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The Geometry of the Functional Space Type of Lebesgue-Morrey with Many Groups of Variables

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Abstract: In mathematics as in everyday life we encounter the concept of the mathematics. We can speak of the space of function with many groups of variables on the plane of Analysis, Function Analysis and so on. The concept of a space is not so general that it would be difficult to give it a definition which would not reduce to simply replacing the word "norm" by one of the equivalent expressions: Lebesgue-Morrey, Bessov-Morrey, etc. The concept of normed function spaces plays an extraordinarily important role in modern mathematics not only because the theory of space itself has become at the present time a very extensive and comprehensive discipline but mainly because of the influence which the theory of spaces, arising at the end of the last century, exerted and still exerts on mathematics as a whole. Here we shall briefly discuss only those very basic normed spaces concepts which will be used in the following areas. The geometry of functional Analysis and functional spaces aims at presenting the theorems and methods of modern mathematics and giving several applications in Geometry and Function Analysis. It is in fact an important theory for mathematics, since introducing some new relationship between Function analysis and Geometry. In this article I discuss some new results which stand between geometry, analysis and functional analysis.

Keywords: normed space; functional spaces; many groups of variables; the geometry of functional spaces

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1. Introduction

The present paper is a revised version of material given by the authors in several scientific articles, which were published. A course in functional analysis which included, on the one hand, basic information about the theory of functions, function spaces and normed spaces and on the other hand, proceedings of the applications of the general giving function spaces type of Lebesgue-Morrey spaces, theory of functions of the several variables, and functional analysis to concrete problems in algebra and geometry was given by the author. The material included in the first papers are clear from the publishing papers of contents. The theory of the function spaces and their some properties, theory of normed spaces with many groups of variables and some applications of the methods of functional analysis to problems arising in the mathematics of giving methods will he considered in this paper.

There is not a clear investigation of the function spaces of the theory of norm and complete norm spaces type of Lebesgue-Morrey. The latter paper also has a discussion of the principle of the geometry and its applications of these spaces, in order to understand of these spaces. The material on algebraic curves in normed spaces is not usually found in papers. The elements of the geometry of these normed spaces are taken up in this, which is very important for mathematics. [3,5,9]

2. Materials and Methods

Let $G \subset R^n$ and $1 \le s \le n$; s, n be naturals, where $n_1 + \dots + n_s = n$. We consider the sufficient smooth function f(x), where the point $x = (x_1, \dots, x_s) \in R^n$ has coordinates $x_k = (x_{k.1}; \dots; x_{k,n_k}) \in$

R^{n_k} (k $\in e_s = \{$ 1,...,s$\}$). More precisely, $R^n = R^{n_1} \times R^{n_2} \times \cdots \times R^{n_s}$. Thus we consider the fixed, non–negative, integral vector l=$(l_1, \dots, l_s)$ such that, $l_k = \left(l_{k.1}; \dots; l_{k,n_k}\right)$, (k$\subset e_s$) that is, $l_{k,j} > 0$, $(j = 1, \dots, n_k)$ for all $k \in e_s$. Here we consider by Q the set of vectors i= $(i_1, \dots, i_s)$ where i_k= 1,2,…, n_k for every $k \in e_s$. The number of set Q is equal to: $|Q| = \prod_{k=1}^{s}(1 + n_k)$. Therefore, to the vector i= $(i_1, \dots, i_s) \in Q$, we shall correspond the vector $l^i = \left(l_1^{i_1}; \dots; l_s^{i_s}\right)$ of the set of non–negative, integral vectors l= $(l_1, \dots, l_s)$, where $l^0 = (0,0, \dots, 0), l_k^1 = \left(l_{k,1}, 0, \dots, 0\right), \dots, l_k^{i_k} = \left(0,0, \dots, l_{k,n_k}\right)$ for all $k \in e_s$. Then to the vector e^i, we let correspond the vector $\bar{l}^i$=$(\bar{l}_1^{i_1}, \bar{l}_1^{i_2}, \dots, \bar{l}_1^{i_s})$, where $\bar{l}_k^{i_k} = \left(\bar{l}_{k,1}^{i_1}, \bar{l}_{k,2}^{i_2}, \dots, \bar{l}_{k,n_k}^{i_k}\right)$ $(k \in e_s)$. Here the largest number $\bar{l}_{k,j}^{i_k}$ is less than $l_{k,j}^{i_k}$ for all $l_{k,j}^{i_k}$>0, when $l_{k,j}^{i_k}$=0 then we assume that $\bar{l}_{k,j}^{i_k} = 0$ for all $k \in e_s$.

