UCH O‘LCHAMLI NILPOTENT ALGEBRANING DIFFERENSIALLASHI LOKAL VA IKKI LOKAL DIFFERENSIALLASHI

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Annotatsiya. Differensiallash matematikaning fundamental tushunchalaridan biri hisoblanadi. Differensiallashlar algebra fanida ham muhim o‘rin tutadi. Differensiallashlarning turli umumlashmalari mavjud. Bular sarasiga antidifferensiallashlar, δ-differensiallashlar, ternar differensiallashlar va (α,β,γ)-differensiallashlar kiradi. Ushbu ishda uch o‘lchamli nilpotent algebralarning differensiallashi lokal va ikki lokal differensiallashi isboti bilan ko‘rsatilgan.

Kalit so‘zlar: Differensiallash, Algebra, lokal differensiallash va ikki lokal differensiallash, chiziqli akslatirish.

Аннотатция. Дифференциация — одно из фундаментальных понятий математики. Дифференциации также играют важную роль в алгебре. Существуют различные обобщения дифференциаций. К ним относятся антидифференциации, δ-дифференциации, тернарные дифференциации и (α,β,γ)-дифференциации. В данной работе демонстрируется дифференциация трехмерных нильпотентных алгебр путем доказательства локальной и билокальной дифференциации.

Ключевые слова: Дифференцирование, алгебра, локальное дифференцирование и два локальных дифференцирования, линейное отражение.

Abstract. Differentiation is one of the fundamental concepts of mathematics. Differentiations also play an important role in algebra. There are various generalizations of differentiations. These include antidifferentiations, δ-differentiations, ternary differentiations, and (α,β,γ)-differentiations. In this paper,

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the differentiation of three-dimensional nilpotent algebras is shown by proving local and bilocal differentiation.

Key words: Differentiation, Algebra, local differentiation and two-local differentiation, linear mapping.

I. KIRISH

1-§. Masalaning qo‘yilishi

Hozirgi kunda jahonda differensiyalashlar nazariyasi bilan bir qatorda, operator algebralarida lokal va 2-lokal differensiyalashlar nazariyasi ham muhim hisoblanadi. So’nggi 20 yil davomida fon Neyman algebralari C^*- algebralari va JB^*- uchliklarda lokal va 2- lokal differensiallashlar nazariyasini o’rganish bo’yicha samarali natijalarga erishildi. Lokal differensiallashlarni o’rganish 1990-yilda R.B.Kadison va D.R.Larson hamda A.S.Sururlar tomonidan boshlangan. Ixtiyoriy uch o’lchamli nilpotent algebra bazislari $\{e_1, e_2, e_3\}$ bo’lgan quyidagi o’zaro izomorf bo’lmagan algebralarning biriga izomorf bo’ladi:

N_1: $e_1^2=e_2$,$e_2^2 = e_3$ N_2: $e_1^2 = e_2$, $e_2e_1 = e_3$, $e_2^2 = e_3$

N_3: $e_1^2 = e_2$, $e_2e_1 = e_3$ $N_4(\alpha)$: $e_1^2 = e_2$, $e_1e_2 = e_3$, $e_2e_1 = \alpha e_3$

N_5: $e_1^2 = e_2$ N_6: $e_1^2 = e_3$, $e_2^2 = e_3$

N_7: $e_1e_2 = e_3$, $e_2e_1 = -e_3$ $N_8(\alpha)$: $e_1^2 = \alpha e_3$, $e_2e_1 = e_3$, $e_2^2 = e_3$

II.ADABIYOTLAR TAHLILI

Differensiallashning ko’plab umumlashmalari mavjud. Eng asosiy umumlashmasi bu lokal va 2-lokal umumlashmalari hisoblanadi. So’ngi yillarda ko’plab olimlar lokal va 2- lokal differensiallashlarga oid ko’plab maqolalar chop etishdi[1- 3] operator algebralarida lokal va 2-lokal differensiyalashlar nazariyasi ham muhim hisoblanadi

III.TADQIQOT METODOLOGIYASI

1-Ta’rif. Agar N algebaradan olingan ixtiyoriy x, y elementlar uchun

$$d(x \cdot y) = d(x) \cdot y + x \cdot d(y)$$

Tenglik bajarilsa d akslantirish qaralayotgan N algebrada differensiallash deb ataladi.

