Prof. Russell Stannard: The questions on everyone's minds
The Nature of Space

Russell: What is space - empty space? I'm not just thinking of outer space. I mean any sort of space - the space here – the space where you're sitting. Well the answer seems obvious you know. Empty space? It's just another name for Nothing. But that's not how the modern physicist views it. Take for example a space station. It's orbiting the earth. Why? Why doesn't it just go drifting off into outer space in a straight line? Gravity - the earth's gravitational force acting on it. Well fair enough. But what if an astronaut steps outside the space craft? He too is orbiting the earth and in more or less the same orbit. Why? Earth's gravity again. But the astronaut is much lighter than the space station, so in order to get him to go in the same orbit the gravity force on him has to be less than on the craft.
So how does gravity know how much less it has to pull on him than on the space craft? And in any case, why would gravity want them to go in the same orbit? The puzzle is solved once one sets aside the idea of the earth exerting a gravitational force and instead thinks of gravity curving the space around it. Okay, this is something I've rigged up. This surface represents normal, empty space and if we have an object going through that space, perhaps a space craft, then the natural path to follow is a straight line, like that. But look what happens once I put a heavy object into that space, the earth. Now you see what it's done to the surface, it's curved the surface so now the natural path for an object passing through it like a space craft is no longer a straight line, it's a curved path a bit like this. Okay well forget about the spiralling in that's just due to the friction we've got here but for the space craft above the atmosphere there's no friction to speak of so we get a steady, repeated orbit.
Let me just show you how it comes about that the astronaut and the spacecraft go in exactly the same orbit at the same sort of speed. As you can see I happen to have got a curved surface here and now we'll make the heavy ball represent the spacecraft and the lighter ball is the astronaut who's just stepped outside the spacecraft to go for a space walk. And this is what happens. So the reason why the astronaut and the spacecraft follow the same orbit is that that is the natural path to follow. The natural path is no longer a straight line, a straight line which has then got to be curved because of the action of a force. This way of viewing gravity we owe to Einstein. It's part of his Theory of Relativity.
So, space is not nothing. Space is a something - a mysterious something that can be curved. And that's not all. The universe is expanding - distant galaxy clusters are receding into the distance. This is all in the aftermath of the Big Bang. But that's not to say the galaxies are moving through space, into an outer space where previously there had been nothing. No. They are moving because it's, it's space itself that is expanding. The space between us and the distant galaxy is carrying the galaxy along on a tide of expanding space. Okay here I've got some galaxies.
The galaxies have moved apart, not because they have slid over the rubber, but because the rubber in between the galaxies has expanded and carried them along with it. Okay that's what's happening out there. Space - so-called 'empty space' - is pushing the galaxy clusters apart. This is a diagram of the various stages of the expansion of the universe. The Big Bang occurred here. A brief period of exceedingly rapid expansion called inflation. And that's followed by the more gentle, normal kind of expansion - like what I showed you with the balloon. The rate of expansion at this stage further slows down somewhat because of the mutual gravity between the galaxies. But look what's happening here. The rate of expansion is now increasing.
This is due to what is called dark energy. Space - empty space - has energy. And whereas matter attracts through its gravity, empty space, through its dark energy, repels.
Now I reckon that's weird. Space, so-called empty space is not only something that can be curved by gravity, but it can also push around heavy things such as galaxies. things as heavy as galaxies around. No, let's face it, the simplest thing we can think of - so-called empty space, is not simple at all. It's a deeply mysterious something - but what?
After piece

Russell: Tony. Can we do the balloon sequence again, I've just had a brilliant idea. Okay, I get this far blowing it up but then if I blow some more and and it burst okay we've got all the bits flying around, that could like the accelerated expansion due to dark energy yeah? Shall I try it yeah?
Tony: No, no, Russell, Russell, no, no.
Russell: Well, well why not?
Tony: Sorry Russell, blowing up universes is not allowed, it's against health and safety, sorry.