TAQSIMOTLARNING FURE INTEGRAL ALMASHTIRISHLARI VA ULARNING XOSSALARI

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Anatatsiya: Umumlashlgan funksiya deganda ba'zi asosiy funksiyalar sinfida aniqlangan chiziqli uzluksiz funksional tushuniladi. Ko'rib chiqilayotgan vazifalarga qarab, funksiyaning o'ziga xos xususiyatlarini hisobga olgan holda, asosiy funksiyalarning turli xil sinflaridan foydalaniladi.

Kalit so'zlar:kompleks son, lokal integral, Fure almashtirish, component

FURE INTEGRAL SUBSTITUTIONS OF DISTRIBUTIONS AND THEIR PROPERTIES

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Annotation: A generalized function is a linear continuous function defined in some class of basic functions. Depending on the tasks under consideration, different classes of basic functions are used, taking into account the specific features of the function.

Keywords: complex number, local integral, Fure substitution, component

Umumlashgan funksiya (taqsimot) tushunchasi fanga birinchi bo'lib P.Dirak tomonidan 1930-yilda uning kvantomexanik tadqiqotlarida kiritilgan va bunda asosan Dirakning mashhur δ- funksiyasidan keng foydalanilgan. Taqsimotlar nazariyasining matematik asosi S.L.Sobolev tomonidan 1936-yilda qurilgan va giperbolik tipdagi tenglamalar uchun Koshi masalasini yechishda qo'llanilgan. Umumlashgan funksiya tushunchasi ko'plab olimlar tomonidan o'rganilgan. Umumlashgan funksiyalar nazariyasining jadal rivojlanishi birinchi navbatda matematik fizika talablaridan, asosan differensial tenglamalar nazariyasi va kvant fizikasi talablaridan kelib chiqdi.

Ta'rif: *f : D(ℝ)→ ℂ*– akslantirishga *D*(*ℝ*) da funksional deyiladi, bu yerda *ℂ*- kompleks sonlar maydoni.

f funksionalning *φ∈D(ℝ)* funksiyadagi qiymati *(φ, f)* bilan belgilanadi.

Ta'rifga asosan *(φ, f)* – kompleks son.

Ta'rif. Agar ixtiyoriy *φ, ψ∈D(ℝ)* va *α,β∈ℂ* lar uchun

$$(f,\alpha\varphi+\beta\psi)=\alpha(f,\varphi)+\beta(f,\psi)$$

tenglik o'rinli bo'lsa, *f : D(ℝ)→ ℂ* funksional chiziqli deyiladi.

Ta'rif. Agar *D(ℝ)* da nolga intiluvchi ixtiyoriy sunksiyalar ketma-ketligi $\{\varphi_k(x)\} \in D(\mathbb{R})$ uchun $k\to\infty$ da $(f, \varphi_k) \to 0$ bo'lsa, $f : D(\mathbb{R}^n)\to \mathbb{C}$ funksional uzluksiz deyiladi.

Ta'rif. Chiziqli, uzluksiz *f: D(ℝ)→ℂ* funksionalga umumlashgan funksiya (taqsimot) deyiladi.

$f(x),\ x\in\mathbb{R}$ funksiyaning Fure almashtirishi deb,

$$\hat{f}(\xi)=\int_{R} e^{i\xi x} f(x)dx \qquad (1)$$

tenglik yordamida aniqlangan ξ o'zgaruvchili funksiyaga aytiladi.

Fure almashtirishining ba'zi xossalarini keltiramiz:

1) $F\left[x^m f(x)\right](\xi)=-i\dfrac{\partial}{\partial\xi}\int_{\mathbb{R}} x^{m-1} f(x)e^{i\xi x}dx=\ldots=(-i)^m \hat{f}^{m}(\xi);$

2) $F\left[f^m(x)\right](\xi)=-\int_{\mathbb{R}} f^{m-1}(x)\dfrac{\partial}{\partial x}e^{i\xi x}dx=\ldots=(-i\xi)^m \hat{f}(\xi);$

3) $F\left[f(x-x_0)\right](\xi)=\int_{\mathbb{R}} f(y)e^{i\xi(y+x_0)}dy=e^{i\xi x_0}\hat{f}(\xi);$

4) $F\left[f(x)e^{i\xi_0 x}\right](\xi)=\int\limits_{\mathbb{R}} f(x)e^{i(\xi+\xi_0)x}dx = f(\xi+\xi_0);$

D(ℝ^n) dan olingan *φ(x)* funksiya ℝ^n da lokal integrallanuvchi bo'lganligi sababli, bunday funksiyalar uchun Fure almashtirishi aniqlangan:

$$F[\varphi](\xi)=\int\limits_{\mathbb{R}^n}\varphi(x)e^{i(\xi,x)}\,dx \tag{2}$$

bu yerda

$$(\xi,x)=\sum_{i=1}^{n}\xi_i x_i$$

$F[\varphi](\xi)-\varphi(x)$ funksiyaning Fure almashtirishi.

