CLOCK WISE

Jun Ye – What really makes me excited every day coming to the lab, is to really push the boundaries of how light and matter interact, and how we can harness the new frontiers of light-matter interactions, to push the corners of the fundamental physics as both from understanding some of fundamental questions in symmetry and in the search for new physics and also looking for emergence of complexity from very normal behavior of atoms and molecules coming together and suddenly you have very complex phenomena emerging from it… For example we laser cool atoms to very, very low temperatures, moving at about one billionth of the room temperature, and we load these atoms, thousands of these atoms in optical traps, arranged in a periodical fashion we call optical lattice. Individual atoms are loaded into these individual optical lattice traps, in a way that can be very orderly, that has very little entropy in the system, and we can control the quantum state of these individual atoms extremely well, such that when we are making a measurement of atomic clock which we're trying to find out orbital time of electrons moving around nucleus, we take pains to making sure, each individual atoms we're investigating, that the information we're getting from those atoms are limited only by quantum mechanical laws, and not limited by any technical noise. And once we can do that, we can also investigate many thousands of atoms in parallel, so that allows us to gain a lot more signal strength. And, as the precision goes further, that there's a minute issues of where you putting more and more atoms in your system, they can have a very weak interactions. And in our case they turn into a strong interaction, the reason being, we were making such a beautiful precise measurements, with all the noise removed from system, and then when the atoms start to interact with each other, they can turn into a systematic issues for our clock!

And I always make analogies that if you have a very little flower that's growing among very tall grasses, you wouldn't see the flower unless the flower grows really tall and you will see a beautiful flower, or if you cut down the grasses to a very, very clean lawn, and then suddenly a very little tiny flower stands out there, it's a beautiful physics that we are looking at… And so, on one hand we are trying to push the measurement precision to the next decimal point, to really allow us to peel the Nature one layer deeper. On the other hand, as you do that, there are unexpected physics that used to be unforeseen, you know, shows up as a problem, and as a problem in a sense of, it could be limiting the accuracy of your clock! But from other people's perspective, some condensed matter physicists, that's actually a very interesting phenomena, you have atoms which are interacting with each other, and suddenly their noise become correlated and they become correlated to quantum physics! So, this experiment, on one hand we are pushing the measurement precision, on the other hand you can turn this into an advanced material studies. But also, they are a lot of mysteries out there in the Universe, such as the existence of dark matter, dark energy, the fundamental asymmetry between matter and antimatter. So if you are able to build the most advanced, the most sensitive scientific instrument, and let this sit out there, in orbit of the Earth in space and being able to listen to whether it's gravitational waves or whether the dark matter is passing through, in the Universe, and then we can detect, because our atoms is so sensitive to any minute changes in the space-time fabric, or the existence of dark matter, then this turns into a very sensitive instrument, for us to try to answer some of the questions that's outstanding at the moment.

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