

Research on Casimir effect at Leipzig university

People:

- PD DR. M. Bordag (staff)
- Prof. B. Geyer (retired)
- Prof. V. Mostepanenko (guest, long term)
- Prof. G. Klimchitskaya (guest, long term)
- Prof. N. Khusnutdinov (guest, short term)
- Dr. I. Pirozhenko (guest, short term)
- Dr. V. Nesterenko (guest, short term)
- Dr. V. Nikolaev (guest, short term)
- D. Ruell (Diploma student)
- D. Maroulakos (Master student)

Lines of research

- Geometry and material dependence of the Casimir force between separate bodies

M. Bordag and V. Nikolaev. Casimir force for a sphere in front of a plane beyond proximity force approximation. J. Phys. A: Math. Gen., 41:164001, 2008.

M. Bordag. Generalized Lifshitz formula for a cylindrical plasma sheet in front of a plane beyond proximity force approximation. Phys.Rev.D, 75:065003, 2007.

M. Bordag. The Casimir effect for a sphere and a cylinder in front of plane and corrections to the proximity force theorem. Phys. Rev., D73:125018, 2006

we obtain

$$E_{\text{Dirichlet}}^{\text{sphere}} = -\frac{\pi^3 R}{1440 L^2} \left\{ 1 + \frac{1}{3} \frac{L}{R} + O\left(\left(\frac{L}{R}\right)^2\right) \right\},$$
$$E_{\text{Neumann}}^{\text{sphere}} = -\frac{\pi^3 R}{1440 L^2} \left\{ 1 + \left(\frac{1}{3} - \frac{10}{\pi^2}\right) \frac{L}{R} + O\left(\left(\frac{L}{R}\right)^2\right) \right\}$$

Discussion

- The correction beyond PFA for the sphere is below 1%

remember: $\epsilon = \frac{L}{R} \sim \frac{0 \dots 1 \mu m}{200 \mu m} \sim 0 \dots 5 \cdot 10^{-3}$

- We expected the electromagnetic case to be of the same order

However, some doubts came in recently

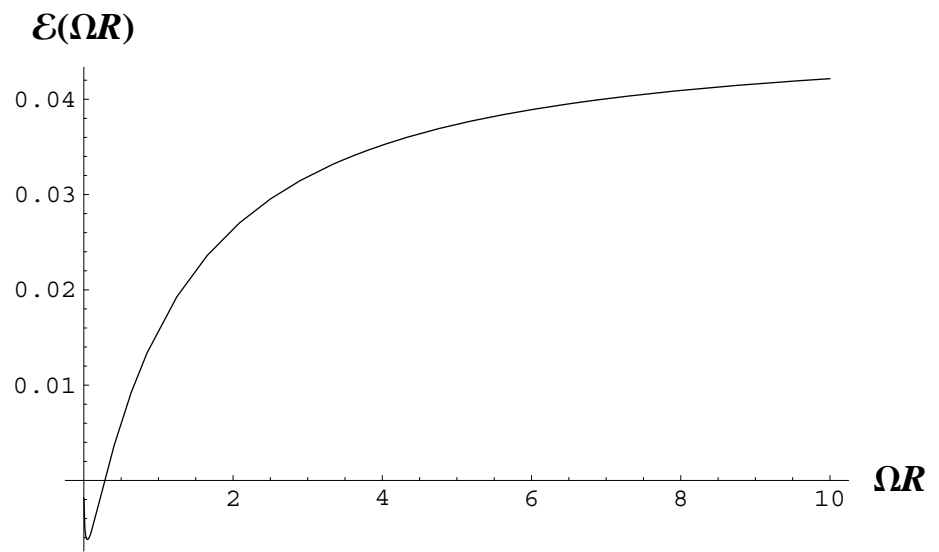
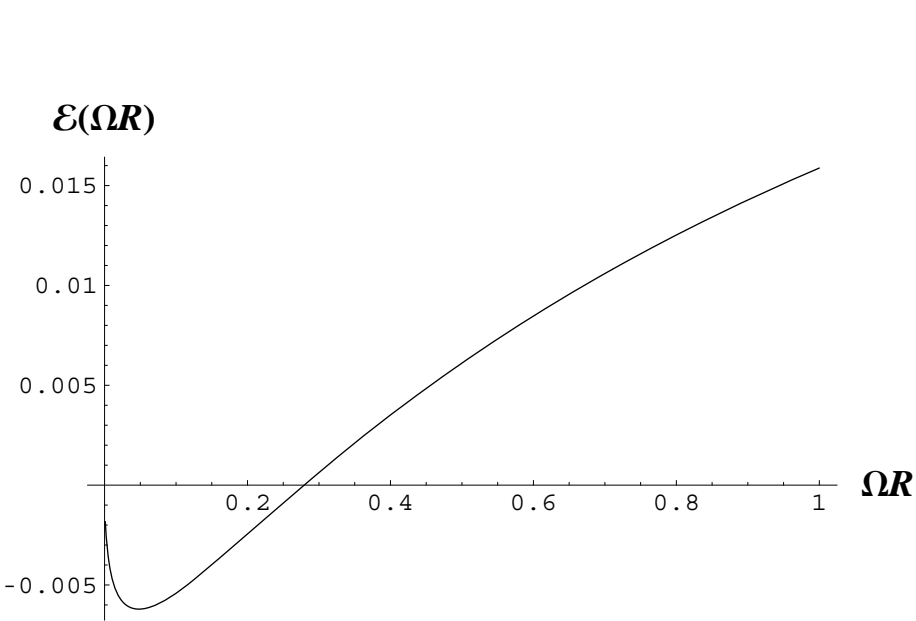
- Interaction with plasma sheet and renormalization

