Are You Receiving Me?

Interview with John Bonnell, Project Physicist, University of California, Berkeley

Hi, John. Tell us a little bit about yourself and your work.

My name is John Bonnell and I am a project physicist here at the Space Sciences Laboratory at UC Berkeley. My work is the design, construction and test and use of all sorts of antennas and receivers for electric fields in space. I've done that on two NASA missions so far: the THEMIS Mission that was launched in 2007 and more recently the recently renamed Van Allen Probes that were launched in late August of 2012.

How would you describe the Van Allen Probes Mission to a high school student?

I would describe the Van Allen Probes Mission to a high school student [this way]: it's a mission of both exploration and discovery to a very dangerous region in the Earth's magnetic field. One of the first things that was discovered when the Space Age opened by Dr. Van Allen and the first American probe Explorer I were the Van Allen radiation belts: regions of high energy, millions of electron volt particles trapped in the Earth's magnetic field at reasonably high altitudes above the Earth's surface. For years this was thought of as a pretty boring area. The particles would be trapped, they'd be energized, they caused problems with satellites; that was about it. But over the past 20 years, it has become clear as we've expanded into these regions with more and more satellites and we've done more and more research that they're actually quite dynamic and there are strongly structured and very highly variable in time features that appear and disappear and come and go and our knowledge and understanding of how these radiation belts behave and develop over time is not as good as we thought it was. The goal of the Van Allen Belts mission is to understand to the point of predictability the dynamics of these radiation belts.

What are the Van Allen Belts? What is your role in the Van Allen Probes mission?

One of the things that the Earth's magnetic field does is it protects us from high-energy charged particles that come off of the Sun and that come from other solar systems as cosmic rays and also from processes that happen inside of our own magnetosphere- the magnetic field around our planet. What happens is that particles – charged particles – are trapped into two basically large donut-shaped regions that circulate around the Earth. Not only are they trapped; their energies are pumped up by the various processes that go on and so particles that start out coming off of the Sun get pumped up by factors of at least a thousand or more in terms of their energy. By doing this they become a hazard. They can become a hazard to any humans that are out there in space, as well as any electronics that are out in space.

My role on the Van Allen Probes Mission was to design and construct and test and deliver a set of antennas and receivers for measuring the geophysical electric field, both very low frequency large scale ones that have to do with moving charged particles around, as well as the higher frequency ones that are responsible for energizing particles as well as scattering them and dumping them into the atmosphere.

What is the connection between the Van Allen Probes Mission and the THEMIS mission?

There's a very interesting and serendipitous connection between the THEMIS mission and the Van Allen Probes mission. The THEMIS mission was set up to understand one of the processes by which energy and particles are injected into the inner magnetosphere. One of the side effects of that is the generation of the Northern Lights. Another side effect of that is -- basically these particles that are injected into the inner magnetosphere act as a seed population from which the Van Allen Belts can grow, as well as a population from which the so-called ring current can grow, distort the Earth's magnetic field, and either better trap or dump these high energy particle populations. Because the radiation belt storm probes measure what's going on closer in towards the Earth you can think of the THEMIS probes as sort of sentinels or up-stream monitors. They're the ones that are sort of watching either out in front of the Earth or back in the tail – the long magnetic tail of the Earth – and seeing what's coming in as sort of the source. And then the Van Allen Probes can then see, in place, what's going on with the waves and the particles and how the belts respond to what's being fed into them.

Could you please describe a challenge you faced in your work and how you overcame it?

I think one of the most challenging aspects of working on space-like hardware is that you have to come up with a precision piece of scientific equipment that you then don't get to touch. One you put it into space, you don't get to fix it, you don't get to touch it. So the challenge there is conceiving of all the known unknowns that you can come up with, as well as characterizing some of the unknown unknowns that could bite you later on in the mission. Build those in, test your equipment as well as you can on ground, and then basically kiss it goodbye and send it into orbit. Our laboratory has had a long history of doing this and doing this well. Oftentimes you are designing your instruments to run for a minimum of two years in orbit. We routinely get them to run for five times longer than that. It's a hand-crafted, careful process that lets us do that. Managing that process; managing the creative technical talent the creative scientific talent that's involved in that process is a real challenge.

Can you demonstrate the boom antennae on the THEMIS satellite? I understand you need to make electric field detector probes that are able to extend far away from the spacecraft so there is no disturbance from the spacecraft itself?

