MINKOVSKIY FAZOSIDA NUQTANING ATROFLARI

Noriyeva Aziza Jasur qizi
O‘zbekiston Milliy universiteti Jizzax filiali, assistent.
noriyevaaziza@gmail.com

ANNOTATSIYA

Ushbu maqolada ko‘p o‘lchamli Minkovskiy fazosi, minkovskiy fazosidagi nuqtaning sferik hamda parallelopipedial atroflari haqidagi lemma keltirilgan bo‘lib, Yevklid hamda Minkovskiy fazolarida sferik hamda parallelopipedial atroflari orasidagi munosabat qiyoslangan.

Kalit so‘zlar: Minkovskiy fazosi, masofa, sferik atrof, parallelopipedial atrof, qism to‘plam.

SURROUNDINGS OF A POINT IN MINKOWSKI SPACE

ABSTRACT

In this article, the lemma about multidimensional Minkowski space, spherical and parallelopipedial surroundings of a point in Minkowski space is given, and the relation between spherical and parallelopipedial surroundings in Euclidean and Minkowski spaces is compared.

Keywords: Minkowski space, distance, spherical circumference, parallelepipedal circumference, subset.

KIRISH

Haqiqiy sonlar to‘plami R yordamida ushbu

$$R \times R \times \ldots \times R = \{(x_1, x_2, \ldots, x_m): x_1 \in R, x_2 \in R, \ldots, x_m \in R\} \ (1)$$

R ning dekart ko‘paytmalaridan tuzilgan to‘plamni hosil qilaylik. Ravshanki, (1) to‘plamning har bir elementi m ta $x_1, x_2, \ldots, x_m$ haqiqiy sonlardan tashkil topgan tartiplangan m lik $(x_1, x_2, \ldots, x_m)$ dan iborat bo‘lib, u (1) to‘plamning nuqtasi deyiladi va bitta harf bilan belgilanadi:

$$x = (x_1, x_2, \ldots, x_m).$$

Bunda $x_1, x_2, \ldots, x_m$ sonlar x nuqtaning mos ravishda birinchi, ikkinchi, … m −koordinatalari deyiladi.

Agar $x = (x_1, x_2, \ldots, x_m), y = (y_1, y_2, \ldots, y_m)$ nuqtalar uchun $x_1 = y_1$, $x_2 = y_2, x_3 = y_3, \ldots, x_m = y_m$ bo‘lsa, $x = y$ deyiladi. [1]

ADABIYOTLAR TAHLILI VA METODOLOGIYA

Faraz qilaylik,

$$x = (x_1, x_2, \dots, x_m), y = (y_1, y_2, \dots, y_m)$$

lar (1) to‘plamning ixtiyoriy ikki nuqtasi bo‘lsin. Ushbu

$$\sqrt{\sum_{k=1}^{m-1} (y_k - x_k)^2 - (y_m - x_m)^2}$$

miqdor x va y nuqtalar orasidagi masofa deyiladi va $\rho(x, y)$ kabi belgilanadi:

$\rho(x, y) = \sqrt{\sum_{k=1}^{m-1} (y_k - x_k)^2 - (y_m - x_m)^2}$. (2)

Endi masofalarning xossalarini keltiramiz:

1) Har doim $\rho(x, y) \geq 0$ va $\rho(x, y) = 0 \leftrightarrow x = y$ bo‘ladi.
2) $\rho(x, y)$ masofa x va y ularga nisbatan simmetrik bo‘ladi: $\rho(x, y) = \rho(y, x)$.
3) (1) to‘plamning ixtiyoriy
$x = (x_1, x_2, \dots, x_m), y = (y_1, y_2, \dots, y_m), z = (z_1, z_2, \dots, z_m)$
nuqtalari uchun

$$\rho(x, z) \leq \rho(x, y) + \rho(y, z)$$

tengsizlik o‘rinli bo‘ladi.

Shunday qilib, (1) to‘plam elementlari orasida masofa tushunchasining kiritilishi hamda masofa uchta xossaga ega bo‘lishini ko‘dik.

Odatda, (1) to‘plam R^m fazo (minkovskiy fazosi) deyiladi. Demak,

$$R^m = \{(x_1, x_2, \dots, x_m): x_1 \in R, x_2 \in R, \dots, x_m \in R\}.$$

Endi R^m fazodagi ba’zi bir to‘plamlarni keltiramiz.

Aytaylik, biror $a = (a_1, a_2, \dots, a_m) \in R^m$ nuqta va $r > 0$ son berilgan bo‘lsin. Ushbu

$$B_r(a) = \left\{(x_1, x_2, \dots, x_m) \in R^m: \sqrt{\sum_{k=1}^{m-1} (x_k - a_k)^2 - (x_m - a_m)^2} < r\right\}$$

yoki qisqacha,

$$B_r(a) = \{x \in R^m: \rho(x, a) < r\}$$

to‘plam markazi a nuqta, radiusi r bo‘lgan shar (m o‘lchovli shar) deyiladi.

Quyidagi

$$\bar{B}_r(a) = \{x \in R^m: \rho(x, a) \leq r\}$$

to‘plam R^m fazo(minkovskiy fazosi)da yopiq shar,

$$B_r^0(a) = \{x \in R^m: \rho(x, a) = r\}$$

to‘plam esa R^m fazo(minkovskiy fazosi)da sfera (m o‘lchovli sfera) deyiladi.

