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BIRINCHI TARTIBLI ELLIPTIK TIPLI TENGLAMALAR SISTEMASI UCHUN INTEGRAL FORMULA

Annotasiya: Birinchi tartibli elliptik tipli tenglamalar sistemasi uchun integral formula keltirilgan.

Xususiy hosilalardagi birinchi tartibli

$$D\left(\frac{\partial}{\partial x}\right)f(x) = 0 \qquad (1.1)$$

chiziqli differensial tenglamalar sistemasini qaraymiz, uning xarakteristik matrisasi

$$D(x) \in A_{k\times l}(p(x), x) \qquad (0.2.2)$$

$$f(x) = \begin{Vmatrix} f_1(x) \\ \dots \\ f_l(x) \end{Vmatrix} \qquad (2.1)$$

esa kompleks qiymatli umumiy holda vektor funksiya .

Kalit so'zlar: differensial tenglamalar sistemasi.

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$g_1(x)...g_l(x)$- mos ravishda

$$p_1\left(\frac{\partial}{\partial x}\right)...p_l\left(\frac{\partial}{\partial x}\right)$$

operatorlarning fundamental yechimlari va

$$g(x) = \begin{Vmatrix} g_1(x) \\ \dots \\ g_l(x) \end{Vmatrix}$$

$$M(x) = \left(E\big(g(x)\big) \cdot \Gamma D\left(\frac{\partial}{\partial x}\right)\right) \cdot \left(* \, D\left(\frac{\partial}{\partial x}\right)\right), \qquad (4)$$

$(l \times l)$ – matrisa differensial operator bu yerda formal ravishda ,

$$N(x) = \left(E\big(g(x)\big) \cdot \Gamma D\left(\frac{\partial}{\partial x}\right)\right) \cdot \left(* \, D\left(\frac{\partial}{\partial x}\right)\right), \qquad (5)$$

$$* \, D\left(\frac{\partial}{\partial x}\right) = D\left(* \frac{\partial}{\partial x}\right) = D\left(\frac{\partial}{\partial x} dx\right) = D\left(\frac{\partial}{\partial x}\right) dx.$$

deb faraz qilamiz.

(2) va (1) dan

$$dM(x) =* \, E\big(g(x)\big)\left((\Gamma D D)\left(\frac{\partial}{\partial x}\right)\right) =$$

$$=* \, E\big(g(x)\big)E(p(\frac{\partial}{\partial x}))) =* \, (E(\delta(x)1_l)) = \delta(x)Edx. \qquad (6)$$

kelib chiqadi, bu erda $E = E(1_l)$ birlik ($l \times l$) – matrisa , $\delta(x)$ Dirak δ-funksiyasi.

Agar (3) vektor funksiya C^1 sinfga tegishli bo'lsa, u holda (2.2.4) va (2.2.5) dan

$$M(x) \wedge df(x) = (-1)^{n-1} N(x) \, f(x) \qquad (7)$$

kelib chiqadi.

(5) va (6) dan birdaniga tayinlangan x uchun ayniyat kelib chiqadi:

$$d\big(M(y-x)f(y)\big) - N(y-x)f(y) = \delta(y-x)f(y)dy \qquad (8)$$

Endi R^n dagi elliptik operatorlarning fundamental yechimlari xossalari sohadagi [3] dagi natijani e'tiborga olib, (2.2.5) ni integrallash bilan silliq bo'lakli ∂G chegarali $G \in R^n$ chegaralangan soha va $C^1(\overline{G})$ sinfning (1) vektor funksiya uchun quyidagi integral formula o'rinli.

$$\int_{\partial G_y} M(y-x)f(y) - \int_{G_y} N(y-x)f(y) = \begin{cases} f(x), x \in G, \\ 0, \quad x \notin \overline{G}. \end{cases} \qquad (9)$$

(6) ni bu sistematik $D(x)$ xarakteristik matrisasiga (2) shartga esa (3) sistema yechimlari ucnun qurilgan Grin formulasi sifatida qarash mumkin.

(3) ni hisobga olib, (5) dan standart usul bilan quyidagi teorema olinadi.

teorema. $G \in R^n$ - silliq bo'lakli chegarali chegaralangan soha va (2.2.5) $f(x) \in C^1(G) \cap C(\overline{G})$ vektor funksiya (2) shartda (1) sistemaning yechimi bo'lsin , u holda

$$M(y-x)f(y) = \begin{cases} f(x), & x \in G, \\ 0, & x \notin \overline{G}. \end{cases} \qquad (10)$$

(7) formuladan natijadan xususan, (1) sistemaning $C^1(G)$ sinfdagi yechimi (2) shart bajarilganda haqiqatdan, G sohada analitik funksiyalar bo'ladi. Bundan va (7) misoldan ko'rinadiki, (1) sistemaga (2) shartning qo'yilishi bu sistema elliptik bo'lishiga teng kuchli.

