Annals of Physics 326 (2011) 657–667

Contents lists available at ScienceDirect

Annals of Physics

journal homepage: www.elsevier.com/locate/aop

Casimir force in presence of multi layer magnetodielectric slabs

Fardin Kheirandish *, Morteza Soltani, Jalal Sarabadani

Department of Physics, University of Isfahan, Isfahan 81746, Iran

ARTICLE INFO

Article history:
Received 4 July 2010
Accepted 27 December 2010
Available online 31 December 2010

Keywords:
Field quantization
Path-integral
Susceptibility
Casimir force
Magnetodielectric medium

ABSTRACT

By using the path-integral formalism, electromagnetic field in the presence of some linear, isotropic magnetodielectric slabs is quantized and related correlation functions are found. In the framework of path-integral techniques, Casimir force between two infinitely large, parallel and ideal conductors, with a different number of magnetodielectric slabs in between, is obtained by calculating the Green's function corresponding to each geometry.

1. Introduction

One of the most direct manifestations of the zero-point vacuum oscillations is the Casimir effect. This effect in its simplest form, is the attraction force between two neutral, infinitely large, parallel and ideal conductors in vacuum. The effect is completely quantum mechanical and is a result of electromagnetic field quantization in the presence of some boundary conditions. The presence or absence of boundary conditions cause a finite change of vacuum-energy which its variation with respect to the distance between the conductors gives the Casimir force [1]. The Casimir force is not necessarily attractive and there are some situations where the Casimir force is repulsive [2,3].

There are usually some main approaches to calculate the Casimir effect. In the first approach, which is the most appropriate when we deal with geometrically regular metallic boundaries, the energy difference in the presence and absence of some boundary conditions is found and the Casimir force is determined from variation of the energy difference with respect to a relevant parameter [4–7]. The second approach, is based on the pressure of quantum-vacuum [9] which is determined from

* Corresponding author.
E-mail addresses: fardin_kh@phys.ui.ac.ir, fkheirandish@yahoo.com (F. Kheirandish), msoltani@Phys.ui.ac.ir (M. Soltani), j.sarabadani@phys.ui.ac.ir (J. Sarabadani).

0003-4916/$ - see front matter
doi:10.1016/j.aop.2010.12.007

the energy–momentum tensor of the electromagnetic field in the presence of some geometrically regular dielectrics which also can be considered as a Green's function approach [8–15]. For a review of these methods see [11,12] and for recent works [16–22]. For a very recent review on the long range interactions in the nanoscale see [23] and for a review on Casimir effect [24]. This approach is used to calculate the Casimir force between some dielectric or magnetodielectric slabs [8–22]. Also the Lifshitz interaction at finite temperature for a multilayered system has been studied [25] which in the limiting case of zero temperature, i.e. $T \to 0$ tends to our results as expected. The third approach is based on the powerful path-integral techniques which is the most effective technique for dealing with general geometries, see for example [26–31].

To calculate the vacuum-energy one can use either the canonical quantization scheme [32–35] or the path-integral method [26–31]. There are some situations where the path-integral method are more effective than the other methods. In these situations, the constraints imposed by the boundary conditions on the fields can be easily included into the process of quantization through a modified action. An interested reader is referred to the calculations of the normal and lateral Casimir force between two rough plates [26–29] and for the dynamic Casimir effect to [31].

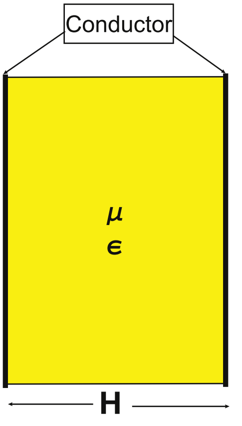

Fig. 1. One magnetodielectric slab.

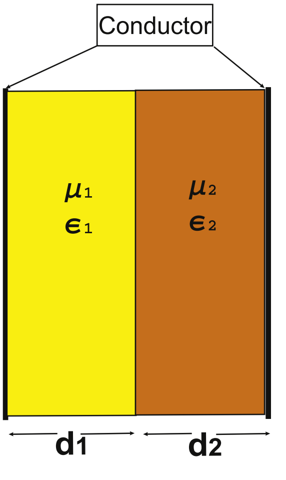

Fig. 2. Two magnetodielectric slab.