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Methods of Analysis”**

Book of abstracts



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LIST OF TOPICS

- Algebraic methods in geometry
- Differential geometry in the large
- Geometry and topology of differentiable manifolds
- General and algebraic topology
- Dynamical systems and their applications
- Geometric problems in mathematical analysis
- Geometric and topological methods in natural sciences
- History and methodology of teaching in mathematics

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ІНСТИТУТ
ОПРАЦІ

Singular monotonic functions defined by a convergent positive series and a double stochastic matrix

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Let

1) $1 = \frac{2}{3} + \sum_{n=1}^{\infty} \frac{1}{(-2)^n} = \frac{2}{3} - \frac{1}{2} + \frac{1}{2^2} - \frac{1}{2^3} + \dots$ be normalized alternating binary series that defines a binary negapositional image of the number of the segment $[0; 1]$:

$$x = \frac{2}{3} + \frac{\alpha_1(x)}{(-2)^1} + \frac{\alpha_2(x)}{(-2)^2} + \frac{\alpha_3(x)}{(-2)^3} + \dots \equiv \overline{\Delta}_{\alpha_1(x)\alpha_2(x)\dots\alpha_n(x)\dots}^2;$$

2) $\|p_{ik}\| = \begin{pmatrix} p_{00} & p_{01} \\ p_{10} & p_{11} \end{pmatrix}$ be a positive double stochastic matrix i.e. $p_{ij} > 0$, $p_{i0} + p_{i1} = 1$, $p_{0j} + p_{1j} = 1$, $i = 0, 1$, $j = 0, 1$;

3) $\bar{p} = (p_0; p_1)$ be a vector $p_0 = \frac{p_{10}}{p_{01} + p_{10}} = \frac{1}{2}$ and $p_1 = \frac{p_{01}}{p_{01} + p_{10}} = \frac{1}{2}$;

It is known that a binary negapositional number representation is a recoding of a classical binary representation:

$$x = \frac{a_1}{2} + \frac{a_2}{2^2} + \dots + \frac{a_n}{2^n} + \dots \equiv \Delta_{a_1(x)a_2(x)\dots a_n(x)\dots}^2, \quad a_n \in \{0; 1\}$$

Considered in the talk is function F , defined by equality

$$F(x) = F(\overline{\Delta}_{\alpha_1(x)\alpha_2(x)\dots\alpha_n(x)\dots}^2) = \beta_{\alpha_1(x)} + \frac{1}{2} \sum_{k=1}^{\infty} (\beta_{\alpha_k(x)\alpha_{k+1}(x)}^{(k)} \prod_{i=1}^{k-1} p_{\alpha_i(x)\alpha_{i+1}(x)}), \quad \text{where} \quad (1)$$

$$\beta_{\alpha_1(x)} = \begin{cases} 0, & \text{if } \alpha_1(x) = 1, \\ \frac{1}{2}, & \text{if } \alpha_1(x) = 0, \end{cases}$$

$$\beta_{\alpha_{2n-1}(x)\alpha_{2n}(x)}^{(2n-1)} = \beta_{\alpha_{2n-1}(x)\alpha_{2n}(x)}^{(1)} = \begin{cases} 0, & \text{if } \alpha_{2n}(x) = 0, \\ p_{00}, & \text{if } \alpha_{2n-1}(x) \neq \alpha_{2n}(x) = 1, \\ p_{10}, & \text{if } \alpha_{2n-1}(x) = \alpha_{2n}(x) = 1, \end{cases}$$

$$\beta_{\alpha_{2n}(x)\alpha_{2n+1}(x)}^{(2n)} = \beta_{\alpha_{2n}(x)\alpha_{2n+1}(x)}^{(0)} = \begin{cases} 0, & \text{if } \alpha_{2n+1}(x) = 1, \\ p_{01}, & \text{if } \alpha_{2n}(x) = \alpha_{2n+1}(x) = 0, \\ p_{00}, & \text{if } \alpha_{2n}(x) \neq \alpha_{2n+1}(x) = 0, \end{cases}$$

and $\alpha_k(x)$ is k negapositional digit of representation of the number x .

Definition 1. Let (c_1, c_2, \dots, c_m) be a orderly set of positive integers. The Cylinder of m rank with basis $c_1 c_2 \dots c_m$ is called a set $\overline{\Delta}_{c_1 c_2 \dots c_m}^2$ of numbers of $x \in (0; 1]$ that is first m negapositional digits of which are c_1, c_2, \dots, c_m respectively, i.e.

$$\overline{\Delta}_{c_1 c_2 \dots c_m}^2 = \left\{ x : x = \overline{\Delta}_{c_1 c_2 \dots c_m a_{m+1} a_{m+2} \dots}^2, \quad a_{m+i} \in \mathbb{N}, \quad i = 1, 2, 3, \dots \right\}.$$

Lemma 2. For a function F defined by the equality (1) the mapping of the cylinder $\overline{\Delta}_{c_1 c_2 \dots c_m}^2$ is a segment $[a; b]$, where

$$a = \beta_{c_1} + \frac{1}{2} \sum_{k=1}^{m-1} \left(\beta_{c_k c_{k+1}}^{(k)} \prod_{j=1}^{k-1} q_{c_j c_{j+1}} \right), \quad b = a + \frac{1}{2} \prod_{j=1}^{m-1} q_{c_j c_{j+1}},$$

Theorem 3. *Images of different cylinders of the same rank with the mapping F do not overlap and in the union give the whole segment $[0, 1]$.*

Theorem 4. *The function $F(x)$ denoted by the equality (1) is:*

- 1) *correctly identified,*
- 2) *continuous,*
- 3) *strictly increasing,*
- 4) *linear for $p_{00} = 0.5$ and singular for $p_{00} \neq 0.5$ (has a derivative equal to zero almost everywhere in the sense of the Lebesgue measure).*

The report proposes the results of studies of the above-mentioned functions.

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