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«AMALIY MATEMATIKA VA AXBOROT TEXNOLOGIYALARINING ZAMONAVIY MUAMMOLARI»  
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# АМАЛИЙ МАТЕМАТИКА ВА АХБОРОТ ТЕХНОЛОГИЯЛАРИНИНГ ЗАМОНАВИЙ МУАММОЛАРИ

ХАЛҚАРО ИЛМИЙ-АМАЛИЙ АНЖУМАН

## МАТЕРИАЛЛАРИ

2022 йил, 11-12 май

БУХОРО – 2022

**ЎЗБЕКИСТОН РЕСПУБЛИКАСИ  
ОЛИЙ ВА ЎРТА МАХСУС ТАЪЛИМ ВАЗИРЛИГИ  
ЎЗБЕКИСТОН РЕСПУБЛИКАСИ ФАНЛАР АКАДЕМИЯСИ  
В.И. РОМАНОВСКИЙ НОМИДАГИ МАТЕМАТИКА ИНСТИТУТИ  
ЎЗБЕКИСТОН МИЛЛИЙ УНИВЕРСИТЕТИ  
ТОШКЕНТ ДАВЛАТ ТРАНСПОРТ УНИВЕРСИТЕТИ  
БУХОРО ДАВЛАТ УНИВЕРСИТЕТИ**

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**АМАЛИЙ МАТЕМАТИКА ВА  
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## KILLING VEKTOR MAYDONLAR GEOMETRIYASI

Boysunova M.Y.

O'zbekiston Milliy Universiteti

**Ta'rif-1.** Agar  $G$  to'plamga tegishli har bir  $p$  nuqtaga bitta  $X(p)$  vektor mos qo'yilsa, bu moslik **vektor maydon** deb ataladi.

**Ta'rif-2** Birorta  $G$  sohada  $X$  vektor maydon berilgan bo'lib va shu sohada  $\vec{p} = \vec{p}(t)$  tenglama bilan aniqlangan differensiallanuvchi  $\gamma$  chiziq ham berilgan bo'lsin. Agar har bir  $t$  uchun  $\vec{p}'(t) = X(\gamma(t))$  bo'lsa  $\gamma$  chiziq  $X$  vektor maydonning **integral chizig'i** deyiladi.

**Ta'rif 3.** Berilgan  $X$  vektor maydonning  $t=0$  da  $p$  nuqtadan o'tuvchi chiziqni  $\gamma(t, p)$  bilan belgilasak,  $p \rightarrow X^t(p)$  akslantirishlar oilasi  $X$  vektor **maydonning oqimi** deyiladi.

**Ta'rif 4.** Agar har bir  $t$  nuqta uchun

$$x \rightarrow \gamma(t, x)$$

akslantirish izometrik akslantirish bo'lsa,  $X$  vektor maydon **Killing vektor maydoni** deb ataladi.

Boshqacha qilib aytganda  $M$  ko'pxillikda berilgan  $X$  vektor maydon hosil qilgan bir parametrli diffeomorfizmlar oilasi  $M$  ko'pxillikda izometrik akslantirishdan iborat bo'lsa  $X$  vektor maydon Killing vektor maydoni deb ataladi.

Uch o'lchovli Yevklid  $R^3(x, y, z)$  fazosida oltita chizikli erkli Killing vektor maydonlari bor.

$$X_1 = \frac{\partial}{\partial x}, X_2 = \frac{\partial}{\partial y}, X_3 = \frac{\partial}{\partial z},$$

$$X_4 = z \frac{\partial}{\partial y} - y \frac{\partial}{\partial z}, X_5 = -z \frac{\partial}{\partial x} + x \frac{\partial}{\partial z}, X_6 = y \frac{\partial}{\partial x} - x \frac{\partial}{\partial y}$$

vektor maydonlardan quyida keltirilgan almashtirish gruppallari, mos  $o_x, o_y$  va  $o_z$  o'qlari yo'nalishi bo'yicha parallel ko'chirish gruppallari bo'ladi, oxirgi uchtasi esa mos  $o_x, o_y$  va  $o_z$  o'qlar atrofida aylanish gruppallari bo'ladi.

Biz to'rt o'lchamli  $R^4(x_1, x_2, x_3, x_4)$  evklid fazosida

$$x_1^2 + x_2^2 + x_3^2 + x_4^2 = 1$$

tenglamani uch o'lchamli  $S^3$  sferada qaraymiz. Bu fazoda berilgan

$$X = -x_4 \frac{\partial}{\partial x_1} + x_1 \frac{\partial}{\partial x_4}$$

vektor maydon sferaga urinadi.

**Teorema.** Uch o'lchamli sferada  $X$  vektor maydonning maxsus nuqtalari

$$\begin{cases} x_1 = 0 \\ x_4 = 0 \end{cases}$$

tenglamalar sistemasi bilan berilgan tekislikda yotuvchi  $x_2^2 + x_3^2 = 1$  aylana nuqtalaridan iborat, maxsus bo'lmagan nuqtalar uchun uning integral chiziqlari

$$\begin{cases} x_2 = c_2 = \text{const} \\ x_3 = c_3 = \text{const} \end{cases}$$

tekislikda yotuvchi

$$x_1^2 + x_4^2 = 1 - (c_2^2 + c_3^2)$$

aylanalardan iborat.

