YANG-MILLS *MASS* *GAP*

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GUCCI

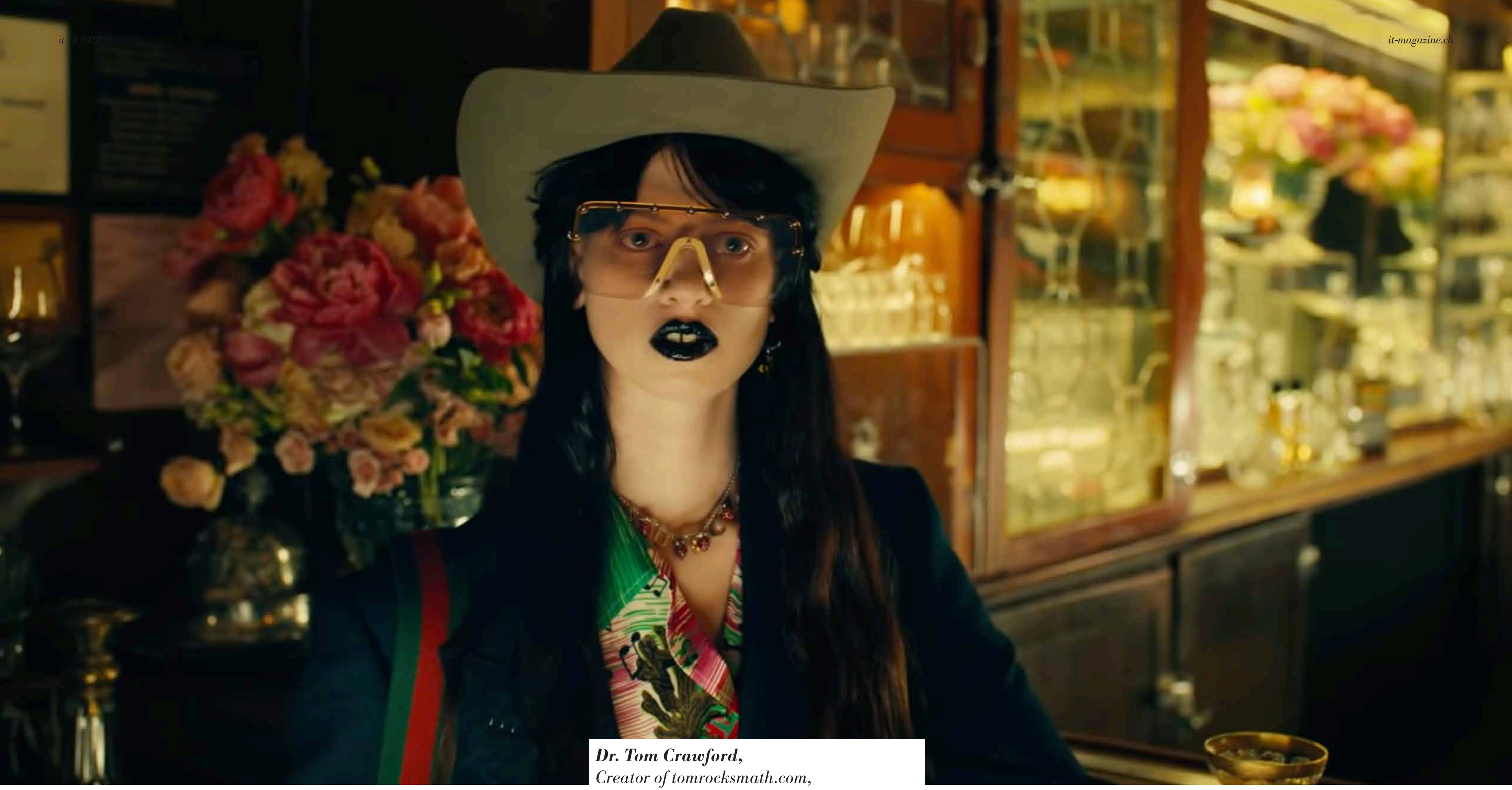
Millennium Problem number three is where things get really tricky really fast as we enter into the quantum world. You can think of the world as made up of two different realms – the one around us that we can see and the tiny one that exists between individual atoms. Imagine taking a giant microscope and just keep zooming in further and further and further and further and further... the idea is summed up perfectly by my favourite couch gag on The Simpsons *(they do it in reverse by zooming out but the idea is the same)*.

The camera starts inside the Simpsons living room and then zooms out to show the Earth, then our Solar System with the Sun at the centre, then our galaxy the Milky Way, then several galaxies and then it gets weird. Each galaxy becomes an atom and then we see several atoms making up a molecule, molecules joining together to make DNA, then pieces of skin and suddenly we are back looking at Homer. This is of course made up, but if you consider it in reverse and zoom in instead then what it essentially shows is that at a very tiny microscopic level another universe exists. This tiny universe is the quantum one and the rules are different.

First up, parts of atoms called electrons *(they whizz around the central part super-fast)* don't actually have a fixed position. You know roughly where they are but you cannot be certain until you make a measurement and even then you're not 100%. This is where Schrodinger and his cat join the party. Schrodinger was an Austrian physicist who really loved cats *(or maybe he hated them?)*. He created a simple thought experiment to demonstrate the idea of uncertainty in the quantum world. Take a cat, put it in a box and add a radioactive source attached to a flask of poison. The radioactive source can be your favourite radioactive material, let's say uranium and the poison can be anything that will kill a cat. It sounds mean so please don't actually do the experiment, it's just meant to make you think – and here's why. The radioactive source will decay after an hour with a probability of say 50%. If it decays, the release of radiation will be measured and a trigger activated to release the poison killing the cat. But if it doesn't decay *(also a 50% chance)* then the cat will be fine. The idea is that after one hour, you have no idea whether or not the cat is alive without making a measurement, which in this case is opening the box. The cat is both dead and alive with equal probability. This is pretty much what happens in the quantum world – things exist in several states at once and we can only assign a probability, or a guess, of what we think that state is.

There are many other rules and laws of physics that don't behave themselves in the quantum world and the Yang-Mills Mass Gap Hypothesis considers another one of them. The question can basically be boiled down to 'why do things have mass?' It seems a little philosophical doesn't it? Why do things have mass? Why are we here? What's the point of life? But this idea of questioning the existence of mass has a mathematical foundation...

A set of equations called, you guessed it, the '*Yang-Mills equations*' do a really good job of describing all forces that exist in nature *(excluding gravity – that's a whole other kettle of fish)*. But these equations have a problem when solving them with computers. The computer simulations say that there is some mass missing – a '*mass gap*' if you will. The third Millennium Problem asks mathematicians to figure out where this mass comes from in the equations. Physicists can measure the missing mass, but have no idea why it's there... they've left that job to mathematicians. Thanks guys.



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