(1) elliptik sistemalar yechimlari uchun soha chegarasi bo'yicha integral tasvirlashlar isbotlangan.

1 eslatma. 1-teoremada $A_{k\times l}(p(x),x)$, determenantda $p_i(x), i = \overline{1,l}$ ko'phadlarni faqat β −gipoelliptikligini talab qilsak, o'zida saqlaydi.

Bunda (1) sistemaning $C^1(G)$ sinfga tegishli barcha yechimlari G sohagan tegishli bo'ladi . Bundan tashqari yuqoridagi barcha hisoblashlar unchalik katta bo'lmagan o'zgarishlar bilan ixtiyoriy sistemalarda, shu sistemalarga o'tkaziladi, faqat qo'shma $*D\left(\frac{\partial}{\partial x}\right)y(x) = 0$ sistemaning tegishli xossalarga ega fundamental yechimlar matrisasi mavjud bo'lishi lozi

misol.

$(n\times n)$ −matrisa $\|a_{ij}\| a_{ij} + a_{ji} = 0, i \neq j,\ a_{ij} = 1$ (11)

shartni qanoatlantiruvchi $a_{ij}, i,j = \overline{1,n}$ kompleks sonlardan iborat bo'lsin.

U holda $(n\times 1) -$ matrisa

$$D(x) = \left\| \begin{matrix} \sum_{j=1}^{n} a_{ji}x_j \\ \cdots\cdot\cdot \\ \sum_{j=1}^{n} a_{jn}x_j \end{matrix} \right\| \in A_{n\times 1}(|x|^2, x) \qquad (12)$$

chunki (11) shartga ko'ra $\Gamma D(x) = \|x_1 \ldots x_n\|$ deb olish mumkin.

misol.

[9] da R^3 fazoda C^1 dagi Koshi-Riman sistemasining uning yechimlari ma'nosidagi analitik o'xshash Koshi integralini tuzish mumkin. (4×4) – matrisa

$$\left\| \begin{matrix} 0 & x_1 & x_2 & x_3 \\ x_1 & 0 & x_3 & x_2 \\ x_2 & x_3 & 0 & -x_1 \\ x_3 & -x_2 & x_1 & 0 \end{matrix} \right\| \qquad (13)$$

(11) ko'rinishidagi Montel-Teodoresko sistemasi hisoblanadi.

(13) matrisa $O_{4\times4}(x)$, $x \in R^3$ sinfga tegishli bo'lishi oson tekshiriladi.

misol.

[10] da [9] ning umumlashmasi sifatida

$$D(f)\frac{\partial}{\partial x} = 0 \qquad (14)$$

sistemaning yechimlari uchun R^n da Koshi integrali analogi o'rnatilgan, bu yerda $D(x) -$ giperkompleks $n \times n$ matrisa (bunda matrisalar faqat $n = 2^m,\ m = 1,2,..$ [10] da mavjud).

Haqiqatdan giperkompleks $n \times n$ matrisa $O_{n\times n}(x), x \in R^n$ sinfga tegishli 1 esa [10] dan formulaning boshqacha ko'rinishi.

misol.

[11] da [9] natijaning boshqa umumlashmasi $(n-2)$ darajali forma (komponentlariga) va

$$\begin{cases} \delta\psi = 0, \\ d\psi =* du \end{cases} (\begin{Vmatrix} \delta & 0 \\ d & -* d \end{Vmatrix} \cdot \begin{Vmatrix} \psi \\ u \end{Vmatrix} = 0) \qquad (15)$$

u differensiallarga nisbatan birinchi tartibli chiziqli differensial tenglamalar sistemasi qaralgan.

δ operator R^n dagi $q -$chi darajali formalarda

$$\delta\psi = (-1)^{n(q+1)+1} * d * \psi \qquad (16)$$

tenglik bilan aniqlanadi.

Bu sistemaning xarakteristik matrisasi

${O^c}_{(C_n^1+C_n^3)\times(C_n^2+1)}(x)$, sinfga tegishli (11) formula [11] dagi integral tasvirlashlarning boshqacha ko'rinishini beradi.

misol.

[12] da

$$(D(x))^2 = E(|x|^2 1_{2^n}) \qquad (17)$$

sharti esa $(2^n \times 2^n)$– $D(x)$ matrisalar qaralgan.

Bunday matrisalar Klifford [13] algebraik tasvirlashlarni tuzishda paydo bo'ladi. Ko'rish qiyin emaski, (17) matrisalar

$A_{2^n\times 2^n}(|x|^2 1_{2^n}, x)$ sinfga tegishli (bu yerda $F = E(1_{2^n})$, (10) –[12] dagi integral formulasi boshqacha ko'rinishi).

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