Interview questions with Bentham Scientific, http://www.benthamscience.com/bensci/

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1. We would like to hear about your childhood. Can you share some good memories from it? Yes: I grew up on a research farm of Rutgers University, and my father studied dairy cows, while my mother taught elementary school. I had a lot of time to do what I wanted to do and I had no duties on the farm. I read as much as I could about science and math, and astronomy caught my attention, then electronics and physics. I was really excited to visit the planetarium and the Museum of Natural History in New York City, and it was easy to see that astronomy was interesting and mysterious, and that evolution was a demonstrated fact. A child of 8 can easily understand it, and it's unfortunate that some religious authorities have denied the obvious evidence, much to the detriment of their credibility. My parents read aloud to my sister and me from biographies of Darwin and Galileo, and they were heroes to me. They showed me that scientific discovery was both noble and dangerous. My grandfather was a scientist too, a bacteriologist who helped learn how to produce penicillin.

2. Tell us briefly about your journey towards your profession? What sparked your interest in Physics? Answer: In my public high school in rural New Jersey, I had a great introduction to physics and math, and I read a lot. Also, my parents found a couple of summer schools I could go to, that were sponsored by the National Science Foundation. One, when I turned 16, was in mathematics, at Assumption College. The next year there was one in physics at Cornell University. They were both thrilling, but I could see that other students were far ahead of me in math. I could also see that there were mysteries that were just now being revealed and solved, and I saw that I was pretty good at physics, and might have a chance to participate and maybe win as a professional. In high school there was a statewide physics contest in New Jersey and I won first place, which was a great encouragement to continue. In college I did very well on all the physics and astronomy classes, which again was encouragement to continue. But in graduate school, my thesis project failed to function, and I had to write about an instrument that did not work. Nevertheless, it paved the way for my Nobel Prize work.

3. Can you tell us about the work you did on the Big Bang which won you the Nobel Prize? How did you collaborate with George Smoot to work with you on your research? Answer: As a young postdoc, I was the original person who suggested we build the Cosmic Background Explorer Satellite, and my advisor suggested that we call three other key people to form a team. My idea was that my thesis project should have been done in outer space. Our proposal was submitted, and NASA later chose some of us to form a new team, along with members of two other teams. One of those was Dr. Smoot. I became the Project Scientist, a NASA position that meant that I worked with the engineering teams to build the observatory, and I was also the principal investigator of the instrument that we used to measure the spectrum of the cosmic microwave background radiation. With that instrument we measured the spectrum of the background radiation to a precision of 50 parts per million, which was far better than we had ever hoped we could do. It fits the theoretical prediction of a perfect blackbody spectrum extremely well. The instrument was a direct descendent of the one that

did not work for my thesis project. Smoot was chosen to be PI of the instrument that would map the radiation, but that instrument was built at Goddard Space Flight Center like the others, so as Project Scientist I had an oversight role for it, as well as over Dr. Smoot. That instrument was a descendent of several versions that had been used on the ground, on balloon payloads, and on aircraft, but its special advantage was being in outer space, far above the interference of the Earth and its atmosphere. With that instrument the team discovered that the map has hot and cold spots on it at a level of about 10 parts per million (root mean square). That difference is just what is needed to explain the structure of the universe we see today.

4. At what point did you start believing that your theory was right? Answer: I didn't have a theory, although I was pretty well aware that the expanding universe (the grossly misnamed hot Big Bang) was the popular theory. I am an observational scientist. Our measurements supported this theory against all competitors, such as the Steady State Theory, which is now very clearly wrong. Our data were extraordinarily precise and they fit the Big Bang theory perfectly, if one is allowed to include exotic ideas like dark matter and dark energy that cannot be observed directly on Earth.

5. How did it feel to finally be acknowledged in such a universal way? Answer: It was overwhelming for me and intensely satisfying for the 1500 people who put their hearts into making the satellite work and figuring out what the data meant.

