COMBINATORIAL GAMES

Daniel Suchet – I remember the first computer we had. I was about seven or eight, it was quite a big machine, running on Windows 3.11. In a stack of floppy disks, I found a game the fascinated me. It was called: “Prof Tim incredible machines”. It was a kind of logical, mechanical puzzle, where simple devices were assembled in complex pattern to reach laughable objectives: a marble would fall on a cage, causing the mouse to run in her wheel, the wheel would drive a belt, setting conveyor in motion that would bring a ball to fall through a pipe and eventually activate a toaster! I remember spending hours trying to figure out how to use a bascule, a pulley or a Nitroglycerin vial, only to trap a cat, burst a balloon or shoot a firework. And it is maybe there that I started enjoying puzzles and understanding how simple pieces can be brought together to generate complex results, whatever the results are.

There is the same kind of game and thrill in physics, where simple equations can be combined to describe seemingly various situations. I was especially seduced by Maxwell’s equations: four tiny equations that fit on the back of a stamp, but that can describe light propagation as well as electrical current or why magnets stick on the fridge.

So it is perhaps not by chance if I find the same kind of thrill with the experiment on which I currently work for my PhD. In the basements of ENS, we cool down atoms with laser, reaching temperatures close to absolute zero. And our experiment looks very much like an Incredible Machine. On the optical table, a laser comes out of a box, goes through a potassium cell, into an amplifier, and through a real maze of lenses, mirrors and cubes following one another. In the end, the initial light is split in a dozen of beams with various frequencies, intensities and polarizations. Each of them is used at one stage of the experiment to cool down, trap or image the atomic cloud. In quantum mechanics, particles are described by waves. At ambient temperature, the spread of the wave packet describing one particle is much smaller than the average distance between particles, and all wave packets are well separated from one another. But as temperature goes down, the wave packets spread more and more and at some point spread so much they overlap, if the temperature is cold enough. The atoms can then not be described as isolated particles anymore. One must take into account their wave behavior, which allows them overlapping. Cold atoms exhibit that way, in the middle of the experiment, the need to introduce quantum mechanics to describe this wave behavior. And what is most exciting is that this quantum nature brings out the universality of physics. All ultracold systems are following the same set of rules. And we can set experimentally an ultracold atomic cloud to mimic the behavior of any other quantum system. We have this way, down in the lab, a system that can be tuned to study every other quantum system in the Universe.

3min 31sec