COSMIC SHOWERS

Angela Olinto – My group is studying the most energetic particles that are produced in the Universe, called ultra-high energy cosmic rays. These extreme cosmic travelers achieve incredibly high energies, 10^{20} electron-volts, which is ten million times higher than any particle we can accelerate on Earth… Their origin is a long-standing puzzle. The challenge in observing these extreme particles is that they are very rare. They arrive at a km^2 area like downtown Chicago only once a century… So we need to monitor very large volumes of the atmosphere to see these interactions happening naturally, they happen because they come from very faraway places and they bring a message to us, these particles, from faraway galaxies. So, the possibility that these particles or some of these particles come from the beginning of the Universe is very exciting.

To see such huge volumes of air, we really need to go to space. And one telescope can be doing the job of many observatories on Earth, and we are hoping that in the next decade we will launch what we call JEM-EUSO, or EUSO in the JEM Station of the International Space Station, that will be a telescope that should be seeing a hundred times more volumes of air then the ones we filled so far, and we are now developing prototypes of that telescope, one that flew in a CNES balloon, that we had to put a graduate student and a postdoc on an helicopter underneath the balloon, shooting lasers to make artificial showers, just like a normal particle would, and when these showers happen, what happens really is like a flash of light moving at the speed of light in the atmosphere. It's like you're trying to observe a 40 watt lamp moving at the speed of light 40 km away! So you have to have an incredibly good telescope and also an incredibly fast camera, because these things are very fast, so they, you know, move at the speed of light. And I should add that the way we see these light bulbs is through ultraviolet light! The way they get generated is that when the particle interacts, the particle that's coming from a very faraway galaxy interacts in the atmosphere, it generates a shower of low-energy particles: one particle translates into hundreds of billions of particles by the time it reaches the ground! That, those hundreds of billions of particles, they shake the air in the atmosphere, the nitrogen in the atmosphere, and that nitrogen fluoresces, so we get very lucky because the air basically tells us these particles are coming through, by sending us ultraviolet photons, ultraviolet light. So it's a tag of what's happening, otherwise we wouldn't be able to see them from faraway. So this is a really wonderful feature, it's called fluorescence, and that's how we are able to see 40 km away a particle that's a tiny subatomic thing moving at the speed of light, which is quite challenging, but fun… Hu, hu…

So now we’re ready to launch a much longer balloon, a balloon that would leave from New Zealand, go around the Earth once, maybe twice, he would be able to stay up there for a month or two, and we would be able then to see many of these natural showers, so if we accomplish this in the next two years, we should be ready to go to space and have a much longer mission to really nail the origin of these particles and also to start probing if they are or not relics from the beginning of the Universe at much higher energies… So, the higher the energy we probe, the closer to the beginning of the Universe we get. And we have many orders of magnitude to go, but we’ve gone halfway, so we have to go the other half, to be able to really reproduce the Big Bang…

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