

**O'ZBEKISTON RESPUBLIKASI
OLIY 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
АНДИЖАНСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ

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**ТЕОРЕТИЧЕСКИЕ ОСНОВЫ И ПРИКЛАДНЫЕ ЗАДАЧИ СОВРЕМЕННОЙ
МАТЕМАТИКИ**
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**THEORETICAL FOUNDATIONS AND APPLIED PROBLEMS OF MODERN
MATHEMATICS**
II

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Zamonaviy matematikaning nazariy asoslari va amaliy masalalari. Respublika ilmiy-amaliy anjuman materiallari to'plami. II qism. Andijon, 2022 yil. 324 bet.

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

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Anjuman materiallari to'plami Andijon davlat universiteti Ilmiy kengashining 2022 yil 17 fevraldagi 8- yig'ilishi qarori bilan nashrga tavsiya 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_λ operator muhim spektrdan chapda yagona z_λ 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_λ operator muhim spektrdan chapda xos qiymatga ega emas.

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

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$d \in \mathbb{N}$ natural soni uchun $T^d := (-\pi; \pi]^d$ orqali d o'lchamli torni, $L_2^s((T^d)^2)$ 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 Fridriks 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

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

formulalar 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 $h_{\mu,\lambda}(x)$ operatarga mos Fredgolm 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 $z \in C \setminus \sum_{\mu, \lambda}$ 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 $z \in C \setminus \sum_{\mu, \lambda}$ 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. $z \in C \setminus \sum_{\mu, \lambda}$ 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.

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