut their teeth on smaller projects and seen them through from beginning to end. So, at the beginning are small projects that can be done at universities, like sounding rocket payloads and balloon launches. Through smaller missions that NASA does, small missions called Small Explorers, various instruments that are flown on bigger projects and finally leading on to missions of higher responsibility, where a person can actually see something through from beginning to end. And it's actually huge.

Kim: Well, you are the Project Scientist for the upcoming James Webb Space Telescope. How does the cosmology of COBE and the Big Bang that you work on relate to some of the things that JWST will do?

John: Okay, the Cosmic Background Explorer certainly showed us the very first moments of the Universe, and told us through a lot of theoretical calculations what we think the first stars and galaxies might be like. But they've never been seen. So one of the great goals of the James Webb Space Telescope is to see them directly. So it clearly needs a bigger telescope than we've had before. The Hubble has shown us objects back to maybe a billion years after the great explosion. We hope to see the things that led into those objects, the precursors, the subminiature galaxies that eventually would grow together to form galaxies like our Milky Way. So our aim here is now to piece together the whole history of the Universe, from the Big Bang through the first stars and galaxies, to the formation of the Milky Way, formation of our own Solar System and our own planet, and the possibility that life can exist on here, on our little planet. For instance, we know that the early Earth would have been very hot, so it's possible there was no water in the early Earth. So, where did that come from? It probably got added later. Well, all of these things are probably subjects for investigation, and JWST will tackle some parts of that. Others, we have to go hunt around in other pieces of the solar system, and look at the Moon, and Mars, and the various other small things that we can get to.

Kim: So, James Webb, the space telescope, detects infrared light, it's different from Hubble. Why is it that infrared light is so important for studying the earliest galaxies and the earliest stars?

John: Okay, the infrared that we measure with the big telescope actually started off as ultraviolet light. The early stars were extremely hot, we think, maybe a hundred thousand degrees. And so almost all of their light is ultraviolet, but the expanding Universe stretches out the wavelengths of the light that we receive from the most distant parts. It's called the redshift, and in fact the redshift of the light is a direct measure of how far away things are from us. So, anyway, we need an infrared telescope to see infrared light that used to be ultraviolet.

Kim: Okay.

John: And so it's actually critically important for the design of the observatory, because infrared is hard to find. The telescope has to be cold enough that it doesn't emit its own infrared light, and that makes the telescope look very different from the Hubble.

Kim: So it's really a challenge to build, also, I would assume.

John: It's a huge engineering challenge, many new inventions were required. I'm happy to say that we've completed them, and we're ready to actually go on and build the telescope.

Kim: Good, good. Well, I believe your life represents the positive lessons of hard work and perseverance. How important is hard work to you?

John: I don't think of it as hard work.

Kim: You have fun!

John: Seems to me that what I am doing is interesting and important, and I like doing it. So I've never felt that I was working hard. People think that work is what you do when you don't want to do it, but they're paying you anyway. And I have the opposite view. Life is too short to treat it like that. If you're not doing what you want to do, then do something else. So I've enjoyed every minute, and sometimes it's a bit of a struggle to wake up and stay alive to do all of the challenges that are in front of us. But I've never thought that I was sacrificing anything, or that I was really working hard. I work as much as I can, because it's what I want to do.

Kim: Well, that's wonderful. Another thing I wanted to ask you about, you were recently named one of Time magazine's "100 Most Influential People in the World." How does it feel to have this sort of popular recognition and acknowledgment now, at this point in your career?

John: Well, it's sort of funny, a little bit washes over me because the Nobel Prize is so ultimate that nothing else can really top that.

Kim: Nothing else can top it.

John: Also, it's also clear to me that what's next is important. And the recognition is for something that was done by a wonderful team quite a long time ago. And I was privileged to be one of the leaders of that team, but this is not my personal thing. And so, I'm probably not accepting the full recognition I'm being given, the way people would like for me to do. But, I've really always felt that NASA projects are huge team projects, and that the miracle of organization is even more important than the particular individuals who are in the projects. So, there's something that's magic about that, and I can't explain it. But huge teams of dedicated people give their lives and their time and they accomplish these most amazing things.

Kim: So what you're saying is that you're still looking very much toward the future.

John: Oh, yes! What comes next is more important to me and more exciting than what we've done in the past.

Kim: Excellent. John, thanks a lot, thanks for coming and talking to us, it was amazing to talk with you, and that's the end of the interview.