[Intro music]

Sara: Welcome to the January 29th, 2009 episode of Blueshift, brought to you from NASA's Goddard Space Flight Center.

At Blueshift, we want to share stories that show you just how science works. Science is a constant process of questions and answers - you ask a question, seek the answer, and chances are, your answer also raises even more questions!

When early astronomers first pointed their telescopes at the sky, their observations revealed a Universe they'd never seen before. But seeing these new objects and phenomena just whet their appetites for more knowledge. So we always keep looking. This thirst for knowledge has led to the development of better telescopes, new understandings, and many of the amazing discoveries and surprises of the past 400 years in astronomy.

For this episode, we're bringing you the story of a cosmic mystery found by a balloon-borne experiment called ARCADE. This mission was looking for the radio signatures of the earliest stars in the Universe... but they stumbled onto a very strange signal. What is it? Well, that's exactly what Al Kogut and Dale Fixsen would like to know.

Al: ARCADE is a instrument we built with the idea of looking for the heat signature of the first stars that would form after the Big Bang. What we saw when we got our data and we looked at the part that we thought was the microwave background and we looked at the part that we thought was coming from our galaxy, we saw there was this big booming signal left over that was extremely hard to explain - in part because there should be a small signal from radio emission from other galaxies. Our galaxy emits radio waves and there are a lot of other galaxies in the Universe and you can roughly estimate how bright the sky should be from just from the radio glow of all these galaxies. And what shocked us was the signal we're seeing was 6 times brighter than the combined emission from every other galaxy in the known Universe.

Dale: Well, I've always resisted saying "What is it?", and first established "Do we really see it?". And so we worked pretty hard at making sure that we didn't have any instrumental errors, so we processed the data in many different ways and looked at making sure that it wasn't anything in the Galaxy that we know about.

Al: I remember when Dale first came into my office with a plot of our results after correcting for the emission from our own Galaxy and you could plainly see on one half of the graph the expected signal from the microwave background and tehn there were these points marching up the left side of the graph getting brighter and brighter. And we looked at each other and said, "These shouldn't be here!". We basically spent the next year trying to make those points go away. It was only after spending a year, trying various ways to account for them, within the instrument, within our galaxy, within the atmosphere, and the only thing left over is something from deep space. For our instrument, we want to get above the atmosphere, which is why we looked at balloons. The atmosphere itself is warm and emits a fair amount of microwave radiation so we just want to get above it to avoid having to account for its signal. So we're lifting a payload that weighs about 3000 pounds up to an altitude of about 120,000 feet. And we put this on on a really big helium balloon. The balloon when it's fully inflated and floats is a little over 100 meters in diameter, which means it would pretty much take up a full-sized football field.

Dale: Yeah, you could play football...

Al: ...in the balloon.

Dale: ...in the balloon. A full football game. I mean, players, kickoff, everything ... would fit inside the balloon.

Al: One of the nicest things about the sub-orbital program is because you get the payload back, you can make iterative improvements. You can take risks in terms of the instrument design that would be crazy to take if you had to shoot it up on a rocket and it had to work once and you never get it back. One very interesting idea would be to take it, make slight modifications to improve its accuracy, and then refly it to observe a much bigger chunk of the sky. Now when we flew it in 2006, which is the data we're talking about here, we got a total of two and a half hours of good observations from a four hour flight. That was limited by the high altitude winds. ARCADE, in order to cool it, is submerged in something like 500 gallons of superfluid liquid helium. And when we launched we were never sure how long that would last. So we took the first flight opportunity we had even though we knew it would be a short flight because there wasn't any point waiting for a long flight if the helium was going to run out after two hours. Well, we got our flight, and after four hours we had actually only burned through about 20% of our helium so we could have flown for 10 or 15 hours. So it would be very interesting to take a slightly improved version of this instrument and take it back to Texas and wait this time for better weather at 120,000 feet.

Dale: If that was interesting, we could also fly it, like, 6 months later and get the other half of the northern hemisphere sky. And then possibly go to Australia for a couple of southern hemisphere flights. If we had four launches, two from Texas and two from Australia, we could get 80% of the sky. Only the polar caps would be missing. Since this radiation is everywhere, that would pretty well be all we want in terms of sky coverage.

Al: Well, we are hoping to refly ARCADE. It was certainly a very enjoyable experiment to build because it was as much a thermal experiment as it was a radio experiment. I guess the other thing that's interesting to say is that if you want to hear this radio background, you actually can do it by taking a standard FM radio, holding your antennae so that it's parallel to the ground, tuning it between stations, and then a few percent of the resulting static, will actually be this signal coming from beyond the Galaxy.

Dale: If you can look at something much better, you can often find something new and interesting. The real thing is if you build an instrument that's better than anyone has built before, to look in some part of the spectrum or some part of space that no one has has looked before, most of the time you get interesting answers.

Sara: If you'd like to know more about ARCADE and its deep space mystery, check out our website at universe.nasa.gov/blueshift. We're also working on our blogs and other cool stuff. And drop us a line on our feedback form - tell us what you think about this episode, and what you'd like to hear about next time!

Join us again in a couple of weeks for another episode about the questions, answers, and mysteries of the Universe. This is Sara Mitchell, bringing the Universe closer to you, with Blueshift.

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