 about 2 weeks ago **Joseph Rogachevsky** Features **Comments** 0

Abhay Ashtekar: On Einstein's Shoulders

"If I have seen further, it is by standing on the shoulders of giants." — Isaac Newton

It was already 2:36. I was late making the call as I finished skimming through the article I was sent the day prior while trying to get some sort of grasp before talking with a leading researcher on his ideas about theoretical physics.

Aside from a short e-mail correspondence to request the interview where I had received the article, we had never communicated before. I could tell from his answers to my first questions that I was speaking with a very thoughtful and articulate individual.

That individual is Abhay Ashtekar, a theoretical physicist who is also the Eberly Professor of Physics, as well as the Director of the Institute for Gravitation and the Cosmos here at Penn State. He is best known as one of the founders of loop quantum gravity, a theory which aims to explain Einstein's incomplete general relativity; namely, to answer some questions of what happened at the very beginning of our universe.

During introductions I found out that he had an office in Whitmore, where he invited me to conduct the interview. I declined, only to regret later not taking the opportunity to properly record the incredible conversation about to ensue.

I began by asking Dr. Ashtekar what attracted him to the sciences. "A quest for truth", he said. "If you look at the laws of nature, it doesn't matter whether you are in China, or Czechoslovakia, or Massachusetts — you know Newton's laws hold. Do you know who was the King of England when Newton was around?" I admitted that I did not.

"Exactly. Nobody remembers who was in power, but everybody knows Newton. Science is so absolute and aloof that it doesn't depend on human affairs. It transcends the pettiness of mankind. That pristine character is what attracts me to science," he remarked.

I joked that scientists are often thought of as rigorous workers, who spend hours per day in a room with artificial lighting writing indecipherable equations on a whiteboard. "I prefer blackboards," he replied with a laugh. He explained that the typical process a scientist must go through is three-fold.

First is the exploratory phase, which is getting the main idea. "As an undergraduate, you don't ask the questions, you are given questions and expected to answer them. When you do research, you make your own questions," said

Ashtekar. "These questions can arise anytime; for instance when lying in bed at night, or while out for a walk."

Second, Ashtekar continued, "If you consider the idea as the skeleton, then the next part is putting the meat on the bone." This is the primary analysis of data, almost like a rough draft. The image of equations on a white or black board comes to mind. "To some extent, yes. But a lot of calculations that were impossible twenty years ago are done with a supercomputer today."

Finally comes the rigorous checking of the entire report before it can be submitted for peer-review and publication. "This process is absolutely essential," remarked Ashtekar. If you think getting your grammar corrected on the internet is annoying, you would not go far in the world of peer-review.

In many ways, it is similar to the field of journalism. A writer must find the idea, elaborate on that idea, and make sure that idea can hold up to ruthless commenters.

What I found most interesting was his description of the first process, one that many people sadly don't associate with scientists. I think this about sums it up. "There are many people who are equal to the best scientists today in terms of ability. What sets aside the best scientists is that they know the right question to ask," said Ashtekar.

So what question did he ask? "Ah, very good," he said, making me feel as though I just answered a problem correctly in class. "When it comes to the very small and the very large traditionally people have been using different techniques. There are domains, such as the beginning of the universe, when the very small and the very large meet. Then one needs a theory which is a full-arching syntax to cover everything. We need a fundamental understanding. It is a search for that grand unifying theory which was the driving force for our research."

He continued, "The best theory which exists now is General Relativity, proposed by Einstein almost 100 years ago. One of the basic lessons we learn in that theory is that a gravitational field is encoded in the geometry of space time. If there is a strong gravitational field then space-time is bent."

This concept of bent space-time can be tough to understand, but its effect is used to make measurements on the distance and age galaxies. The amount of distortion is taken into account to measure the size of these objects, with the idea that objects of larger mass have a greater effect.

"So basically space-time is not an inert object. Matter affects space and time, so space and time is not a canvas on which things are painted. It's part of the painting itself, like planets and light and particles. If space and time are really like matter, then maybe space and time itself also has an atomic structure," he elaborated.

"Well, maybe it is a physical entity which has fundamental building blocks. Under normal circumstances, these blocks come together to form a continuum. Near a black hole it tears, and we have to describe everything in terms mathematics. Look at water; we can describe its properties according to the laws of nature. But when you boil water, it becomes vapor, and you need a new description for vapor," he elegantly concluded.

The fuse leading to my mind exploding was sparked. In an effort to extend the time until detonation, I inquired about research teams in general. "There are seminars, almost one per day, in which people come together to discuss discoveries which have just appeared in the literature," said Ashtekar. "There are a dozen different groups working together toward the same goal, with communication. There's a lot of brainstorming."

And how did his team come together? "Research positions are filled by postdoctoral students who have finished their Ph.D., but not entered faculty yet. These students are vouched for through a network of contacts developed in the community." Sounds familiar. Somewhat different from the business world, in that 'who you know' is only as important as 'what you know'.

At this point our conversation turned to more technical aspects of the loop quantum gravity theory, and the polymer-like nature of space-time. I hoped to make this article accessible to everyone, so to preserve your innocence, and hopefully your interest, so here's the release to investigate on your own.

In order to better understand the paper, I asked him for clarification on a phrase that seemed to be taken for granted in the release when referencing the evolution of the universe, the term "fundamental fluctuations in the quantum nature of space-time". With a modest understanding of what it could mean, I was eager to hear his response.

After a moment to collect his thoughts, he answered, "The quantum world is probabilistic, whereas the space-time we normally think of is considered to be deterministic. Saying 'essential quantum nature' is to recognize that for space and time, even at the fundamental level, they are only probabilities, not certainties. A chair could spontaneously appear in the next room, but the probability is so small that it is considered zero. For a little particle like an atom, this probability becomes sizable due to the quantum tunneling phenomenon."

Loop quantum gravity is currently competing with string theory to pose a solution to the questions raised in general relativity. One issue preventing mainstream acceptance (have you ever heard of loop quantum gravity before this article?) is the lack of experimental observations that aren't predicted by other theories. "What my group is doing is the cutting edge, trying to go beyond Einstein. He discovered relativity 100 years ago, and later admitted that it was not perfect. What we are looking for is signatures in the large scale structure of the universe as an effect of the quantum nature of space-time," he said. "We are making predictions that could be verified in as soon as ten years."

Science and in particular technology have come a long way in the twenty-five years since Ashtekar first lectured on the possibility of loop quantum gravity as an explanation for the laws governing the universe. Where will we be twenty-five years from today?

IMAGE *Urban Philosophy Physics*

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