$\alpha=(\alpha_1,\alpha_2,...,\alpha_n)$ manfiy bo'lmagan, komponentlari butun α_j sonlardan iborat vektor bo'lsin. $D^\alpha f(\mathrm{x})$ orqali *f(x)* funksiyaning $|\alpha|=\alpha_1+\alpha_2+...+\alpha_n$ tartibli hosilasini ifodalaymiz:

$$D^\alpha f(\mathrm{x})=\frac{\partial^{|\alpha|}f(\mathrm{x}_1,\mathrm{x}_2,...,\mathrm{x}_n)}{\partial x_1^{\alpha_1}x_2^{\alpha_2}...x_n^{\alpha_n}},\, D^0 f(\mathrm{x})=f(\mathrm{x})$$

$$D=(\mathrm{D}_1,\mathrm{D}_2,...,\mathrm{D}_n),\mathrm{D}_j=\frac{\partial}{\partial x_j},\, j=1,2,..,n$$

φ(x) asosiy funksiyalar uchun (2) integral aslida chekli soha bo'yicha integraldan iborat. Shuning uchun Fure almashtirishini ξ o'zgaruvchi bo'yicha integral ostida istalgancha differensiallash mumkin:

$$D^\alpha F[\varphi](\xi)=\int(ix)^\alpha\varphi(x)e^{i(\xi x)}\,dx=F\left[(ix)^\alpha\varphi\right](\xi)$$

D(ℝ^n) dan olingan *φ(x)* funksiyalarning Fure almashtirishi ℝ^n da absolyut integrallanuvchi va uzluksiz differensiallanuvchi bo'lgani uchun, Fure almashtirishlarning umumiy nazariyasidan unga teskari F^{-1} almashtirishning mavjudligi kelib chiqadi:

$$\varphi(x) = F^{-1}\left[F\left[\varphi\right]\right] = F\left[F^{-1}\left[\varphi\right]\right]$$

bunda

$$F^{-1}\left[\varphi\right](x) = \frac{1}{(2\pi)^n}\int_{\mathbb{R}^n}\varphi(\xi)e^{-i(\xi,x)} = \frac{1}{(2\pi)^n}F\left[\varphi\right](-x) = \frac{1}{(2\pi)^n}\int_{\mathbb{R}^n}\varphi(-\xi)e^{-i(\xi,x)} = \frac{1}{(2\pi)^n}F\left[\varphi(-\xi)\right]$$

Endi *f(x)* funksiya $\mathbb{R}^n$ da absolyut integrallanuvchi bo'lsin. U holda uning Fure almashtirishi

$$F\left[f\right](\xi) = \int_{\mathbb{R}^n} f(x)e^{i(\xi,x)}dx, \left|F\left[f\right](\xi)\right| \le \int_{\mathbb{R}^n}\left|f(x)\right|dx < \infty$$

$\mathbb{R}^n$ da uzluksiz va chegaralangan bo'lib, ixtiyoriy $\varphi \in D(\mathbb{R}^n)$ funksiyalar uchun umumlashgan funksiyani aniqlaydi:

$$(F\left[f\right],\varphi) = \int_{\mathbb{R}^n} F\left[f\right](\xi)\varphi(\xi)\,d\xi$$

Integrallash tartibini o'zgartirish haqidagi Fubini teoremasidan foydalanib, oxirgi integralni o'zgartiramiz:

$$\int_{\mathbb{R}^n} F\left[f\right](\xi)\varphi(\xi)\,d\xi = \int_{\mathbb{R}^n}\left[\int_{\mathbb{R}^n} f(x)e^{i(\xi,x)}dx\right]\varphi(\xi)\,d\xi = \int_{\mathbb{R}^n} f(x)\int_{\mathbb{R}^n}\varphi(\xi)e^{i(\xi,x)}dx = \int_{\mathbb{R}^n} f(x)F\left[\varphi\right](x)\,dx$$

Demak,

$$\left(F\left[f\right],\varphi\right) = \left(f, F\left[\varphi\right]\right), f \in D'(\mathbb{R}^n), \varphi \in D(\mathbb{R}^n)$$

Bu tenglikni umumlashgan funksiyalarning Fure almashtirishi sifatida qabul qilamiz.

Misollar.

$$F\left[\delta\left(x - x_0\right)\right] = e^{i(\xi, x_0)}$$

tenglikning o'rinli ekanligini ko'rsatamiz.

Haqiqatan ham, ixtiyoriy $\varphi \in D\left(R^n\right)$ uchun

$$\left(F\left[\delta\left(x-x_0\right)\right],\varphi\right)=\left(\delta\left(x-x_0\right),F[\varphi]\right)=$$

$$=F[\varphi]\left(x_0\right)=\int_{R^n}\varphi(\xi)e^{i(\xi,x_0)}d\xi=\left(e^{i(\xi,x_0)},\varphi\right)$$

Agar bunda $x_0=0$ bo’lsa, $F[\delta]=1$ bo’ladi. Bu yerdan

$$\delta(x)=F^{-1}[1]=\frac{F[1]}{(2\pi)^n}$$

Shuning uchun $F[1]=(2\pi)^n\delta(\xi)$ tenglik o’rinli bo;ladi.

Foydalanilgan adabiyotlar ro’yxati

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