$d(x) = Ax$ chiziqli akslantirishni qaraylik, bu yerda A – 3×3 o’lchamli kvadrat matritsa. Ravshanki, agar $N_4(\alpha)$ algebaradan olingan ixtiyoriy x, y elementlar uchun

$$A(xy) = (Ax)y + x(Ay) \qquad (1)$$

tenglik bajarilsa $d(x) = Ax$ akslantirish qaralayotgan $N_4(\alpha)$ algebrada differensiallashdan iborat bo’ladi.

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R haqiqiy sonlar maydoni ustida aniqlangan $\{e_1, e_2, e_3\}$ bazisli nilpotent algebra $N_4(\alpha)$ berilgan. Bu algebrada ko‘paytirish jadvali quyidagicha aniqlanadi:

$$e_1^2 = e_2, e_1e_2 = e_3, e_2e_1 = \alpha e_3$$

$N_4(\alpha)$ algebrada ihtiyoriy x vektorni

$$x = x_1e_1 + x_2e_2 + x_3e_3$$

ko‘rinishda yozishmumkin. $d : N_4(\alpha) \to N_4(\alpha)$ akslantirishni qaraylik.

1-tarifga ko‘ra $d(x) = Ax$ chiziqli akslantirishni qaraylik, bu yerda A – 3×3 o‘lchamli kvadrat matritsa. Ravshanki, agar $N_4(\alpha)$ algebaradan olingan ixtiyoriy x, y elementlar uchun

$$A(xy) = (Ax)y + x(Ay)$$

Tenglik bajarilsa $d(x) = Ax$ akslantirish qaralayotgan $N_4(\alpha)$ algebrada differensiallashdan iborat bo‘ladi.

1-Teorema. $d(x) = Ax$ akslantirish $N_4(\alpha)$ algebrada differensiallashdan iborat bo‘lishi uchun A matritsa

$$A = \begin{pmatrix} a_{1,1} & 0 & 0 \\ a_{2,1} & 2a_{1,1} & 0 \\ a_{3,1} & (\alpha+1)a_{2,1} & 3a_{1,1} \end{pmatrix} \qquad (5)$$

ko‘rinishda bo‘lishi zarur va yetarli.

Isbot. Zarurligi. $d(x) = Ax$ akslantirish $N_4(\alpha)$ algebrada differensiallashdan iborat bo‘sin. U holda

$$A = \begin{pmatrix} a_{1,1} & a_{1,2} & a_{1,3} \\ a_{2,1} & a_{2,2} & a_{2,3} \\ a_{3,1} & a_{3,2} & a_{3,3} \end{pmatrix}$$

Matritsa ixtiyoriy x, y vektorlar uchun (1) tenglikni qanoatlantirishi kerak.

Xususan $e_1e_1 = e_2$ tenglikdan foydalanib quyidagi ayniyatni

$$(Ae_1)e_1 + e_1(Ae_1) = A(e_2)$$

qaraylik:

$$Ae_1 = \begin{pmatrix} a_{1,1} & a_{1,2} & a_{1,3} \\ a_{2,1} & a_{2,2} & a_{2,3} \\ a_{3,1} & a_{3,2} & a_{3,3} \end{pmatrix}\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} a_{11} \\ a_{21} \\ a_{3,1} \end{pmatrix} = a_{1,1}e_1 + a_{2,1}e_2 + a_{3,1}e_3$$

$$Ae_2 = \begin{pmatrix} a_{1,1} & a_{1,2} & a_{1,3} \\ a_{2,1} & a_{2,2} & a_{2,3} \\ a_{3,1} & a_{3,2} & a_{3,3} \end{pmatrix}\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} = \begin{pmatrix} a_{1,2} \\ a_{2,2} \\ a_{3,2} \end{pmatrix} = a_{1,2}e_1 + a_{2,2}e_2 + a_{3,2}e_3$$