6. Professor U.R. Rao, former Chairman ISRO, has said that it may take another 1000 years to colonize Mars. Do you think it is an accurate prediction? Answer: No, I don't think it will ever happen. I don't see any way in which such a colony could be economically viable in the way that terrestrial colonies were centuries ago. I can see that we can send people there temporarily for touristic or scientific reasons, but we will have to live in airtight bubbles and only go out rarely, otherwise we will die of cosmic radiation damage. However, I could imagine a future in which robotic intelligent life might find value in going to Mars and succeed in doing so. Robots don't have to breathe and they don't mind so much being cold or getting bombarded by cosmic rays. So they could live perfectly well on Mars if they want to. Terraforming is probably not totally impossible but would require many technical marvels.

7. Advances in understanding human biology & disease are opening up exciting new possibilities for breakthrough medicine; would you like to share your knowledge in this aspect? Answer: I only know that every week brings astonishing discoveries, ranging from the molecular level to worldwide system. But it seems that the most important and least expensive thing we can do for our personal health is to avoid addictions to dangerous behaviors (like fighting and surfing the Internet and watching TV) and substances (like tobacco and excessive salt, sugar, fat, and alcohol).

8. Which projects are you currently working on? Answer: The James Webb Space Telescope is my current main interest. It is the planned successor to the great Hubble Space Telescope, extending its discoveries to greater distances in space, closer to the formation of the first stars and galaxies, and looking into how stars like the Sun and planets like the Earth were formed and became capable of supporting life. The JWST could help us understand how we got here

and where we are going, and of course whether we are alone in the universe, or might have intelligent company elsewhere.

9. The ongoing research seems to be exhausted in most fields and yet the world encounters diversified problems replicated out of one problem. Are you optimistic about science that it can still accomplish to change the world? Answer: The premise that ongoing research seems exhausted in most fields is just wrong. It's true that some areas of science are now mature in the sense that it takes great effort to make additional fundamental discoveries; for example, Maxwell's equations describe electricity and magnetism perfectly and have already done so for around 150 years. But the application of those equations to scientific and technical challenges is still fascinating and astonishingly successful. I am writing to you on a laptop computer that embodies brilliant recent discoveries in basic physics as well as incredible applications of engineering talent, provided by organizations that have been built up from nothing in only a few years. So yes, science and engineering continue to change the world. The global challenges we face can be managed only through the continued investigation that is the hallmark of science, and the respect for evidence that leads to success.

10. How has the citation practice of authors changed in the past few decades? What factors influence author's citation practices? Answer: I don't know.

11. The idea of open access publication has received much attention from the authors. What is your opinion about this? Do you support this? Answer: Yes I do. But somebody has to pay for the work, both the research and the publication. In science, most fundamental research is supported by governments and paid for by taxes, so it's clear that the public has a right to know promptly what has been done with their money. But in many areas, scientific and engineering research is supported by organizations that seek to profit from the results. That work is unlikely to become open access very soon. And of course, some research is opposed by organizations that profit from pretending not to know the right answers. The tobacco and fossil fuel industries comes to mind.

12. How has the internet revolution changed the way in which you worked in your field? Answer: I spend my life typing instead of talking with people!

13. Is diversity the key to success in contemporary science? What could motivate one to create a Nobel worthy future? Answer: Diversity of thought is essential to discovery! One can't discover something new by thinking the same was as everyone else. But we don't have to look different to be different inside. Conversely I am really impressed that brilliant scientists are now appearing from so many different countries. As you know scientists are able to migrate like fish and birds to where they have the best opportunities to work. For now many are still migrating to the western nations but rapidly growing research programs in Asia, Africa, and Latin America are paying off for those areas too. I expect Nobel-worthy discoveries to come increasingly from the new economies where new scientific and engineering challenges are being met.

14. How can research in your field contribute to the process of socio-economic development & Global peace? Answer: Astrophysics is as far removed from practical application as possible.

However, scientists as a group are already a worldwide community with a kind of government, in which the truth will eventually triumph, and the truth is decided by nature, not by vote. If the world could be equally well governed, wouldn't that be interesting?

15. Any advice that you would like to give to scientists from the developing world? Answer: I would think that scientific and engineering problems are all around us, in all parts of the world. Who does not need clean water, clean air, good food, good shelter, good work, and good friends and family? The scientific method is to systematically search for evidence of what works, and I think such a method could apply to almost every area of life, in all parts of the world.