Quantum Slip

Science works to neutralize the Casimir force in miniature motion sensors.

Air-bag actuators, handhelds such as iPhones, and video-game controllers all get motion or orientation information from tiny motion sensors whose even-tinier parts rotate or bend freely when the device is spun or accelerated.

As Diego Dalvit of T-Division knows, an arcane quantum-mechanical force—the "Casimir" force—can stop those parts from rotating or bending at all. But he and his Los Alamos team appear to have found a way to keep things moving.

Each motion sensor is usually fabricated on a chip called a microelectromechanical system, or MEMS. As MEMS are made smaller, several forces arise that can cause the sensor's moveable parts to stick to nearby surfaces. For nanoscale MEMS—devices a thousand times smaller than the width of a human hair—the Casimir force dominates. In fact, unless it can be neutralized, the Casimir force threatens to halt the progress of the incredible shrinking MEMS.

The Casimir force is subtle. Quantum physics predicts that photons can suddenly appear and disappear from the vacuum in a very short time. During their fleeting existence, these "virtual" photons exert a "radiation" pressure on surfaces, in the same way that sunlight pushes on comet tails. For example, between two thin parallel conducting plates, the only wavelengths of light that can exist are those that exactly match the distance between the opposing surfaces of the plates. Outside the plates, the light has no such constraints. As a result, the radiation pressure of the virtual photons outside the plates is greater than it is between them, so the plates are pushed together.

Previous theoretical studies of the Casimir force considered only conducting or semiconducting surfaces, for which the force is always attractive. However, Dalvit's team found that special magnetic metamaterials—materials whose properties derive from tiny structures patterned onto their surface—can neutralize the attraction and even make the Casimir force repulsive! Team members are planning an experiment to test the theory. If it's right, then nanoscale MEMS with nonstick, metamaterial parts could make for some very freewheeling devices.