$$(Ae_1)e_1 = (a_{1,1}e_1 + a_{2,1}e_2 + a_{3,1}e_3)e_1 = a_{1,1}e_2 + \alpha a_{2,1}e_3$$

$$e_1(Ae_1) = e_1(a_{1,1}e_1 + a_{2,1}e_2 + a_{3,1}e_3) = a_{1,1}e_2 + a_{2,1}e_3$$

$$a_{1,1}e_2 + \alpha a_{2,1}e_3 + a_{1,1}e_2 + a_{2,1}e_3 = a_{1,2}e_1 + a_{2,2}e_2 + a_{3,2}e_3$$

$$2a_{1,1}e_2 + (\alpha+1)a_{2,1}e_3 = a_{1,2}e_1 + a_{2,2}e_2 + a_{3,2}e_3$$

bundan

$$a_{2,2} = 2a_{1,1}\ , \quad a_{1,2} = 0\ , \quad a_{3,2} = (\alpha+1)a_{2,1}$$

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$$Ae_2 = 2a_{1,1}e_2 + (\alpha+1)a_{2,1}e_3$$

tengliklarni aniqlaymiz.

Endi $e_1e_2 = e_3$ tenglikdan foydalanib quyidagi ayniyatni

$$(Ae_1)e_2 + e_1(Ae_2) = A(e_3)$$

qaraylik:

$$(Ae_1)e_2 = (a_{1,1}e_1 + a_{2,1}e_2 + a_{3,1}e_3)e_2 = a_{1,1}e_3$$

$$e_1(Ae_2) = e_1\left(2a_{1,1}e_2 + (\alpha+1)a_{2,1}e_3\right) = 2a_{1,1}e_3$$

$$a_{1,1}e_3 + 2a_{1,1}e_3 = a_{1,3}e_1 + a_{2,3}e_2 + a_{3,3}e_3$$

bundan

$$a_{1,3} = 0\,, \qquad a_{2,3} = 0, \qquad a_{3,3} = 3a_{1,1}\,, \quad Ae_3 = 3a_{1,1}e_3$$

tengliklarni aniqlaymiz.

Endi $e_1e_3 = 0$ tenglikdan foydalanib quyidagi ayniyatni

$$(Ae_1)e_3 + e_1(Ae_3) = A(0)$$

qaraylik:

$$(Ae_1)e_3 = \left(a_{1,1}e_1 + a_{2,1}e_2 + a_{3,1}e_3\right)e_3 = 0$$

$$e_1(Ae_3) = e_1 3a_{1,1}e_3 = 0$$

$$0 = 0$$

bo‘ldi.

Endi $e_2e_1 = \alpha e_3$ tenglikdan foydalanib quyidagi ayniyatni

$$(Ae_2)e_1 + e_2(Ae_1) = A(\alpha e_3)$$

qaraylik:

$$(Ae_2)e_1 = (2a_{1,1}e_2 + (\alpha+1)a_{2,1}e_3)e_1 = 2\alpha a_{1,1}e_3$$

$$e_2(Ae_1) = e_2\left(a_{1,1}e_1 + a_{2,1}e_2 + a_{3,1}e_3\right) = \alpha a_{1,1}e_3$$

$$2\alpha a_{1,1}e_3 + \alpha a_{1,1}e_3 = 3\alpha a_{1,1}e_3$$

$$3\alpha a_{1,1}e_3 = 3\alpha a_{1,1}e_3$$

bundan

$$3\alpha a_{1,1} = 3\alpha a_{1,1}$$

bo‘ladi

Endi $e_2e_2 = 0$ tenglikdan foydalanib quyidagi ayniyatni

$$(Ae_2)e_2 + e_2(Ae_2) = A(0)$$

qaraylik:

