

**O'ZBEKISTON RESPUBLIKASI  
OLIV VA O'RTA MAXSUS TA'LIM VAZIRLIGI  
ANDIJON DAVLAT UNIVERSITETI**



**ZAMONAVIY MATEMATIKANING NAZARIY  
ASOSLARI VA AMALIY MASALALARI**

Respublika ilmiy-amaliy anjumani materiallari to'plami

**II**



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Andijon, 28 mart 2022 yil

МИНИСТЕРСТВО ВЫСШЕГО И СРЕДНЕГО СПЕЦИАЛЬНОГО ОБРАЗОВАНИЯ  
РЕСПУБЛИКИ УЗБЕКИСТАН  
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МАТЕМАТИКИ**  
**II**

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MATHEMATICS**  
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To'plamga kiritilgan tezislar mazmuni, ilmiyligi va dalillarning haqqoniyligi uchun mualliflar mas'uldirlar.

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Atabayev Odiljon

Anjuman materiallari to'plami Andijon davlat universiteti Ilmiy kengashining 2022 yil 17 fevraldagi 8- yig'ilishi qarori bilan nashrga tavsifa etilgan.

$$(V_\mu f)(p) = \frac{\lambda}{2\pi} \sin p \int_T \sin q f(q) dq, \quad f \in L^{2,0}(T).$$

$V$  operatorning rangi ko'pi bilan birga teng bo'lganligi uchun, muhim spektr turg'unligi haqidagi Veyl teoremasiga ko'ra

$$\sigma_{ess}(H_\mu) = \sigma(H_0) = \left[0, \frac{25}{8}\right].$$

**Teorema:** a)  $\lambda > \frac{20}{25-7\sqrt{5}}$  bo'lsin. U holda  $H_\lambda$  operator muhim spektrdan chapda yagona  $z_\lambda$  xos qiymatga ega va unga mos xos funksiya

$$f(p) = \frac{C\lambda \sin p}{2 - \cos p - \cos 2p - z_\lambda}, \quad C - \text{normallashtiruvchi o'zgarmas}$$

ko'rinishda.

b)  $\lambda < \frac{20}{25-7\sqrt{5}}$  bo'lsin. U holda  $H_\lambda$  operator muhim spektrdan chapda xos qiymatga ega emas.

#### FOYDALANILGAN ADABIYOTLAR RO'YXATI:

1. Albeverio S., Lakaev S.N., Makarov K.A., Muminov Z.I.: The threshold effects for the two-particle hamiltonians on lattices, Comm.Math.Phys. **262**(2006), 91-115.

2. Lakaev S.N., Abdukhakimov S.Kh. Threshold effects in a two-fermion system on an optical lattice. Theoretical and Mathematical Physics, 2020. – Vol.203. – №2. – P. 251-268.

#### PANJARADAGI UCH ZARRACHALI SISTEMAGA MOS MODEL OPERATORNING XOS FUNKSIYALARI UCHUN FADDEYEV TENGLAMASI

**Bahronov Bekzod**

Buxoro davlat universiteti

$d \in \mathbb{N}$  natural soni uchun  $T^d := (-\pi; \pi]^d$  orqali  $d$  o'lchamli tori,  $L_2^s((T^d)^2)$  orqali  $(T^d)^2$  da aniqlangan kvadrati bilan integrallanuvchi (umuman olganda kompleks qiymatlarni qabul qiluvchi) simmetrik funksiyalarning Hilbert fazosini belgilaymiz.  $L_2^s((T^d)^2)$  Hilbert fazosida ta'sir qiluvchi

$$H_{\mu,\lambda} := H_0 - \mu(V_{11} + V_{12}) + \lambda(V_{21} + V_{22}) \quad (1)$$

tenglik orqali aniqlanuvchi operatorni qaraymiz. Bunda  $\mu, \lambda > 0$  ta'sirlashish parametrlari,  $H_0$  operator  $u(\cdot, \cdot)$  funksiyaga ko'paytirish operatori:

$$(H_0 f)(x, y) = u(x, y) f(x, y),$$

$V_{ij}$ ,  $i, j = 1, 2$  – operatorlar esa lokal bo'lmagan potensial operatorlari:

$$(V_{i1} f)(x, y) = v_i(x) \int_{T^d} v_i(t) f(t, y) dt, \quad (V_{i2} f)(x, y) = v_i(y) \int_{T^d} v_i(t) f(x, t) dt;$$

$u(\cdot, \cdot) - (T^d)^2$  aniqlangan haqiqiy qiymatli uzluksiz, simmetrik funksiya,  $v_i(\cdot), i = 1, 2$  lar esa  $T^d$  da aniqlangan haqiqiy qiymatli uzluksiz funksiyalar.