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## FINITENESS OF THE DISCRETE SPECTRUM OF THE LATTICE SPIN-BOSON HAMILTONIAN WITH AT MOST TWO PHOTONS

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Block operator matrices are matrices where the entries are linear operators between Banach or Hilbert spaces [1]. One special class of block operator matrices are Hamiltonians associated with systems of non-conserved number of quasi-particles on a lattice. Their number can be unbounded as in the case of spin-boson models or bounded as in the case of "truncated" spin-boson models. In this note we consider a lattice spin-boson Hamiltonian with at most two photons. The standard spin-boson Hamiltonian with at most two photons was completely studied in [2] for small values of the coupling constant.

Let  $T^3$  be the three-dimensional torus,  $\mathcal{H}_0 := C$  be the set of all complex numbers,  $\mathcal{H}_1 := L_2(T^3)$  be the Hilbert space of square integrable (complex) functions defined on  $T^3$ ,  $\mathcal{H}_2 := L_2^{\text{sym}}((T^3)^2)$  be the Hilbert space of square integrable (complex) symmetric functions defined on  $(T^3)^2$  and  $\mathcal{H} = \mathcal{H}_0 \oplus \mathcal{H}_1 \oplus \mathcal{H}_2$ .

We consider a lattice spin-boson Hamiltonian  $A_2$  with most two photons. Then [3] the operator  $A_2$  act on  $C^2 \otimes \mathcal{H}$  and has the  $3 \times 3$  tridiagonal block operator matrix representation

$$A_2 := \begin{pmatrix} A_{00} & A_{01} & 0 \\ A_{01}^* & A_{11} & A_{12} \\ 0 & A_{12}^* & A_{22} \end{pmatrix},$$

where the matrix entries  $A_{ij}$ ,  $i, j = 0, 1, 2$ ,  $i \leq j$ , are defined by

$$A_{00}f_0^{(s)} = \varepsilon f_0^{(s)}, \quad A_{01}f_1^{(s)} = \alpha \int_{T^3} v(t) f_1^{(-s)}(t) dt,$$

$$(A_{11}f_1^{(s)})(k_1) = (\varepsilon + w(k_1))f_1^{(s)}(k_1), \quad (A_{12}f_2^{(s)})(k_1) = \alpha \int_{T^3} v(t) f_2^{(-s)}(k_1, t) dt,$$

$$(A_{22}f_2^{(s)})(k_1, k_2) = (\varepsilon + w(k_1) + w(k_2))f_2^{(s)}(k_1, k_2).$$

Here  $s = \pm$  and  $f = \{f_0^{(s)}, f_1^{(s)}, f_2^{(s)}; s = \pm\} \in C^2 \otimes \mathcal{H}$ .

We make the following assumptions:  $\varepsilon > 0$ ; the dispersion  $w(\cdot)$  is a non negative analytic function on  $T^3$  and has the non-degenerate minimum at the points  $(x_1^{(i)}, x_2^{(i)}, x_3^{(i)}) \in T^3$ ,  $i = 1, \dots, n$ ,  $n < \infty$ ;  $v(\cdot)$  is a real-valued analytic function on  $T^3$ ; the coupling constant  $\alpha > 0$  is an arbitrary.

Recall that the location of the essential spectrum of  $A_2$  for 1D case was described in [3]. The results were obtained by considering a more general model  $H$  for which the lower bound of its essential spectrum is estimated. Conditions which guarantee the finiteness of the number of eigenvalues of  $H$  below the bottom of its essential spectrum were found. It was shown that the discrete spectrum might be infinite if the parameter functions are chosen in a special form.

Let  $E_{\min} := \min \sigma_{\text{ess}}(A_2)$ .

**Theorem.** For all values of the coupling constant  $\alpha > 0$  the operator  $A_2$  has a finitely many eigenvalues smaller than  $E_{\min}$ .

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## ON AN EXAMPLE OF A SEMIRING WHICH IS NOT IDEMPOTENT

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Let  $[a, b]$  be a closed subinterval of  $[-\infty, +\infty]$  (in some cases we will also take semiclosed subintervals). The full order on  $[a, b]$  will be denoted by  $\prec$ .

**Definition 1.** The operation  $\oplus$  (pseudo-addition) is a function  $\oplus: [a, b] \times [a, b] \rightarrow [a, b]$  which is commutative, nondecreasing (with respect to  $\prec$ ), associative and with a zero element, denoted by  $\mathbf{0}$ , i. e.  $\mathbf{0} \oplus x = x$  for each  $x \in [a, b]$  (usually  $\mathbf{0}$  is either  $a$  or  $b$ ).

Let  $[a, b]_+ = \{x : x \in [a, b], x \succ \mathbf{0}\}$ .

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