$$(Ae_2)e_2 = (2a_{1,1}e_2 + (\alpha+1)a_{2,1}e_3)e_2 = 0$$

ISSN 3030-3907

$$e_2(Ae_2) = e_2(2a_{1,1}e_2 + (\alpha+1)a_{2,1}e_3) = 0$$
$$0 = 0$$

bo‘ladi

Endi $e_2e_3 = 0$ tenglikdan foydalanib quyidagi ayniyatni

$$(Ae_2)e_3 + e_2(Ae_3) = A(0)$$

qaraylik:

$$(Ae_2)e_3 = (2a_{1,1}e_2 + (\alpha+1)a_{2,1}e_3)e_3 = 0$$
$$e_2(Ae_3) = e_2 3a_{1,1}e_3 = 0$$
$$0 = 0$$

bo‘ladi.

Endi $e_3e_1 = 0$ tenglikdan foydalanib quyidagi ayniyatni

$$(Ae_3)e_1 + e_3(Ae_1) = A(0)$$

qaraylik:

$$(Ae_3)e_1 = 3a_{1,1}e_3e_1 = 0$$
$$e_3(Ae_1) = e_3(a_{1,1}e_1 + a_{2,1}e_2 + a_{3,1}e_3) = 0$$
$$0 = 0$$

bo‘ladi.

Endi $e_3e_2 = 0$ tenglikdan foydalanib quyidagi ayniyatni

$$(Ae_3)e_2 + e_3(Ae_2) = A(0)$$

qaraylik:

$$(Ae_3)e_2 = 3a_{1,1}e_3e_2 = 0$$
$$e_3(Ae_2) = e_3(2a_{1,1}e_2 + (\alpha+1)a_{2,1}e_3) = 0$$
$$0 = 0$$

bo‘ladi.

Endi $e_3e_3 = 0$ tenglikdan foydalanib quyidagi ayniyatni

$$(Ae_3)e_3 + e_3(Ae_3) = A(0)$$

qaraylik:

$$(Ae_3)e_3 = 3a_{1,1}e_3e_3 = 0 \quad , \quad e_3(Ae_3) = e_3 3a_{1,1}e_3 = 0$$
$$0 = 0$$

bo‘ladi.

Yetarliligi. Endi A matritsa (5) ko‘rinishda bo‘lsa $d(x) = Ax$ chiziqli akslantirish differensiallashdan iboratligini ko‘rsataylik.

$$xy = (x_1e_1 + x_2e_2 + x_3e_3)(y_1e_1 + y_2e_2 + y_3e_3) =$$
$$= x_1y_1e_2 + (x_1y_2 + \alpha x_2y_1)e_3$$

tenglikka ko‘ra

ISSN 3030-3907

$$A(xy) = \begin{pmatrix} a_{1,1} & 0 & 0 \\ a_{2,1} & 2a_{1,1} & 0 \\ a_{3,1} & (\alpha+1)a_{2,1} & 3a_{1,1} \end{pmatrix} \begin{pmatrix} 0 \\ x_1y_1 \\ x_1y_2 + \alpha x_2y_1 \end{pmatrix} =$$

$$2a_{1,1}x_1y_1e_2 + ((\alpha+1)a_{2,1}x_1y_1 + 3a_{1,1}(x_1y_2 + \alpha x_2y_1))e_3$$

boshqa tamondan

$$Ax = \begin{pmatrix} a_{1,1} & 0 & 0 \\ a_{2,1} & 2a_{1,1} & 0 \\ a_{3,1} & (\alpha+1)a_{2,1} & 3a_{1,1} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = a_{1,1}x_1e_1 + (a_{2,1}x_1 + 2a_{1,1}x_2)e_2 +$$

$$(a_{3,1}x_1 + (\alpha+1)a_{2,1}x_2 + 3a_{1,1}x_3)e_3$$

$$(Ax)y = (a_{1,1}x_1e_1 + (a_{2,1}x_1 + 2a_{1,1}x_2)e_2 +$$

$$(a_{3,1}x_1 + (\alpha+1)a_{2,1}x_2 + 3a_{1,1}x_3)e_3)(y_1e_1 + y_2e_2 + y_3e_3) =$$

