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АМАЛИЙ МАТЕМАТИКА ВА АХБОРОТ ТЕХНОЛОГИЯЛАРИНИНГ ЗАМОНАВИЙ МУАММОЛАРИ

ХАЛҚАРО ИЛМИЙ-АМАЛИЙ АНЖУМАН

МАТЕРИАЛЛАРИ

2022 йил, 11-12 май



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

Бухоро фарзанди, Беруний номидаги Давлат мукофоти лауреати, кўплаб ёш изланувчиларнинг ўз йўлини топиб олишида раҳнамолик қилган етук олим, физика-математика фанлари доктори Файбулла Назруллаевич Салиховнинг 90 йиллик юбилейларига бағишланади

**АМАЛИЙ МАТЕМАТИКА ВА
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Assume $\{\mathbf{x}^{(n)} \in S^{m-1} : n = 0, 1, 2, \dots\}$ is the trajectory of the initial point $\mathbf{x} \in S^{m-1}$, where $\mathbf{x}^{(n+1)} = V(\mathbf{x}^{(n)})$ for all $n = 0, 1, 2, \dots$, with $\mathbf{x}^{(0)} = \mathbf{x}$.

Definition 1. A point $\mathbf{x} \in S^{m-1}$ is called a fixed point of a QSO V if $V(\mathbf{x}) = \mathbf{x}$.

Definition 2. A QSO V is called regular if for any initial point $\mathbf{x} \in S^{m-1}$, the limit

$$\lim_{n \rightarrow \infty} V(\mathbf{x}^{(n)})$$

exists.

Definition 3. A continuous function $\phi : \text{int } S^{m-1} \rightarrow R$ for an operator V if the limit $\lim_{n \rightarrow \infty} \phi(V^n(\mathbf{x}))$

exists and finite for all $\mathbf{x} \in S^{m-1}$.

Definition 4.[2] A fixed point \mathbf{x}^* is called hyperbolic if its Jacobian $D_{\mathbf{x}}V(\mathbf{x}^*)$ has no eigenvalues on the unit circle.

Definition 5.[2] A hyperbolic fixed point \mathbf{x}^* is called:

- i) attracting if all the eigenvalues of the Jacobian $D_{\mathbf{x}}V(\mathbf{x}^*)$ are less than 1 in absolute value;
- ii) repelling if all the eigenvalues of the Jacobian $D_{\mathbf{x}}V(\mathbf{x}^*)$ are greater than 1 in absolute value;
- iii) a saddle otherwise.

Consider the following two strictly non-Volterra QSOs on the two-dimensional simplex

$$V : \begin{cases} x'_1 = \frac{1}{3}x_1^2 + \frac{1}{3}x_2^2 + \frac{1}{3}x_3^2 + 2x_1x_2, \\ x'_2 = \frac{1}{3}x_1^2 + \frac{1}{3}x_2^2 + \frac{1}{3}x_3^2 + 2x_2x_3, \\ x'_3 = \frac{1}{3}x_1^2 + \frac{1}{3}x_2^2 + \frac{1}{3}x_3^2 + 2x_3x_1. \end{cases} \quad (3)$$

Lemma 1. The center \mathbf{x} is a unique and attracting point of the QSO (3).

Lemma 2. The function $\phi(\mathbf{x}) = |x_1 - x_2| \cdot |x_2 - x_3| \cdot |x_3 - x_1|$ is a Lyapunov function for the operator (3).

Lemma 3. $\lim_{n \rightarrow \infty} V^n(\mathbf{x}^{(0)}) = \mathbf{c}$ for any initial point $\mathbf{x}^{(0)} \in S^2$.

Theorem. a) The QSO (3) has a unique fixed point $\mathbf{c} = (1/3, 1/3, 1/3)$;

b) The fixed point \mathbf{c} is an attracting point;

c) For any $\mathbf{x}^{(0)} \in S^2$, the trajectory $\{\mathbf{x}^{(n)}\}$ tends to the fixed point \mathbf{c} ;

d) The QSO (3) is a regular transformation.

