The indefinite expressions in mathematics

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***Abstract*—With help of a new system of coordinates from the point of view of the reverse functions we obtain a two z=f(r+A)=f(p), z=f(r+A)=h(r) equation, which are possible to be considered as the equation of the one M graph on the complex plane, (the set of points M=(z, f(p)): z=f(p) for all p, if p and z are the complex variables), but z=h(r) is the M equation, and z=f(r+A) is the equation of a other set of point with point of view of the revers functions, (moved to the left on the A>0, for all the values of the complex r=p variable), r is the variable for the (A,0) center of coordinates. In the situation z is the unmoved variable, and p is the other designation of r.**

Similar facts are proved without the use of reverse functions. It is proved, that a two different variables are possible to be considered as one argument in the primary system of coordinates on the complex plane for the *z* = *f*(*p*) function: both z=f(p) and z=f(P) equations are the M equation with P-A=p, A>0. For all the p+A=s, r=p<P, z variables we obtain (s is variable in the third system of coordinates with the (-A,0) center). With help of the second theme in some other new system of coordinates the M equations is a x-field of motions in relation to some regular function (z=f(-x+iy) is the x-field of motions in relation to the z=f(x+iy) function). It is proved, that the M equation is possible to be considered as regular function with point of view of other mathematical facts in the same new the system of coordinates: in the system of coordinates instead of the OX axis we consider the iOX axis, and instead of the iOY axis we consider the OY axis. The M set of points is fixed.

We consider the surprising regularity of the transform of Laplace from the transform of Fourier from the point of view of the odd or even reflection of the transform in relation to the center of co-ordinates too. As result, the transform of Laplace from the transform of Fourier of S(x) is odd or even in usual assumption about the S(x) function.

***Keywords* — Analytical functions different coordinate system of coordinates, fields of complex functions, periodicity, surprising regularity, transform of Laplace.**

I. Introduction

. In the article in main situations the existence of new equation of the fixed set of points (graph) is proved, if we consider a new systems of coordinates on the complex plane, (the 1,2,3 theorems [1,2]); we obtain the different equations with only the p argument in the primary system of coordinates. It is **the first theme** of the article, (sections 3) [2].

The second theme of article is considered in the fourth part of the article (lemma 1) [2]. As result of the lemma 1 the transform of Laplace from the transform of Fourier of S(x) is odd or even in the usual assumption about the S(x) function. We obtain the surprising regularity of the

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$LF_{\pm}^{0}S(x)(\cdot)(v)$ function in the full complex J plane without some n points (the lemma 1), where

$$LF_{\pm}^{0} = LF_{\pm}^{0}S(x)(\cdot)(v) = \int_{0}^{\infty} e^{-vt}dt \int_{0}^{\infty} e^{\pm ixt}S(x)dx.$$

The regularity is proved from the point of view of the odd or even reflection of the $LF_{\pm}^{0}$ function in relation to other center of co-ordinates.

With other point of view it is the multiple-meaning function, [1-4], (see the interesting example in the conclusion too).

Both themes result in the paradoxical results. We will illustrate the untraditional assertion **for the first theme** with help of the obvious example [2]: we can consider the regular $z = f(p)$ functions as in a primary coordinates (with the $0,0)$ center of coordinates) so as in different coordinate system, $p \in G$; the center of coordinates of the second system is located in the $(A,0)$ point,

$$G = |\,p\,| < A_0,\ A_0 \in (0,\infty), 0 < 7A < A_0,$$

r is the new complex variable in the new coordinate system, where

$$z = h(r) = f(p + A)|_{p=r}$$

is the new equation of the M set of points (graph) in the second system:

$$M = \{(z, f(p)) : p \in G \bigcap z = f(p)\},$$

$G = |\,p\,| < A_0$. The M set is the $y = f(x)$ graph, if $p = x \in (-\infty,\infty), z = y \in (-\infty,\infty)$. We can consider the $z = f(r + A)$ equation for $r = p$. For all $r = p$ the $z = f(p + A)$ equation is the equation of M_{leftA}, where the M_{leftA} set of points is the M set moved to the left on the A value, $p - A = r, 7A < A_0$ [2].