$$a_{1,1}x_1y_1e_2 + (a_{1,1}x_1y_2 + \alpha(a_{2,1}x_1 + 2a_{1,1}x_2)y_1)e_3$$

$$Ay = \begin{pmatrix} a_{1,1} & 0 & 0 \\ a_{2,1} & 2a_{1,1} & 0 \\ a_{3,1} & (\alpha+1)a_{2,1} & 3a_{1,1} \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \\ y_3 \end{pmatrix} = a_{1,1}y_1e_1 + (a_{2,1}y_1 + 2a_{1,1}y_2)e_2 +$$

$$(a_{3,1}y_1 + (\alpha+1)a_{2,1}y_2 + 3a_{1,1}y_3)e_3$$

$$x(Ay) = (x_1e_1 + x_2e_2 + x_3e_3)(a_{1,1}y_1e_1 + (a_{2,1}y_1 + 2a_{1,1}y_2)e_2 +$$

$$(a_{3,1}y_1 + (\alpha+1)a_{2,1}y_2 + 3a_{1,1}y_3)e_3) =$$

$$a_{1,1}x_1y_1e_2 + ((a_{2,1}y_1 + 2a_{1,1}y_2)x_1 + \alpha a_{1,1}x_2y_1)e_3$$

Yuqoridagi xisoblashlar (5) tenglik to‘g‘riligini ko‘rsatadi.

Teorema isbotlandi.

Endi biz lokal differensiallashni ko‘rib chiqamiz.

2-Teorema. Agar Δ matritsasi pastki uchburchak shaklda bo‘lsa, $N_4(\alpha)$ dagi Δ chiziqli akslantirish lokal differensiallash bo`ladi.

Isboti. Δ- $N_4(\alpha)$ bo‘yicha ixtiyoriy lokal differensiallash bo‘lsin va Δ matritsasi

$$A = \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{pmatrix}$$

bo‘lsin. Barcha $x = x_1e_1 + x_2e_2 + x_3e_3$ uchun ta’rifga ko‘ra $N_4(\alpha)$ ustida A differensiallash mavjudki

$$\Delta(x) = A_x\,(x)$$

tenglik o`rinli.

2-teoremaga ko`ra $A_x$ differensiallash quyidagi ko`rinishga ega bo`lsin

ISSN 3030-3907

$$A_x = \begin{pmatrix} \beta_x & 0 & 0 \\ \gamma_x & 2\beta_x & 0 \\ \delta_x & (\alpha+1)\gamma_x & 3\beta_x \end{pmatrix}$$

$x = e_1, x = e_2, x = e_3$ larni tanlab va $\Delta(x) = A_x(x)$ tenglikdan foydalanib, ya`ni $A\bar{x} = A_x\bar{x}$ ga ko`ra $b_{12} = b_{13} = b_{23} = 0$ natijaga ega bo`lamiz. Bu yerda $\bar{x} - x$ ga mos vektor. Bundan A matritsa

$$A = \begin{pmatrix} b_{11} & 0 & 0 \\ b_{21} & b_{22} & 0 \\ b_{31} & b_{32} & b_{33} \end{pmatrix}$$

ko`rinishga keladi.

Yana $\nabla(x) = A_x(x)$ dan foydalanib, ya'ni $A\bar{x} = A_x\bar{x}$ ga ko`ra

$$\begin{pmatrix} b_{11} & 0 & 0 \\ b_{21} & b_{22} & 0 \\ b_{31} & b_{32} & b_{33} \end{pmatrix}\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} \beta_x & 0 & 0 \\ \gamma_x & 2\beta_x & 0 \\ \delta_x & (\alpha+1)\gamma_x & 3\beta_x \end{pmatrix}\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}$$

Tenglamalar sistemasiga ega bo`lamiz.