Theremore, we consider $D^{\bar{l}^i} f = D_1^{\bar{l}_1^{i_1}} \cdots D_s^{\bar{l}_s^{i_s}} f$, $D_k^{\bar{l}_k^{i_k}} f = D_{k,1}^{\bar{l}_k^{i_k}} \cdots D_{k,n_k}^{\bar{l}_k^{i_k}} f$, $G_{t^{\varkappa}} = G \cap I_{t^{\varkappa}}(x)$, $I_{t^{\varkappa}}(x) = I_{t_1^{\varkappa_1}}(x_1) \times I_{t_2^{\varkappa_2}}(x_2) \times \cdots \times I_{t_s^{\varkappa_s}}(x_s)$, $I_{t_k^{\varkappa_k}}(x_k) = \left\{y_k : |y_k - x_k| < \frac{1}{2} t_k^{|\varkappa_k|}, k \in e_s\right\}$ and $|\beta_k| = \sum_{j=1}^{n_k} \beta_{k,j}^{i_k}$; $\left|\beta_k^{i_k}\right| = \sum_{j=1}^{n_k} \beta_{k,j}^{i_k}$ $\frac{dt_k}{t_k} = \prod_{j \in e_k^i} \frac{dt_{k,j}}{t_{k,j}}$, we take $0<\beta_{k,j}^{i_k} = l_{k,j}^{i_k} - \bar{l}_{k,j}^{i_k} \le 1$, when $l_k^{i_k} > 0$, but when $l_{k,j}^{i_k} = 0$, then $\beta_{k,j}^{i_k} = 0$; $t = (t_1, \dots, t_s)$, $t_k = \left(t_{k,1}, \dots, t_{k,n_k}\right), \omega = (\omega_1, \dots, \omega_s), \omega_k = \left(\omega_{k,1}, \dots, \omega_{k,n_k}\right)$ and we take $\omega_{k,j} = 1$, when k$\in e^i$, or we give $\omega_{k,j}$ =0, when k$\in e_s / e^i$, $e^i = suppl\bar{l}^i = suppl^i = supp\omega, 1 \le \theta \le \infty$; $1 \le p < \infty$. Here $t_0 = (t_{0,1}, \dots, t_{0,s}), t_{0,k} = \left(t_{0,k,1}, \dots, t_{0,k,n_k}\right)$ –is fixed vector and $\varkappa \in (0, \infty)^n$, $\delta \in [0, 1], \tau \in [1, \infty], [t_k]_1 = \min\{1, t_k\}, k \in e_s$. Here $\Delta^{\omega}(t) f = \Delta_1^{\omega_1}(t_1) \cdots \Delta_s^{\omega_s}(t_k) f$, when $2\omega = (2, 2, \dots, 2)$, and $\Delta_k^{\omega_k}(t_k) f = \Delta_{k,1}^{\omega_{k,1}}(t_{k,1}) \cdots \Delta_{k,n_k}^{\omega_{k,n_k}}(t_{k,n_k}) f, (k \in e_s)$, following $\Delta_{k,j_k}^{\omega_{k,j_k}}(t_{k,j_k}) f$ are finite difference function, which has direction with variables t_{k,j_k} and with order ω_{k,j_k}, by step t_{k,j_k} for $j = 1, \dots, n_k$ and for all and $k \in e_s$, following $\Delta_{k,j_k}^1(t_{k,j_k}) f(\cdots, x_{k,j_k}, \cdots) = f(\cdots, x_{k,j_k} + t_{k,j_k}, \cdots) - f(\cdots, x_{k,j_k}, \cdots)$, and $\Delta_{k,j_k}^{\omega_{k,j_k}}(t_{k,j_k}) f(\cdots, x_{k,j_k}, \cdots) = \Delta_{k,j_k}^1(t_{k,j_k}) \left\{\Delta_{k,j_k}^{\omega_{k,j_k}-1}(t_{k,j_k}) f(\cdots, x_{k,j_k}, \cdots)\right\}$, but when $\omega_{k,j_k} = 0$, then $\Delta_{k,j_k}^0(t_{k,j_k}) f(\cdots, x_{k,j_k}, \cdots) = f(\cdots, x_{k,j_k}, \cdots)$. [2,4,13]

Definition. We denote by

$$L_{p,a,\varkappa,\tau}(G) \quad (1)$$

normed Lebesgue–Morrey space of locally summability functions f, on G, with finite norm ($N^i > l^i > m^i \ge 0$, i=1,2,…,n)

$$\|f\|_{p,a,\varkappa,\tau: G} = \|f\|_{L_{p,a,\varkappa,\tau}(G)} = sup_{x \in G}\left\{\int_0^{\infty}\left[\prod_{k \in e_s}[t_k]_1^{-\frac{|\varkappa_k| a}{p}} \times \|f\|_{p,G_{t^{\varkappa}}(x)}\right]^{\tau} \prod_{k \in e_s}\frac{dt_k}{t_k}\right\}^{1/\tau}, \quad (2)$$

where $|\varkappa_k|$=$\sum_{j=1}^{n_k} \varkappa_{k,j}$; $[t_k]_1 = \min\{1, t_k\}$. [7,8,12]

