

THE MIRACLE OF THE ABACUS

Denis Gratias – The story that I am going to tell you began in March 1985. That was the moment when we discovered quasicrystals. Now a crystal is a solid that, when observed through an electron microscope, comprises motifs that are atoms and that are repeated identically, side by side, just like paving or like a sheet of postage stamps. There are no holes and the pattern is always the same. A quasicrystal is an object that has the same properties of repetition but that has lost its periodicity. That is to say that it repeats itself but in a manner that is not exactly periodic. We call that quasiperiodicity.

Now during a meeting of the IHÉS, Duneau and Katz, two theoretical physicists, showed us that these objects could be three-dimensional representations of objects that would be crystals, meaning periodic objects, but with six dimensions! Now obviously six dimensions do not exist, we live in three, so the suggestion emerged that we would imagine making an object in six dimensions, then we would slice it down to the three dimensions in which we live. And thinking about what we would see, well it would simply be the slice of this thing. Hmm... that really caught the imagination of John Cahn, Danny Shechtman and me and the question we asked ourselves was how we might interpret the X-ray diffraction images of these quasicrystals. X-rays are directed at quasicrystals in a well-defined direction in the form of a high-quality beam like a light-house or laser. It hits the quasicrystal which is a small metallic object, in this case Aluminium-Manganese-Silicon, and we examine all the directions where photons emerge. And what happens with quasicrystals is that they emerge in well-determined directions, exactly as with crystals. But these directions are not at all the same as for crystals. The directions are bizarre. And thanks to what Duneau and Katz told us at the IHÉS, we worked out that the extent of this diffraction i.e. the deviation of the central beam, should be something that is proportional to – and here I am going to use a bad word – the square root of a whole number plus a whole number times the golden number!... Fine. What's more, we would be all the more likely to see it, it would be even more clear if this same whole number N times the golden number minus the other whole number M were as small as possible.

So one evening, I made an abacus, that is to say that I placed all these possible numbers on a straight line. For example $N=18$, $M=29$. If you take 18 tau minus 29, you get 0.01. That seems very promising... So that ought to be a strong reflection. I ought to be able to see that! And then I took a point off the line, and I constructed segments that ran from the point of exit, and that gave me a beam. And then I took my diagram, the one that shows what really happens, and I placed it on my own diagram, I put it down very gently and in an instant something extraordinary happened, the spots as they fell landed exactly, exactly,

where I had expected. I did this three, four times... I was stupefied. I couldn't believe that nature had done such a thing, she doesn't have time to wander around in six dimensions, if I dare to say such a thing... And here we have, all of a sudden, that a combination of Aluminium, Manganese and Silicon, on which we make an X-ray spectrum, obeys these mathematical laws that had been pure thoughts, purely intellectual, that impressed me enormously. Like a child who plays an imaginary game, if you like, and then who all of a sudden realises that it is real life. I had this sensation that this couldn't be reality. And yet it was.

4 min 27 s