ELEKTROMAGNIT TEBRANGICHLI KVANT OSSILATORLARI

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ANNOTATSIYA

Elektromagnit tebranishlar ta'sirida garmonik kvant ossilatorlarida elektromagnit to'lqinlarining xossalari va tebranish energiyasi o'rganilgan.

Kalit so'zlar: *elektromagnit maydonlar, foton, tebranish konturi, kvantlashgan energiya.*

ABSTRACT

The properties of electromagnetic waves and vibration energy were studied in harmonic quantum oscillators under the influence of electromagnetic vibrations.

Keywords: *electromagnetic fields, photon, vibration contour, quantized energy.*

KIRISH

Yorug'lik (fotonlar, elektromagnit maydonlar) va materiya (elektronlar yoki atomlar) o'rtasidagi o'zaro ta'sir fizikaning eng keng tarqalgan mavzularidan biri bo'lib, kvant elektrodinamikasi (KED) deb nomlanadi. O'ta-o'tkazuvchi mikroto'lqinli tebranishlarda amalga oshirilgan fotonlar va kvant zarralar kvant elektrodinamikasi KED mikrozarralari deb ataladi. U tashqi ta'sirdan himoyalangan muhitda yorug'lik bilan o'zaro ta'sir qiluvchi neytral atomlar yordamida oldindan mavjud bo'lgan KED maydonlar fizikasiga turtki beradi. KED ni muhokama qilishdan oldin, keling, KEDning kengroq tahlil qilaylik. KEDning birinchi muvaffaqiyatli yutug'i kvant maydon nazariyasi bo'lib, u uchun Richard Feynman, Julian Shvinger va Sinitero Tomonaga 1965 yilda fizika bo'yicha Nobel mukofotiga sazovor bo'lgan.

MUHOKAMA

Nazariya fotonlar yordamida zaryadlangan zarrachalarning elektromagnit maydonlari natijasida yuzaga keladigan barcha hodisalarga tegishli. U kvant mexanikasi va elektrodinamikaning relyativistik nazariyasi o'rtasidagi bog'liqlikni ta'minlaydi. Bundan tashqari, KED zarrachalarni hosil qilish va yo'q qilish,

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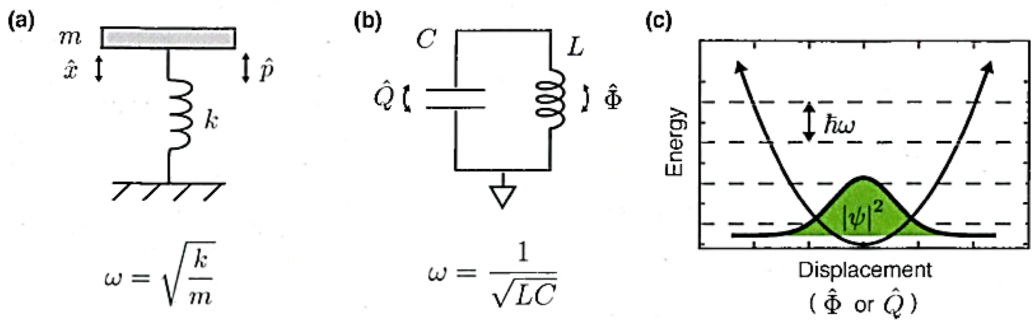
shuningdek, bozonik kuch - tashuvchilar kabi g'oyalarni o'z - o'zidan izchil hal qilishda shu masalalarni o'rganishni talab qiladi.

NATIJALAR

Yorug'lik va materiyaning o'zaro ta'sirini o'z ichiga olgan sistemalar fizikaviy tushunchalarni beradi va yangi texnologiyalarni ta'minlaydi. Lazerlar, tranzistorlar va magnit-rezonans tomografiyaning ishlashini faqat KED fizikasi bilan tushuntirish mumkin. Bu, shuningdek, kvant zarrachalarining har qanday muhitda qo'llanilishi bilan ma'lumotlarni qayta ishlashga imkon beradigan fizikadir. Biroq, biz kvant tabiatiga ega bo'lgan qurilmalar (masalan, lazerlar va tranzistorlar) farqni ko'rsatishimiz kerak. Bizga boshqariladigan superpozitsiyalar va chalkashliklar bilan izchil kvant maydonlari kerak.



1-rasm: LC konturda ifodalangan kvant garmonik ossilatorining energiya tasavvuri.