We begin by briefly recalling some basic notions of function spaces. A norm defined on a Lebesgue-Morrey space satisfies

1) nonnegativity: $\|f\| \ge 0$, for all f.
2) homogeneity: $\|\lambda f\| = |c| \times \|f\|$, for all $\lambda \in R$.
3) triangle inequality: $\|f + g\| \le \|f\| + \|g\|$.

Proof: The first property is a clear. Let us proof second property:

$$\|\lambda f\|_{p,a,\varkappa,\tau: G} = sup_{x \in G}\left\{\int_0^{\infty}\left[\prod_{k \in e_s}[t_k]_1^{-\frac{|\varkappa_k| a}{p}} \times \|\lambda f\|_{p,G_{t^{\varkappa}}(x)}\right]^{\tau} \prod_{k \in e_s}\frac{dt_k}{t_k}\right\}^{1/\tau} =$$

$$sup_{x \in G}\left\{\int_0^{\infty}\left[\prod_{k \in e_s}[t_k]_1^{-\frac{|\varkappa_k| a}{p}} \times |\lambda| \times \|f\|_{p,G_{t^{\varkappa}}(x)}\right]^{\tau} \prod_{k \in e_s}\frac{dt_k}{t_k}\right\}^{1/\tau} =$$

$$sup_{x \in G}\left\{\int_0^{\infty} |\lambda| \times \left[\prod_{k \in e_s}[t_k]_1^{-\frac{|\varkappa_k| a}{p}} \times \|f\|_{p,G_{t^{\varkappa}}(x)}\right]^{\tau} \prod_{k \in e_s}\frac{dt_k}{t_k}\right\}^{1/\tau} =$$

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$$sup_{x\in G}\left\{|\lambda^n|\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|\lambda f\|_{p,G_{t^\varkappa}(x)}\right]^\tau\prod_{k\in e_s}\frac{dt_k}{t_k}\right\}^{1/\tau}=$$
$$c\times sup_{x\in G}\left\{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|f\|_{p,G_{t^\varkappa}(x)}\right]^\tau\prod_{k\in e_s}\frac{dt_k}{t_k}\right\}^{1/\tau}$$
$$=c\times\|f\|_{p,,a,\varkappa,\tau:\,G}.$$

Following taking Minkowski's inequality we obtain

$$\|f+g\|_{L_{p,a,\varkappa,\tau}(G)}=$$
$$sup_{x\in G}\left\{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|f+g\|_{p,G_{t^\varkappa}(x)}\right]^\tau\prod_{k\in e_s}\frac{dt_k}{t_k}\right\}^{1/\tau}\le$$

$$sup_{x\in G}\left(\left\{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|f\|_{p,G_{t^\varkappa}(x)}\right]^\tau\prod_{k\in e_s}\frac{dt_k}{t_k}\right\}^{1/\tau}+\right.$$
$$\left.\left\{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|f\|_{p,G_{t^\varkappa}(x)}\right]^\tau\prod_{k\in e_s}\frac{dt_k}{t_k}\right\}^{1/\tau}\right)=$$

$$sup_{x\in G}\left\{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|f\|_{p,G_{t^\varkappa}(x)}\right]^\tau\prod_{k\in e_s}\frac{dt_k}{t_k}\right\}^{1/\tau}+$$
$$sup_{x\in G}\left\{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|g\|_{p,G_{t^\varkappa}(x)}\right]^\tau\prod_{k\in e_s}\frac{dt_k}{t_k}\right\}^{1/\tau}=$$
$$\|f\|_{L_{p,a,\varkappa,\tau}(G)}+\|g\|_{L_{p,a,\varkappa,\tau}(G)}.$$

3. Results

Their importance for the study of geometric properties of Banach spaces was realized through the work of some mathematicians. In this collection for a discussion of the development of this theory.

$$\left(\sum_{i=1}^m\|x_i\|^q\right)^{1/q}\le c\left(\int_0^\infty\left\|\sum_{i=1}^m r_i(t)x_2\right\|^2\prod_{k\in e_s}\frac{dt_k}{t_k}\right)^{1/2}.$$