It is obviously, for all r the $z = f(r + A)$ equation is the $z = f(p)$ equation of the M set; we use the definitions of the second system of coordinates with the $p = r + A$ variable (argument) in the primary system, where $z = f(r + A) = h(r)$, (further $r = p$ too).

(About the two different $p + A = P$ variables as one argument in the primary system of coordinates see the theorem 2 ; we will mark, that the two obvious variant are the main rezone of the section 2 [2]).

From the point of view of the reverse

$$f_2^{-1}(z) \equiv f_1^{-1}(z)$$

functions with $f_1^{-1}(z) = p$, $f_2^{-1}(z) = r$ for all the $p = r, z$ we obtain the new $z = f(p + A)$ equation of the fixed M set,

$$f_1(p) = f(p + A) = f(r + A) = f_2(r) = z,$$

for all $p = z \in G, f_2^{-1}(f(r + A)) = f_2^{-1}(h(r)) = r$,

$$f_1^{-1}(f(p + A)) = p, f_2^{-1}(f(r + A)) = r$$

$p + A = r + A$, [2]: $z = h(r)$ is the equation of the M set of points, $f(p + A) = z$ is the equation of the M_{leftA} set of points, and in the situation z is the "unmoved" variable, p is the other designation of r.

The example is the first interesting fact of the article.

In the theorem 1 we consider a constructive proof of the example without the reverse functions, (see so the remark 2 in the second section) [2]. It is proved in the theorem 2, that a two different variables are possible to be considered as one argument in the primary system of coordinates on the complex plane for the $z = f(p)$ function [1]: both $z = f(p_1)$ and $z = f(p_2)$ equations are the M equation with fixed M for all the $A > 0$, but $p_1 - A = p_2 \neq p_1$, and $p = p_1$ or $p = p_2$.

The third theme of the article is considered in the section 3. A new result we can obtain for the complex $z = F_x(p) = F(p)$ x-field in the theorem 3, where, by definition,

$$F_x(x + iy) = f(-x + iy)$$

for all $p = x + iy$ complex variables, $p \in G$, [2].

In the theorem 3 instead of the OX axis we consider the iOX axis, and instead of the iOY axis we consider the OY axis: it is the second $K2$ system of coordinates for the fixed M set of points. If on the coordinate axes in the primary system of coordinates we will change the x, y variables by places, we obtain the third $K3$ system of coordinates for the fixed M set of points. In the $K3$ system the equation of the fixed M set of points (graph) is

$$z = u(y, x) + v(y, x)i = f(y + ix),$$

if the M equation is equal to

$$z = f(p) = u(y, x) + v(y, x)i$$

in the primary system of coordinates. It is obvious, that the M equation in the $K3$ system is the diagonal-field, (the $F_{dia}(p)$ field in relation to the $x = y$ diagonal, the precise definitions are resulted in the section 3).

The OY, iOX axes of K2 system are the result of rotation of the $K3$ system on the $\pi/2$ angle and the change of the new iOX direction on opposite, (from the last action the x-field becomes some regular function in the K2 system in relation to the (x, y) variables). We obtain, that one of the M equations in the $K2$ and $K3$ systems is the field and the other equation is the $z = f(p)$ analytical function [1], (the same result we obtain from

$$z = f(i(y + Xi))|_{X=-x} = f(x + yi) = u + iv$$

in the K2 system).

For the fixed M set of points in the K2 system of coordinates we get the two different equations [1,2] **in the same K2 system**, (the theorem 3): the $z \to x + iy$ representation correspond to the first $z = f(x + iy) = u + iv$ equation in the $K2$ system, and the $z \to ix + y$ representation in the same K2 system of the fixed M set of points correspond to **the other second** equation. The last $z \to ix + y$ representation in K3 system is the diagonal-field (the "field of change") as the representation of the complex x,y numbers, (the theorem 3, [2]).

II. NEW SYSTEMS OF COORDINATES

In the theorems 1,2 we proved the example of the introduction without the use of the reverse f^{-1} function; the $z = f(p)$ function is regular in $G = |p| < A_0$. By definition, the

$$z = f(p)\,,\; z = h(r)\,,\; z = g(s)$$

equations are the equations of the M set of points in the systems of co-ordinates with the $(0,0)$, $(A,0)$ and $(-A,0)$ centers of coordinates accordingly, $A > 0, 7A < A_0$.