M. Bordag and N. Khusnutdinov. On the vacuum energy of a spherical plasma shell. Phys.Rev.D, 77:085026, 2008

M. Bordag. On the interaction of a charge with a thin plasma sheet. Phys.Rev.D, 76:065011, 2007

The Casimir effect for thin plasma sheets and the role of the surface plasmons. J. Phys. A: Math. Gen., 39:6173{6185, 2006

M. Bordag, I. G. Pirozhenko, and V. V. Nesterenko. Spectral analysis of a at plasma sheet model. J. Phys., A38:11027, 2005.



Conclusions

The function $\mathcal{E}(\Omega R) = RE_{\text{vac}}^{\text{ren}}$ plotted as function of Ω . For large Ω it tends to the ideal conductor limit, $\lim_{\Omega R \rightarrow \infty} \mathcal{E}(\Omega R) = 0.0046$ (left panel). We have constructed a model where the ultraviolet divergences can be 'hidden' in a redefinition of the parameters of the classical part (right panel) it takes negative values and decreases as $\mathcal{E}(\Omega R) \sim$

$-0.0589\sqrt{\Omega R}$. The arbitrariness inherent to the renormalization procedure is removed by demanding the vacuum energy to take its 'correct' value for a conducting sphere

Considered from the point of view of a conducting sphere we have a kind of physical regularization by making the sphere semitransparent

- Some result from the work within the PARNASS project

M. Bordag, A. Ribayrol, G. Conache, L. E. Froberg, S. Gray, L. Samuelson, L. Montelius, and H. Pettersson. Shear stress measurements on InAs nanowires by AFM manipulation. *Small*, 3:1398 { 1401, 2007.

- Planned continuation of work on vacuum energy in QCD and other models

M. Bordag. Vacuum energy of a color magnetic vortex. *Phys. Rev.*, D67:065001, 2003

M. Bordag and I. Drozdov. Fermionic vacuum energy from a Nielsen-Olesen vortex. *Phys. Rev.*, D68:065026, 2003.

- **Casimir effect at finite temperature and related problems**

Thermal Casimir effect in ideal metal rectangular boxes. Eur. Phys. J. C, 2008, v. 57, N4, p.823–834 (G. Klimchitskaya, B.Geyer, V.M.Mostepanenko)

Conductivity of dielectric and thermal atom-wall interaction. J. Phys. A: Math. Theor., 2008, v.41, N31, 312002(F)-1-8 (G. Klimchitskaya ,V.M.Mostepanenko)

Problems in the theory of thermal Casimir force between dielectrics and semiconductors
J. Phys. A: Math. Theor., 2008, v.41, N16, 164032-1-12 (G. Klimchitskaya, B. Geyer).

New approach to the thermal Casimir force between real metals. J. Phys. A: Math. Theor., v.41, N16, 164014-1-12, 2008 (V.M.Mostepanenko, B. Geyer).

comment: problem not solved so far, discussion mostly on what does not go

- **Relating theory and experiment**

Pulsating Casimir force. *J. Phys. A: Math. Theor.*, 2007, v.40, N34, p.F841–F847 (G. Klimchitskaya, U.Mohideen, V.M.Mostepanenko)

Control of the Casimir force by the modification of dielectric properties with light. *Phys.Rev. B*, 2007, v.76, N3, 035338-1–15 (G. Klimchitskaya, F.Chen, V.M.Mostepanenko, U.Mohideen)

- **Constraints on hypothetical interactions**

Novel constraints on light elementary particles and extra-dimensional physics from the Casimir effect. *Europ. Phys. J. C*, 2007, v.51, N4, p.963–975 (G. Klimchitskaya, R.S.Decca, D.L´opez, E.Fischbach, D.E.Krause, V.M.Mostepanenko).

Workshops

V. Mostepanenko M. Bordag, editor. Papers Presented at the 8th Workshop on Quantum Field Theory under the Influence of External Conditions (QFEXT07) (Leipzig, Germany, 16-21 September, 2007). IOP, 2008. appeared as Special Issue of J.. Phys. A, v. 41, Nr. 16, 2008.

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