Funksional analiz elementlaridan foydalanib, (1) tenglik yordamida ta'sir qiluvchi  $H_{\mu,\lambda}$  operatorning  $L_2^s((T^d)^2)$  Hilbert fazosidagi chiziqli, chegaralangan va o'z-o'ziga qo'shma ekanligini ko'rsatish mumkin.

Mazkur ishning asosiy natijalarini bayon qilish maqsadida  $H_{\mu,\lambda}$  operator bilan bir qatorda  $L_2(T^d)$  Hilbert fazosida

$$h_{\mu,\lambda}(x) := h_{0,0}(x) - \mu v_1 + \lambda v_2, \quad \mu, \lambda > 0, \quad x \in T^d$$

kabi ta'sir qiluvchi va Fridrixs modellari oilasi deb ataluvchi operatorni qaraymiz. Bu yerda

$$(h_{0,0}(x)f)(y) = u(x, y) f(y),$$

$$(v_i f)(y) = v_i(y) \int_{T^d} v_i(t) f(t) dt.$$

Kiritilgan  $h_{\mu,\lambda}(x)$  operator  $L_2(T^d)$  Hilbert fazosidagi chiziqli, chegaralangan va o'z-o'ziga qo'shma ekanligini oson ko'rsatish mumkin.

Chekli o'lchamli qo'zg'alishlarda muhim spektrning o'zgarmasligi haqidagi Veyl teoremasiga ko'ra

$$\sigma_{ess}(h_{\mu,\lambda}(x)) = [m(x); M(x)]$$

tenglik o'rinlidir, bu yerda  $m(x)$  va  $M(x)$  sonlari

$$m(x) := \min_{y \in T^d} u(x, y), \quad M(x) := \max_{y \in T^d} u(x, y).$$

formular orqali aniqlanadi.

Har bir fiksirlangan  $\mu, \lambda > 0$  va  $x \in T^d$  lar uchun  $C \setminus [m(x), M(x)]$  sohada regulyar bo'lgan

$$\Delta_{\mu,\lambda}(z) := \Delta_{\mu}^{(1)}(z) \Delta_{\lambda}^{(2)}(z) + \mu \lambda (I_{12}(z))^2$$

funksiyani qaraymiz. Odatda  $\Delta_{\mu,\lambda}(z)$  funksiya  $h_{\mu,\lambda}(x)$  operatrogga mos Fredgolv detrimanti deyiladi.

Quyidagi belgilashlarni kiritamiz:

$$m := \min_{x,y \in T^d} u(x, y), \quad M := \max_{x,y \in T^d} u(x, y),$$

$$\sum_{\mu,\lambda} := \bigcup_{x \in T^d} \sigma_{disc}(h_{\mu,\lambda}(x)) \cup [m; M].$$

Har bir fiksirlangan  $\mu, \lambda > 0$  va  $z \in C \setminus [m; M]$  sonlari uchun  $L_2^{(2)}(T^d)$  fazoda

$$A_{\mu,\lambda}(z) := \begin{pmatrix} A_{11}(\mu, z) & A_{12}(\lambda, z) \\ A_{21}(\mu, z) & A_{22}(\lambda, z) \end{pmatrix}, \quad K_{\mu,\lambda}(z) := \begin{pmatrix} K_{11}(\mu, z) & K_{12}(\lambda, z) \\ K_{21}(\mu, z) & K_{22}(\lambda, z) \end{pmatrix}$$

kabi aniqlanuvchi 2-tartibli operatorli matritsalarini qaraymiz. Ularning matritsaviy elementlari

$$(A_{11}(\mu, z) \varphi_1)(x) = \varphi_1(x) - \mu \varphi_1(x) \int_{T^d} \frac{v_1^2(t)}{u(x, t) - z} dt;$$