O'ta-o'tkazuvchi moddalarga o'tishdan oldin, biz elektromagnit ossilatorlarni kvantlangan tilda tushunamiz. Boshlash uchun, barcha garmonik ossilatorlar kvadratik potensial energiya munosabatlari bilan tavsiflanganligini unutmasligimiz kerak. Elektromagnit ossilatorlar xuddi mexanik garmonik ossilator bilan bir xil dinamikaga amal qiladi, masalan, mayatnik yoki prujinadagi massa, hamda barchamizga tanish Gamiltonian bilan:

$$H = \frac{1}{2m}p^2 + \frac{m\omega^2}{2}x^2, \quad (1)$$

Bu yerda m –yuk massasi, ω –burchak chastotasi. Endi indukiv g'altak L va kondansator C o'z ichiga olgan oddiy elektromagnit ossilator uchun Gamiltonianni yozamiz. Moment va inersiya o'zgaruvchilari oqim va zaryad uchun kvant operatorlari $(\widehat{\Phi})$bilan almashtiriladi (Q)

$$\widehat{H} = \frac{1}{2L}\widehat{\Phi}^2 + \frac{1}{2C}\widehat{Q^2}. \quad (2)$$

Zarralarning impulsi va harakat miqdor momenti singari, oqim va zaryad ham vaqt o'tishi bilan o'zgaruvchilardir. Kommutatsiya munosabati impuls va harakat miqdor momentining kvant o'zgaruvchilari bilan o'xshashdir. Gamiltonning harakat tenglamalari bizga kattaliklarning $[\hat{\Phi}, \hat{Q}] = -i\hbar$ munosabatiga olib keladigan oqim va LC zanjirining tugunidagi kuchlanish uchun tanish munosabatlarni beradi :

$$\dot{Q} = \frac{\partial \hat{H}}{\partial \Phi} = \frac{\Phi}{L} = I \tag{3}$$

$$\dot{\Phi} = -\frac{\partial \hat{H}}{\partial Q} = -\frac{Q}{C} = V. \tag{4}$$

Asosiy holat energiyasi

$$\langle 0|H|0\rangle = \frac{1}{2C}\langle 0|\hat{Q}^2|0\rangle + \frac{1}{2L}\langle 0|\hat{\Phi}^2|0\rangle = \frac{\hbar\omega_0}{2} \tag{5}$$

bu yerda $\omega_0 = 1/\sqrt{LC}$- zanjirning rezonans chastotasi. Keyinchalik, zarralar maydoni oqimidagi nol nuqtali tebranishlarni yozish uchun impuls momentlarning teng bo'linish qoidasidan foydalanishimiz mumkin:

$$Q_{ZPF}^2 = \langle 0|\hat{Q}^2|0\rangle = \frac{\hbar\omega_0 C}{2} = \frac{\hbar}{2Z_c}, \tag{6}$$

$$H_{ZPF}^2 = \langle 0|\hat{\Phi}^2|0\rangle = \frac{\hbar\omega_0 \cdot L}{2} = \frac{\hbar Z_c}{2}, \tag{7}$$

Bu yerda $Z_c = \sqrt{L}/C$ zanjirning to'la qarshiligidir. Biz 2 tenglamaning o'zgaruvchilarini ko'tarish va tushirish operatorlariga o'zgartirishimiz mumkin ,$\hat{a}$ va $\hat{a}^\dagger$. Bundan quyidagilarga ega bo'lamiz

$$\hat{Q} = -iQ_{ZPF}(\hat{a} - \hat{a}^\dagger) \tag{8}$$

Bu oddiy kvant garmonik ossilatori uchun odatiy Gamiltonianni beradi:

$$\hat{H} = \hbar\omega_0(\hat{a}^\dagger\hat{a} + 1/2) = \hbar\omega_0(\hat{N} + 1/2), \tag{9}$$

Bu yerda $N^n = \hat{a}^\dagger a -$ fotonlar soni operatori. Ko'tarish va tushirish operatorlari kommutatsiya munosabatini to'liq tushuntirib beradi $[\hat{a}^\dagger a\,] = 1$.

XULOSA

Kvant garmonik ossilatorining kvadratik potensiali 1 - rasmda ko'rsatilgan . Yuqorida tavsiflangan zaryad va oqimning eng kichik (minimum) nuqtasi tebranishlari tufayli asosiy holat nolga teng bo'lmagan energiyaga ega. Tarkorlanuvchi energiyaning holatlari doimiy sakrashlar oralig'i bilan ajratiladi $\hbar\omega_0$. Endi bizda elektromagnit ossilatorning kvant tasavvuri bor. Kvantlangan holatlarni simdagi elektronlarning tartibli oqimi harakatining alohida qo'zg'alish usullari yoki butun kontaktlarning ta'sirlashuviga olib keladigan alohida fotonlar sifatida talqin qilish mumkin. Bizning LC tebrangichimizda elektr maydonining tebranishlari kondansator qoplamalari o'rtasida almashinuvda bo'ladi va magnit maydon induktiv g'altagida qayta taqsimlanadi.

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