Theorem 1.

From the point of view of the new system of coordinates $z = f(s) = h(r)$ for all

$$r + A = s \in \{|p| < 7A\} \in G\}, r = p,$$

(instead of $s + A = P$ - the new P argument in the primary system of coordinates), and the

$$z = f(s) = h(P - A)$$

equations are the M_{left} and M equations for all the

$$z = f(s) = h(P - A), P = s \in G,$$

and P is the usual version of the p variable.

Proof.

We will consider two statements: the $z = f(p)$ equation is the $z = f(s - A)$ equation, (we use $s = p + A \in G, p \in G$) in the "left" system of co-ordinates, $A > 0$; the $z = f(p)$ equation is the $z = h(r - A)$ equation with the same $z = z_0$ and $r = p$, (we use $z = f(p) = h(r - A)$ for all $p = r$) in the "right" system of co-ordinates, $s = p + A, p = r$. We obtain

$$z_0 = z = f(s - A) = h(r - A)$$

with all the

$$r + A = s \in G, p = r$$

values. We obtain

$$z = f(s) = h(r)$$

for all $r+A=s\in G$ with other z. The $z=f(s)$ is the M_{leftA} equalities, the $z=h(r)$ is the M equalities with the $r+A=s$ association as in the "neighboring" systems with the $(-A,0)$ and $(0,0)$ centers of co-ordinates, (instead of $r+A=P$ -the argument in the primary system of coordinates)!?. We obtain

$$z=f(s)=h((r+A)-A)=h(P-A),$$

where $s=r+A=P\in G$. The $z=f(s)$ is the M_{leftA} equalities, $z=h(P-A)$ is the M equality, (we use the $z=h(P)$ equality is the M_{leftA} equality with the same $z=f(s)=h(P-A), s=r+A=P\in G$).

The theorem 1 is proved.

The remark 1 repeats the statement of the example of introduction without the inverse f^{-1} functions too.

Remark 1.

The $z=f(p+A)=h(r)$ equality takes place with the same $r=p$, $7A<A_0, p=r\in[0,A]$, (p is the complex variable (an argument) in the primary system with the $(0,0)$ center); r is the complex variable in the system with $(A,0)$ center, $A>0$. From the definition of the system with the $(-A,0)$ center $p+A=s$, and for the same z we obtain $z=f(p+A)=f(s)=h(r)$, s is the complex variable in the system with $(-A,0)$ center, $A>0$, the $f(p)$ function is regular in G, $7A<A_0$. We obtain

$$z=f(s), p=r,$$

(the M_{leftA} equation), and $z=h(r)$ is the M equation for the same $p+A=s, r=p, z$ and the $z=f(p+A)$ is the equation as of M_{leftA} so as M for the all $A>0$.

Theorem 2.

From the point of view of the "left" and "right" system of co-ordinates the two $p=p_1$, $p=p_2$ versions of the p variables take place for the same

$$M=\{(z,f(p)):p\in G\bigcap z=f(p)\},$$

set of points in the primary system of coordinates,

$$p_1-A=p_2\in G$$

for all $A>0$, $p_1,p_2,p\in G, 7A<A_0$.

Proof.

By definition,

$$M=\{(z,f(p)):p\in G\bigcap z=f(p)\},$$

p is the complex variable [1-4]. The M set is the $y=f(x)$ graph, if

$$p=x\in(-\infty,\infty), z=y\in(-\infty,\infty).$$

As in the introduction the

$$z=f(p-A)|_{p=s}=g(p)|_{p=s}=g(s)$$

equality takes place with $s=p>A$,

$$p>A, p=s\in[A,2A],$$

(p - the complex variable (an argument) in the primary system with the $(0,0)$ center); s - the complex variable in the system with $(-A,0)$ center, $A>0$. In the equalities p **is the first version of the variable for the** $z=f(p)$ **function,** $p=p_1>A.$.