$$(A_{12}(\mu, z) \varphi_2)(x) = \lambda \varphi_2(x) \int_{T^d} \frac{v_1(t)v_2(t)}{u(x, t) - z} dt;$$

$$(A_{21}(\mu, z)\varphi_1)(x) = -\mu \varphi_1(x) \int_{T^d} \frac{v_1(t)v_2(t)}{u(x,t) - z} dt ;$$

$$(A_{22}(\mu, z)\varphi_2)(x) = \varphi_2(x) + \lambda \varphi_1(x) \int_{T^d} \frac{v_2^2(t)}{u(x,t) - z} dt ;$$

$$(K_{11}(\mu, z)\varphi_1)(x) = \mu v_1(x) \int_{T^d} \frac{v_1(t)\varphi_1(t)}{u(x,t) - z} dt ;$$

$$(K_{12}(\mu, z)\varphi_2)(x) = -\lambda v_2(x) \int_{T^d} \frac{v_1(t)\varphi_2(t)}{u(x,t) - z} dt ;$$

$$(K_{21}(\mu, z)\varphi_1)(x) = \mu v_1(x) \int_{T^d} \frac{v_2(t)\varphi_1(t)}{u(x,t) - z} dt ;$$

$$(K_{22}(\mu, z)\varphi_2)(x) = -\lambda v_2(x) \int_{T^d} \frac{v_2(t)\varphi_2(t)}{u(x,t) - z} dt ;$$

tengliklar orqali ta'sir qiladi.

**1-teorema.** Agar  $\mu, \lambda > 0$  va  $z \in C \setminus \Sigma_{\mu, \lambda}$  sonlari uchun  $A_{\mu, \lambda}(z)$  teskarilanuvchan operator bo'lib, uning  $A_{\mu, \lambda}^{-1}(z)$  teskari operatori

$$A_{\mu, \lambda}^{-1}(z) = \frac{1}{\Delta_{\mu, \lambda}(z)} \begin{pmatrix} A_{22}(\lambda, z) & -A_{12}(\lambda, z) \\ -A_{21}(\mu, z) & A_{11}(\mu, z) \end{pmatrix}$$

ko'rinishga ega.

Endi har bir fiksirlangan  $\mu, \lambda > 0$  va  $z \in C \setminus \Sigma_{\mu, \lambda}$  sonlari uchun  $L_2^{(2)}(T^d)$  Hilbert fazosida

$$T_{\mu, \lambda}(z) = A_{\mu, \lambda}^{-1}(z) K_{\mu, \lambda}(z)$$

operatorni qaraymiz.

Quyidagi teorema  $H_{\mu, \lambda}$  va  $T_{\mu, \lambda}(z)$  operatorlarning xos qiymatlari orasidagi bog'lanishni ifodalaydi.

**2-teorema.**  $z \in C \setminus \Sigma_{\mu, \lambda}$  soni  $H_{\mu, \lambda}$  operatorning xos qiymati bo'lishi uchun 1 soni  $T_{\mu, \lambda}(z)$  operatorning xos qiymati bo'lishi zarur va yetarli. Bundan tashqari  $z$  va 1 sonlarining karraligi ustma-ust tushadi.

Odatda  $\varphi = T_{\mu, \lambda}(z)\varphi$  operatorli tenglamaga  $H_{\mu, \lambda}$  model operator xos funksiyalariga mos Faddeyev tenglamasi deyiladi. Bu tenglama yordamida  $H_{\mu, \lambda}$  operator muhim spektrini tavsiflash mumkin.

### FOYDALANILGAN ADABIYOTLAR

1. T.H.Rasulov, B.I.Bahronov. Structure of the numerical range of a Friedrichs model: 1D case with rank two perturbation Bulletin of the Institute of Mathematics, 2020.

2. Т.Х.Расулов, Б.И.Бахронов. О спектре тензорной суммы моделей Фридрихса. Молодой ученый. №9 (89), 2015, С. 17-20.

3. Т.Х.Расулов, Б.И.Бахронов. Условия существования виртуальных уровней модели Фридрихса с двумерным возмущением. Сборник тезисов Международной

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