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EXISTENCE OF THE EIGENVALUES OF A TENSOR SUM OF THE FRIEDRICHS MODELS WITH RANK 2 PERTURBATION

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Let T^1 be the one-dimensional torus. In the Hilbert space $L_2^s(T^2)$ of square-integrable symmetric (complex) functions defined on T^2 , we consider the model operator:

$$H_{\mu, \lambda} := H_{0,0} - \mu(V_{11} + V_{12}) + \lambda(V_{21} + V_{22}), \quad \mu, \lambda > 0, \quad (1)$$

where $H_{0,0}$ is the multiplication operator:

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

and V_{ij} , $i, j = 1, 2$ are non-local interaction operators:

$$(V_{i1}f)(x, y) = v_i(x) \int_{T^1} v_i(t) f(t, y) dt, \quad (V_{i2}f)(x, y) = v_i(y) \int_{T^1} v_i(t) f(x, t) dt.$$

Here, $f \in L_2^s(T^2)$, the functions $u(\cdot)$ and $v_i(\cdot)$, $i = 1, 2$ are real-valued continuous functions on T^1 .

Under these assumptions, the operator $H_{\mu, \lambda}$ is bounded and self-adjoint.

To study the spectral properties of the model operator $H_{\mu, \lambda}$, we introduce a Friedrichs model $h_{\mu, \lambda}$ with rank 2 perturbation, acting on $L_2(T^1)$ by the rule:

$$h_{\mu, \lambda} := h_{0,0} - \mu k_1 + \lambda k_2,$$

where the operators $h_{0,0}$ and $k_i(\cdot)$, $i = 1, 2$ are defined as

$$(h_{0,0}g)(x) = u(x)g(x), \quad (k_i g)(x) = v_i(x) \int_{T^1} v_i(t) g(t) dt, \quad i = 1, 2.$$

From the definitions of $H_{\mu, \lambda}$ and $h_{\mu, \lambda}$ we obtain the representation

$$H_{\mu, \lambda} = h_{\mu, \lambda} \otimes I + I \otimes h_{\mu, \lambda},$$

where I is an identity operator on $L_2(T^1)$.

Therefore, by theorem on the spectrum of the tensor sum of two operators the equality

$$\sigma(H_{\mu, \lambda}) = \sigma(h_{\mu, \lambda}) + \sigma(h_{\mu, \lambda})$$

holds.

Let $\text{supp}\{v_\alpha(\cdot)\}$ be the support of the function $v_\alpha(\cdot)$ and $\text{mes}(\Omega)$ be the Lebesgue measure of the measurable set $\Omega \subset T^1$ and

$$m := \min_{x \in T^1} u(x), \quad M := \max_{x \in T^1} u(x).$$

Assume that the function $u(\cdot)$ has the non-degenerate global minimum at the points $x_1, x_2, \dots, x_m \in T^1$ and the non-degenerate global maximum at the points $y_1, y_2, \dots, y_n \in T^1$.

Main result of the note is the following theorem.

Theorem. Suppose that

$$\text{mes}(\text{supp}\{v_1(\cdot)\} \cap \text{supp}\{v_2(\cdot)\}) = 0$$

and $v_1(x_i) \neq 0$, $v_2(y_j) \neq 0$ for some $i \in \{1, \dots, m\}$, $j \in \{1, \dots, n\}$.

(a) For all values of $\mu, \lambda > 0$ the operator $h_{\mu, \lambda}$ has a two simple eigenvalues $E_\mu^{(1)} < m$ and $E_\lambda^{(2)} > M$.

(b) For any $\mu, \lambda > 0$ the numbers $2E_\mu^{(1)}$ and $2E_\lambda^{(2)}$ are simple eigenvalues of $H_{\mu, \lambda}$. Moreover

$$\sigma_{\text{ess}}(H_{\mu, \lambda}) = [E_\mu^{(1)} + m; E_\mu^{(1)} + M] \cup [2m; 2M] \cup [E_\lambda^{(2)} + m; E_\lambda^{(2)} + M]$$

$$\sigma_{\text{pp}}(H_{\mu, \lambda}) = \{2E_\mu^{(1)}; E_\mu^{(1)} + E_\lambda^{(2)}; 2E_\lambda^{(2)}\}.$$

(c) For any fixed a and $b > M$, there are two numbers $\mu_0 = \mu_0(a) > 0$ and $\lambda_0 = \lambda_0(b) > 0$, respectively, such that the numbers $2a$, $a + b$ and $2b$ are eigenvalues of H_{μ_0, λ_0} .

(d) For any $c \in [2m; 2M]$ there exist two numbers $\mu_1 = \mu_1(c) > 0$ and $\lambda_1 = \lambda_1(c) > 0$ such that the number c is an eigenvalue of H_{μ_1, λ_1} .

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