If τ=2 then because of a norm induces a distance then

$$d(f,g)=\|f-g\|_{p,a,\varkappa,2:\,G}=$$
$$sup_{x\in G}\left\{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|f-g\|_{p,G_{t^\varkappa}(x)}\right]^2\prod_{k\in e_s}\frac{dt_k}{t_k}\right\}^{1/2}=$$
$$sup_{x\in G}\sqrt{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|f-g\|_{p,G_{t^\varkappa}(x)}\right]^2\prod_{k\in e_s}\frac{dt_k}{t_k}}\le$$
$$2\times sup_{x\in G}\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|f-g\|_{p,G_{t^\varkappa}(x)}\right]^2\prod_{k\in e_s}\frac{dt_k}{t_k}.$$

More precisely, we obtain It has $a^2+b^2=r^2$, which are called a Pythagorean triple. In addition, this is the general standard equation for the circle centered at (0, 0) with radius r. If τ=3 then we obtain

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$$\|f\|_{p,a,\varkappa,3:\,G} = \|f\|_{L_{p,a,\varkappa,3}(G)} =$$

$$sup_{x\in G}\left\{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|f\|_{p,G_{t^{\varkappa}}(x)}\right]^3\prod_{k\in e_s}\frac{dt_k}{t_k}\right\}^{1/3} =$$

$$sup_{x\in G}\sqrt[3]{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|f\|_{p,G_{t^{\varkappa}}(x)}\right]^3\prod_{k\in e_s}\frac{dt_k}{t_k}}.$$

Hence using Minkowski's integral inequality we have

$$sup_{x\in G}\sqrt[3]{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|f\|_{p,G_{t^{\varkappa}}(x)}\right]^3\prod_{k\in e_s}\frac{dt_k}{t_k}} \le$$

$$sup_{x\in G}\sqrt[3]{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\prod_{k\in e_s}\frac{dt_k}{t_k}\right]^3}\times\|f\|_{p,G_{t^{\varkappa}}(x)}.$$

It has shown as $a^3+b^3+c^3=r^3$, which are called Plato's number. Indeed, a cubic surface is a surface in 3-dimensional space defined by equation of degree 3 with one variable. I have to note that, cubic surfaces are fundamental applications in algebraic geometry. [1,6,15]

Following if τ=m then

$$\|f\|_{p,a,\varkappa,\tau:\,G} = \|f\|_{L_{p,a,\varkappa,m}(G)} =$$

$$sup_{x\in G}\left\{\int_0^\infty\left[\prod_{k\in e_s}[t_k]_1^{-\frac{|\varkappa_k|a}{p}}\times\|f\|_{p,G_{t^{\varkappa}}(x)}\right]^m\prod_{k\in e_s}\frac{dt_k}{t_k}\right\}^{1/m}.$$

One approach would be to m-th power each side of the expression immediately, expecting to remove the radical. Then we get $a_1^m+a_2^m+\cdots a_m^m=r^m, n\ge m$, which are called Euler's sum of powers conjecture. With aid of the Hilbert Basic Theorem, that is, an algebraic set to be defined by some set of polynomials and in fact a finite number will always do. In addition, we have that, every algebraic set is the intersection of a finite number of hypersurfaces. Then we get that it is a equation of some hypersurfaces. [10,11]

If r=1, then the sum is a kissing number. The "kissing number problem" asks for the maximal number of blue spheres that can touch a red sphere of the same size in n-dimensional space. [14,16]

4. Discussion

In recent years the applications of the techniques from geometric science of function spaces in the study of functions theory has transformed important tool. Beginning with the great works of some authors, the theory of function spaces and their applications have quickly changed most important branch of mathematics. From frame of reference of one of their basic methods, the theory of function spaces gives as their branches the mathematical relationships between functions spaces and geometry. The theory of function spaces is connected with the geometry and function spaces, belonging to Lebesgue-Morrey type spaces with many groups of variables. Using it one can solve some mathematical problems, which are important for study.

5. Conclusions

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Although algebraic geometry is a highly developed and thriving field of mathematics, it is not difficult for the mathematicians to give relationships between this subject and other areas of mathematics. There are several papers about function analysis algebra and geometry which give an excellent treatment of the classical theory of plane curves, space curves and function spaces, but there are few papers which these do not prepare the reader adequately for relationships between given areas of mathematics. On the other hand, this paper gives geometry of normed spaces type of Lebesgue-Morrey with many groups of variables with a modern approach demand considerable background in algebra and function analysis, which is very variable for mathematical study. The aim of this paper is to develop and to introduce the theory of function spaces from the viewpoint of normed spaces with many groups of variables, but with algebraic geometry. I considered n-dimensional normed spaces with many groups of variables. Analogously, I studied several normed spaces type of Lebesgue-Morrey with many groups of variables. This theory grew out of functional analysis and grew up its applications.

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