Ravshanki,

$$\bar{B}_r(a) = B_r(a) \cup {B_r}^0(a)$$

bo‘ladi.

Ushbu

$$\prod(a_1, \dots, a_2;\ b_1, b_2, \dots, b_m) =$$
$$= \{(x_1, x_2, \dots, x_m) \in R^m : a_1 < x_1 < b_1, a_2 < x_2 < b_2, \dots, a_m < x_m < b_m\}$$

to‘plam R^m fazoda parallelepiped deyiladi, bunda $a_1, a_2, \dots, a_m;\ b_1, b_2, \dots, b_m$ –haqiqiy sonlar. [2], [3], [4]

NATIJA

Biror $x^0 = (x_1^0, x_2^0, \dots, x_m^0) \in R^m$ nuqta hamda $\varepsilon > 0$ son berilgan bo‘lsin.

1-ta'rif. Markazi x^0 nuqtada, radiusi ε bo‘lgan R^m fazodagi shar $x^0 \in R^m$ nuqtaning *sferik atrofi* deyiladi va $U_\varepsilon(x^0)$ kabi belgilanadi:

$$U_\varepsilon(x^0) = \{x \in R^m : \rho(x, x^0) < \varepsilon\}.$$

2-ta'rif. Ushbu

$$\prod(\delta_1, \delta_2, \dots, \delta_m) = \{(x_1, x_2, \dots, x_m) \in R^m:$$
$$: x_1^0 - \delta_1 < x_1 < x_1^0 + \delta_1,\ x_2^0 - \delta_2 < x_2 < x_2^0 + \delta_2, \dots$$
$$\dots\ x_m^0 - \delta_m < x_m < x_m^0 + \delta_m\}$$

parallelepiped x^0 nuqtaning parallelepipedial atrofi deyiladi va $\bar{U}_{\delta_1,\delta_2,\dots,\delta_m}(x^0)$ kabi belgilanadi, bunda $\delta_1 > 0, \delta_2 > 0, \dots, \delta_m > 0$.

R^m minkovskiy fazosidagi nuqtaning bu atroflari orasidagi munosabatni quyidagi lemma ifodalaydi. [5], [6], [7]

Lemma. $x^0 \in R^m$ nuqtaning har qanday $U_\varepsilon(x^0)$ sferik atrofi olinganda ham har doim x^0 nuqtaning shunday $\bar{U}_{\delta_1,\delta_2,\dots,\delta_m}(x^0)$ parallelepipedial atrofi topiladiki, bunda

$$\bar{U}_{\delta_1,\delta_2,\dots,\delta_m}(x^0) \subset U_\varepsilon(x^0)$$

bo‘ladi.

MUHOKAMA

$x^0 \in R^m$ nuqtaning sferik atrofi

$$U_\varepsilon(x^0) = \{x \in R^m : \rho(x, x^0) < \varepsilon\}$$

berilgan bo‘lsin. Demak, $\varepsilon > 0$ son berilgan. Unga ko‘ra $\delta < \frac{\varepsilon}{\sqrt{m-2}}$ tengsizlikni qanoatlantiruvchi δ sonni olib, x^0 nuqtaning ushbu

$$\bar{U}_\delta(x^0) = \bar{U}_{\delta\delta\dots\delta}(x^0) = \{(x_1, x_2, \dots, x_m) \in R^m:$$
$$: x_1^0 - \delta < x_1 < x_1^0 + \delta,\ x_2^0 - \delta < x_2 < x_2^0 + \delta, \dots$$
$$\dots\ x_m^0 - \delta < x_m < x_m^0 + \delta\}$$

Parallelopipedial atrofini tuzamiz. Natijada x^0 nuqtaning

$U_\varepsilon(x^0)$ va $\bar{U}_\delta(x^0)$

atroflarga ega bo‘lamiz.

Aytaylik, $\forall x \in \bar{U}_\delta(x^0)$ bo‘lsin. U holda

$$|x_k - x_k^0| < \delta, (k = 1,2, \dots, m)$$

bo‘lib,

$$\sqrt{\sum_{k=1}^{m-1} (x_k - x_k^0)^2 - (x_m - x_m^0)^2} < \sqrt{\sum_{k=1}^{m-2} \delta^2} = \delta \cdot \sqrt{m-2}$$

bo‘ladi. Yuqoridagi $\delta < \frac{\varepsilon}{\sqrt{m-2}}$ tengsizlikni e’tiborga olib topamiz:

$$\sqrt{\sum_{k=1}^{m-1} (x_k - x_k^0)^2} < \varepsilon$$

XULOSA

Demak, $\rho(x, x^0) < \varepsilon$ bo‘lib, $x \in U_\varepsilon(x^0)$ bo‘ladi. Bundan $\bar{U}_{\boldsymbol{\delta}}(\boldsymbol{x}^{\mathbf{0}}) \subset U_{\boldsymbol{\varepsilon}}(\boldsymbol{x}^{\mathbf{0}})$ bo‘lishi kelib chiqadi.

Minkovskiy fazosida Yevklid fazosi kabi nuqtaning sferik va parallelopipedial atroflari bir-biriga ichki joylasha olmaydi, faqat nuqtaning parallelopipedial atrofi uning sferik atrofiga ichki bo‘lib, tashqi bo‘lmaydi. [8], [9], [10].

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