The physical world: quantum
Einstein's objections to quantum theory

Presenter:
Einstein fought against the idea that nature was uncertain. Does that mean the moon isn't there if I'm not looking at it, Einstein would say. Bohr's position was – to paraphrase Hamlet – there are more things in Heaven and Earth than I'd dreamt of in your philosophy, Einstein.

Paul Davies, Visiting Professor - Imperial College, London:
I think the thing that Einstein fundamentally hated about quantum mechanics was the element of uncertainty or indeterminism, and I think that deeply offended Einstein who felt that we live in an orderly universe which is fundamentally rational, and that there should always be a reason for why things occur.

V/O:
For hundreds of years scientists have believed in a deterministic universe, that things happened for a reason, and that the secrets of the Universe were just waiting to be unlocked.

Paul Davies, Visiting Professor - Imperial College, London:
In daily life we're used to the fact that events occur always with well defined causes; we may not know what the causes are but if we investigate, if we have complete information about the system, we could say why something happened. Things don't occur spontaneously or arbitrarily, they don't occur for no reason. But in the quantum realm they do occur for no reason that generally speaking, from one moment to the next, you don't know what an atom or an electron is going to do, so indeterminism or uncertainty is the central feature of quantum mechanics.

Abraham Pais - Rockefeller University:
Actually I didn't like that; it was as what he called objective reality that you could make a statement about physical world independent of the way in which you observe. And that was the crucial fundamental argument between the two of them.

Presenter:
Despite Einstein's objections, the quantum theory was a huge success. Mysterious effects like radioactivity could be understood, and new technologies like microelectronics were being born. But what it said about the uncertainty of nature nobody really liked. Everybody worried. What did it all mean?
Niels Bohr would go on long, rambling walks, pulling together the ideas, trying to make sense of the theory that said 'to be, not to be, or maybe to be'.

Neil Johnson, University Of Oxford:
It's not difficult to do the mathematics of quantum mechanics. It's incredibly difficult to try and understand the consequences of that, of the quantum theory.

David Papineau - King's College, London:
You have one attitude when you're working in the small, another attitude towards large scale objects, and that works well enough, I mean that's good enough for working physicists, but it doesn't really make philosophical sense because there is this question about what counts as small, what counts as big, and why do they work differently if the big things are just made of lots of small things?

V/O:
Eventually Bohr came to the conclusion that you've just got to accept that nature's odd. The theory might not make common sense but you can't argue with its success. Stop the navel

gazing and get on with the job. His so called Copenhagen interpretation of quantum mechanics became the new orthodoxy on the nature of reality.

David Papineau - King's College, London:
Bohr's idea was that we could think of reality from two perspectives, or that reality kind of contained two alternative dimensions. So where there was reality as there was at the microscopic level, and then everything behaved as quantum mechanics said, and things were wavy and didn't have definite positions or definite speeds, and then there was reality at the macroscopic level, and that was as we'd always assumed it had behaved, the classical physics ethnic, everything was definite and un-puzzling. But somebody who's worrying about what is really going on won't be happy about that.

V/O:
They were determined to solve this but it was really hard to test the quantum ideas. 1930's technology wasn't up to the job, so instead Einstein and his colleagues would test nature in their heads to expose the flaws in Niels Bohr's philosophy. Einstein dreamt up elaborate thought experiments.