$$\begin{cases} \beta_x x_1 = b_{1,1}x_1 \\ \gamma_x x_1 + 2\beta_x x_2 = b_{2,1}x_1 + b_{2,2}x_2 \\ \delta_x x_1 + (\alpha+1)\gamma_x x_2 + 3\beta_x x_3 = b_{3,1}x_1 + b_{3,2}x_2 + b_{3,3}x_3 \end{cases}$$

Agar $x_1 \neq 0$ bo‘lsa

$$\beta_x = b_{1,1}$$

$$\gamma_x = b_{2,1} + (b_{2,2} - 2\beta_x)\frac{x_2}{x_1}$$

$$\delta_x = b_{3,1} + (b_{3,2} - (\alpha+1)\gamma_x)\frac{x_2}{x_1} + (b_{3,3} - 3\beta_x)\frac{x_3}{x_1}$$

Agar $x_1 = 0,\ x_2 \neq 0$ bo‘lsa,

$$2\beta_x = b_{2,2},$$

$$(\alpha+1)\gamma_x = b_{3,2} + (b_{3,3} - 3\beta_x)\frac{x_3}{x_1}$$

Agar $x_1 = x_2 = 0,\ x_3 \neq 0$ bo‘lsa,

$$3\beta_x = b_{3,3}.$$

Teorema isbotlandi.

Endi 2-lokal differensiallashini bayon etamiz.

ISSN 3030-3907

2-Ta'rif. Akslantirish (chiziqli bo'lishi shart bo'lmagan) $\nabla: A \to A$ 2-lokal differensiallshlari deyiladi, agar har qanday $x, y \in A$ elementlar uchun shunday $\nabla_{x,y}: A \to A$ differensiallshlari mavjud bo'lsaki,

$$\nabla(x) = A_{x,y}(x), \nabla(y) = A_{x,y}(y).$$

3-Teorema. $N_4(\alpha)$ algebraning har bir 2-lokal differensiallashi differensiallashdir.

Isbot. Aytaylik ∇–bu $N_4(\alpha)$ ning ixtiyoriy 2-lokal differensiallashlari bo'lsin.

U holda, 2-tarifga ko'ra har bir $x \in N_4(\alpha)$ element uchun,

$$x = x_1 e_1 + x_2 e_2 + x_3 e_3,$$

$\beta_{x,e_1}, \gamma_{x,e_1}, \delta_{x,e_1}$ shunday elelemt mavjudki

$$A_{x,e_1} = \begin{pmatrix} \beta_{x,e_1} & 0 & 0 \\ \gamma_{x,e_1} & 2\beta_{x,e_1} & 0 \\ \delta_{x,e_1} & (\alpha+1)\gamma_{x,e_1} & 3\beta_{x,e_1} \end{pmatrix},$$

$\nabla(x) = A_{x,e_1}\bar{x}$, bu yerda $\bar{x} = (x_1, x_2, x_3)^T$–$x$ ga mos vektor va

$$\nabla(e_1) = A_{x,e_1}\overline{e_1} = (\beta_{x,e_1}, \gamma_{x,e_1}, \delta_{x,e_1})^T.$$

Tengliklar $\nabla(e_1) = A_{x,e_1}(e_1) = A_{y,e_1}(e_1)$o'rinli bo'lgani uchun

$$\nabla(e_1) = (\beta_{x,e_1}, \gamma_{x,e_1}, \delta_{x,e_1})^T =$$

$$= (\beta_{y,e_1}, \gamma_{y,e_1}, \delta_{y,e_1})^T$$

$N_4(\alpha)$ dagi elementlarning har bir x, y juftligi uchun.

Shunday qilib,

$$\beta_{x,e_1} = \beta_{y,e_1}, \gamma_{x,e_1} = \gamma_{y,e_1}, \delta_{x,e_1} = \delta_{y,e_1}.$$

Shuning uchun

$$\nabla(x) = A_{y,e_1}\bar{x}$$

Har qanday $x \in N_4(\alpha)$uchun va $\nabla(x)$ matritsasi x ga bog'liq emas.

SHunday qilib, 3-teoremaga ko'ra, ∇ differensiallashdir.

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