So, one of the things that we do here at Space Sciences Lab is we build antennas and mechanisms and receivers for measurement of electric fields out in space. So what I'm going to show you are some of those mechanisms that are used in those antenna systems. The first one is something that's called a stacer boom. A stacer boom is a really clever piece of mechanism. It allows you to pack a really long boom into a really small space on the spacecraft with not very much weight, with not very much volume. And, what it does is it combines both storage and deploy power all in one package. Normally, when this is completely stowed, all of this length goes into something about this long. On the Van Allen Probes, we actually have two of these mounted back to back. Each one of these is seven meters when it's fully deployed so that's a total length, tip to tip, of 42 feet (14 meters, give or take). What you get out of it – this is just a helical metal spring that wraps on itself, tightens down, and gives you a very stiff, very straight thing to put your electric field probe on. One of the key things that we have to do when we're measuring the electric field is we get them away from the disturbances that radiate from the body of the spacecraft. So this is one of the ways that we do that. We do this along the spinning axis of the space craft. There's no centripetal force along this [axis], so we have to push it out ourselves. For the other directions we use something like this [shows]: These are called wire booms. What we have is like a relatively thin, flexible cable with electrical wires in it, and this gets deployed out quite a long distance away from the body of the spacecraft. It's held out rigid by centrifugal force. On Van Allen, each of these would go out fifty meters and produce an antennae system that is 100 meters tip to tip. So that's one full football field from one antenna to another. Now to optimize the electrical connection of this antenna to the ionized gas around it, we have a tiny fine wire. This fine wire allows us to get this sensor ten feet away from the electronics package. Again, we're reducing the source of noise that gets picked up by this antenna element that gets carried out by this part. It also gives us this nice long wire which you probably can't see because it's only 9/1000th of an inch in diameter. But that allows us to make really really good antenna contact to high frequency fluctuations in the plasma. So it gives us a nice stable low frequency connection – a really good frequency connection all in a package that stows down this big.

Looking back at your educational and personal background, what would you say were the key decisions, opportunities, influences that got you to where you are today?

I think some of the key decisions that I made and influences that I had when I was in grade school, I had quite a few teachers that were in an essence indulgent in the fact that they had someone who was bright and interested and were able to then say, "Sure, let this second-grader go into the sixth-grade part of the library" "Sure, this kid's bored in chemistry class, I'll give him something else to do, and in the process teach him about computer programming." The way that I got involved up here was approaching a professor on campus and saying "I'm just looking for a job," and he hooked me up with someone that

I'm going to give you this grunt work, but I'm going to make you do research too. And so that was a key thing – having a good set of mentors. The other thing is just the inspiration. What is it that inspires a kid to work on things? And that comes from your parents. My parents were handy people. My mother was a biology teacher and she took us out and showed us pond water and things like that. So, being exposed to these opportunities to see the world not just as a place where you ride in a car and you go around and go to the store, but you actually go outside and see that there's all sorts of different things going on.

Another source of inspiration was science fiction. When I was a young child, the original *Star Trek* was in syndication and I rushed home every single day and watched every single episode as many times as I could because there was just this amazing world that they were showing and an amazing way of going out and not like blowing it up but actually exploring it and having adventures because of that.

he other piece of it was the space program. I was a young child at the tail end of the Apollo program; I can remember trying to stay up desperately to see the Apollo 17 launch and falling asleep well before it happened. The time was full of promise from the human space flight program and after that you had the Voyagers, the Mariners, and other missions that then sort of took up the mantle and carried us forward and showed us amazing things out in the Jupiter system, the Saturn system, that people like Carl Sagan and Neil deGrasse Tyson have gone to show and popularize for the audience. Having that out there – both the missions as well as people popularizing them served as agents for inspiration.

What advice do you have for a high school student who's interested in studying astronomy or astrophysics in college?

One piece of advice I have for someone who's interested in physics and astronomy in college is to try and get some experience and do well in math. Math is – whether you like it or not – the language that one uses to talk quantitatively about the world around us. It is a language that you should learn and learn well and be able to use in creative and different ways. It's very important. Also, depending on where you are, get an opportunity to go and take an observational astronomy lecture or class at a natural history museum, something that I did as a grade schooler, and I found it to be just wonderful. To actually having read about things like the moons of Jupiter and the phases of the moon and sun spots and to have the opportunity to actually see those things for real as opposed to just reading about them – it's something tangible that you can grab hold of and carry with you as a reason why you're interested and when you're staying up too late to try to finish something up you can remember "Oh yeah, this is going to turn out very interesting in the end."

What do you like to do when you're not at work? Any hobbies?

When I'm not at work, I actually have two sons: one's going to be in middle school and one's in high school both of which are interested in technical things; I've done projects with my older son where he does the building and I'll do the designing with him. I do a lot of carpentry and tinkering and repairing of things. I'm very fond of repairing rather than buying. So I spend a lot of time working on that. I do some writing.