



## NANOCASE NEST ADVENTURE

*One key challenge the project faces is designing nanotechnology devices that can transmit force between components without contact – an essential prerequisite for practical nano-machines. © Insitute for Molecular Manufacturing.*

The Casimir Force derives essentially from the physics of nothing – empty space. Nevertheless, it could have very real application in nanotechnology devices. The NANOCASE project will use state-of-the-art instrumentation to investigate this force between surfaces which becomes significant at nanometre distances. Success will lead to the design of nanotechnology devices that can transmit force between components without contact – an essential prerequisite for practical nano-machines.

# Energy in a vacuum

It may seem unlikely from our everyday experience, but quantum theory tells us that the energy density of completely empty space is, in fact, staggeringly high at  $\sim 10^{115}$  J per cubic metre. Of course, all the normal processes we observe in the universe have energies relative to this point, known as the quantum zero point energy of a vacuum.

However, at microscopic distances this quantum phenomenon results in potentially very useful forces. One such is the Casimir Force – first predicted in 1948 – which is an attractive force between two surfaces.

The force becomes measurable on the sub-micron ( $10^{-6}$  m) scale and for two perfectly flat reflecting surfaces increases rapidly as they get closer to each other. In principle, by using surfaces that have a nano-scale texturing, this ‘normal’ force can be converted to a ‘lateral’ force that could be used to drag (or push) an object through empty space without physical contact. The existence of this ‘vacuum force’ was confirmed soon after it was predicted, but with the advent of modern scanning probe technology we can now measure it more accurately and possibly put it to good use.

## Nanotech potential

A significant problem for the development of nanotechnology is force transmission. In order to make nano-scale machines, a method of transmitting force is necessary that avoids damage-inducing contact between component surfaces. Macroscopic solutions, such as lubrication, are not practical, but application of the Casimir Force could be. Enhanced understanding of the force will also benefit progress in quantum theory.

The NANOCASE project partners will combine their considerable expertise in nanolithography, cryogenic scanning tunnelling microscopy (STM), and quantum field theory to investigate the Casimir Force in full. Scientists from the UK, France and Sweden will measure the force between parallel flat reflecting plates accurately in ultra-high vacuum (UHV), along with its variation depending on the surface coating of the plates, their separation and temperature. The measurements will be the most accurate performed to date.

The next stage will be to examine the effect of plate geometry and material. The Casimir Force is versatile and, in theory, changing shape and/or material of the ‘optical cavity’



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*Force transmission is a significant problem hampering the development of nanotechnology.*

### AT A GLANCE

#### Official title

*Nano-scale machines exploiting the Casimir Force*

#### Coordinator

*UK: University of Leicester*

#### Partners

- UK: University of Birmingham
- France: Université Pierre et Marie Curie
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can significantly change its strength and even transform it into a repulsive force. The understanding acquired will enable optimisation of the surface properties required to maximise the force. This will be used to design a simple nano-machine capable of transmitting force between components without physical contact.

### Nano ball on a stick

Fabrication of the devices and measurement of forces will involve state-of-the-art instrumentation and etching techniques. The initial 'simple' device will essentially be a flat square plate suspended above a substrate by four silicon springs. The unstressed distance between the two surfaces will be in the range 0.5-1 microns and the movable plate will be a 10 micron square. The distance between the plates and the force between them will be measured by an Atomic Force Microscope (AFM). The AFM uses a very fine probe on a cantilever to provide images of surfaces down to atomic resolution by scanning and effectively 'feeling' the surface – rather like a high-resolution Braille reader.

For the NANOCASE project, a nanosphere of around 0.5 micron in diameter will be attached to the AFM tip and used to apply force to the centre of the flat plate. This should allow the Casimir Force between the plates to be measured for separations in the range of 800-10 nanometres ( $10^{-9}$  m) – a wider range than previously attempted. One of the silicon surfaces can also be coated with gold to examine the effect of changing the surface coating. Further experiments will use Micro-Electro-Mechanical Systems (MEMS) to measure the force using a well-characterised combi-drive technology that has a resolution of 0.1 nanometres.

**This lateral force could be used to drag (or push) an object through empty space without any physical contact.**

The experimental data obtained will allow the theorists to define the optimum parameters for a practical nano-machine design. Such a device could open the way for the construction of real machines capable of

manipulating matter at the scale of individual cells or even molecules – with huge potential for academic, industrial and societal application.



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SIXTH FRAMEWORK PROGRAMME