Casimir Effect

Advanced

- Imagine some space filled with "absolute" vacuum. It contains nothing whatsoever.
  - Is that possible? Technically no. We don't have the equipment (vacuum pumps and so on) to really suck out the last molecule or atom from inside some container, but conceptually you should have no problem to imagine an absolute vacuum.
- However, if you can imagine an absolute vacuum, you didn't pay enough attention to your quantum mechanics. There you learned about the Heisenberg uncertainty relations in the form

$$\Delta x \cdot \Delta p_x \geq h$$

$$\Delta E \cdot \Delta t \geq h$$

- The second one is the interesting one. here. It says that for small times Δt you may violate energy conservation by ΔE.
  - That means that even in absolute vacuum, some elementary particle may come into existence (needing some energy ΔE for its generation) if it has a short enough live.
  - This is not a joke but an accepted fact of quantum electrodynamics: even an absolute vacuum is teeming with so-called virtual particles that come into existence for a short time span and the disappear again. For some reasons of conserving charge etc, virtual particles always appear as particle - anti-particle pair. While they "live" they have some wave function with some **exp(i*kr*)** term and thus also some wavelength. The same thing, off course, also happens in air
- In the words of an article from Alexander E. Braun, Senior Editor in the ***Semiconductor International, 1/19/2010***:
  - "*Predicted in 1948 by Dutch physicist Hendrik B.G. Casimir, the Casimir Effect results from the fact that space is filled with vacuum fluctuations, virtual particle-antiparticle pairs that continually form out of nothing then quickly vanish. This effect is observable between two metallic parallel plates placed 100 nm apart. The gap between the plates restricts the range of wavelengths possible for these virtual particles. With fewer of them present within that space this results in a lower energy density between the two plates than is present in open space. This creates negative energy and pressure that pulls the plates together; the narrower the gap, the more restricted virtual particles' wavelength, the more negative the energy and pressure, the stronger the attractive force. At nanoscale, it becomes the dominant force between uncharged conductors. Depending on surface geometry and other factors, at separations of 10 nm the Casimir Effect can produce the equivalent of 1 atmosphere of pressure (101.3 kPa)*."
- In other words: the Casimir effect is real and a problem (possibly also an asset) to ***NEMS*** = Nano-EMS
  - The rest of the article delves into details: the problems caused to **NEMS**, possible ways to avoid them, and what else one might encounter at these dimensions.