What do Racquel Welch and quantum physics have in common?

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The University of Leicester is leading a three-nation consortium in a 'fantastic voyage' to explore empty space - with potential benefits that have only been explored in the realms of science fiction. The study aims to delve into a 'void' or empty space in which atoms move, which has a large intrinsic energy density known as zero-point energy.

Recent investment by the University of Leicester in the Virtual Microscopy Centre and the Nanoscale Interfaces Centre has put the University in a key position to take a lead in Casimir force measurements in novel geometries.

The Casimir force is a mysterious interaction between objects that arises directly from the quantum properties of the so-called 'void'. Within classical Physics the void is a simple absence of all matter and energy while quantum theory tells us that in fact it is a seething mass of quantum particles that constantly appear into and disappear from our observable universe. This gives the void an unimaginably large energy density.

The research team carrying out this work has received a grant of 800,000€ from the European framework 6 NEST (New and Emerging Science and Technology) programme to lead a consortium from three countries (UK, France and Sweden).

The programme, entitled Nanocase, will use the ultra-high vacuum Atomic Force Microscope installed in the Physics and Astronomy

Department to make very high precision Casimir force measurements in non-simple cavities and assess the utility of the force in providing a method for contactless transmission in nano-machines.

Chris Binns, Professor of Nanoscience at the University of Leicester explained: "The research will help to overcome a fundamental problem of all nano-machines, that is, machines whose individual components are the size of molecules, which is that at this size everything is 'sticky' and any components that come into contact stick together. If a method can be found to transmit force across a small gap without contact, then it may be possible to construct nano-machines that work freely without gumming up.

"Such machines are the stuff of science fiction at present and a long way off but possible uses include the ability to rebuild damaged human cells at the molecular level.

"In a sense the actual value of the zero-point energy is not important because everything we know about is on top of it. According to quantum field theory every particle is an excitation (a wave) of an underlying field (for example the electromagnetic field) in the void and it is only the energy of the wave itself that we can detect.

"A useful analogy is to consider our observable universe as a mass of waves on top of an ocean, whose depth is immaterial. Our senses and all our instruments can only directly detect the waves so it seems that trying to probe whatever lies beneath, the void itself, is hopeless. Not quite so. There are subtle effects of the zero-point energy that do lead to detectable phenomena in our observable universe.

"An example is a force, predicted in 1948 by the Dutch physicist, Hendrik Casimir, that arises from the zero-point energy. If you place two mirrors facing each other in empty space they produce a disturbance in the quantum fluctuations that results in a pressure pushing the mirrors together.

“Detecting the Casimir force however is not easy as it only becomes significant if the mirrors approach to within less that 1 micrometre (about a fiftieth the width of a human hair). Producing sufficiently parallel surfaces to the precision required has had to wait for the emergence of the tools of nanotechnology to make accurate measurements of the force.”

The new instrumentation at the University of Leicester will enable researchers to extend measurements to yet more complex shapes and, for the first time, to search for a way to reverse the Casimir force.

This would be a ground-breaking discovery as the Casimir force is a fundamental property of the void and reversing it is akin to reversing gravity. Technologically this would only have relevance at very small distances but it would revolutionise the design of micro- and nano-machines.

The Nanocase partner institutions are: University of Leicester Department of Physics and Astronomy, UK (lead institution); University of Birmingham, UK; Université Pierre et Marie Curie, France; Linköping University, Sweden.

Source: University of Leicester