By definition, the $z=g(s)$ equation of the M set is equivalent to the $z=f(p)=g(s)$ equation of the same M set of points, but in the new system of coordinates with the s variable, $s\in[A,2A], p=s, A>0$, and p **is the second version of the** p **argument** in the primary system of coordinates, $p=p_2$, but $p_2<p_1$ [2].

The theorem 2 is proved.

III. The moved x-fields and the regular functions

In the section we consider the complex $z=F(p)=F_x(p)$ field $F_x(p)=f(-x+iy)$ for all $p=x+iy$ complex variables, , $p\in G$,

$$G=\{p:|p|<A_0\}, A_0>0, \text{ [1-4].}$$

The field we will name x-field of motions in relation to $f(p)$ function, $p=x+iy$, $F_y(p)=f(x-iy)$ we will name y-field of motions in relation to $f(p)$ function, $p=x+iy$. The second

$$F_{dia}(p)=f(y+ix)=u(y,x)+v(y,x)i$$

field we will name diagonal-field of motions in relation to $f(p)$ function, $p=x+iy$, (diagonal-field relatively the $x=y$ diagonal). It is obvious,

$$f(y+ix)=f(i(-yi+x)),$$

and $F_{dia}(p)$ is y-field of motions in relation to $f(ip)$ function [1].

Theorem 3.

In some new system of coordinates (in the K2 system of coordinates) the M equations is x-field of motions in relation to some regular function, and the fixed M equation is possible to be considered as regular $z=f(p)$ function with point of view of other mathematical facts in the same K2 system of coordinates for the all $p\in G$.

Proof.

If instead of the OX axis we consider the iOX axis, and instead of the iOY axis we consider the OY axis, we obtain the second K2 system of coordinates. If on the coordinate axes in the primary system of coordinates we will change the x,y variables by places, we obtain the third K3 system of coordinates. In the K3 system the equation of the fixed M set of points (graph) is

$$z=u(y,x)+v(y,x)i=f(y+ix)=F_{dia}(p).$$

It is the diagonal-field in relation to the $f(p)$ function in the K3 system of coordinates. We will mark an useful fact: the OY,iOX axes of K2 system are the result of rotation of the K3 system on the $\pi/2$ angle and the change of the new iOX direction on opposite. As result one of the M equations in the K2 or K3 systems is x-field of motions in relation to some regular $f(\pm ip)$ function, and other the M equations is a regular function, (for the fixed M set of points). But it is obviously, the both M equations in the K2 and K3 systems are not regular functions: the M equation in the K2 system is the diagonal-field of motions in relation to $f(p)$ function in the K2 system of coordinates. But, as result of the rotation and the change the M equation is equal to the

$$z = f(p) = u(x,y) + v(x,y)i$$

equality, and, simultaneously, from the definition of the $z \to ix + y$ representation we obtain, that the

$$z = f(p) = u(y,x) + v(y,x)i$$

equality is the other equality of the fixed M set of points in the same K2 system.

We can use, that the $z \to x+iy$ representation for the $z = f(x+iy) = u+iv$ equation in the K2 system is not equal to the $z \to y+ix$ representation for the $z = f(x+iy) = u+iv$ equation in the same K2 system. By definition, the $z \to ix+y$ representation in theK2 system is the diagonal-field of motions in relation to $f(p)$ function in the K2 system of coordinates (in relation to the $z = u(x,y) + iv(x,y)$ equalities in the K2 system), (see .Mathematical Physics and Computer Simulation, vol. 27, no.4, pp. 17-22, 2024).

The theorem 3 is proved.

IV. The regularity of the transform of Laplace

The main result of the part is the lemma 1 [8].

By definition,

$$\int_0^\infty cosxv\, S(x)dx = C^0 S(x)(\cdot)(v) = C^0,$$

$$\int_0^\infty sinxv\, S(x)dx = S^0 S(x)(\cdot)(v) = S^0, v \in (-\infty,\infty),$$

$$C^0 S^0 = C^0[S^0 S(x)(\cdot)(v)](\cdot)(t),$$

$$S^0 C^0 = S^0[C^0 S(x)(\cdot)(v)](\cdot)(t), t \in [0,\infty),$$

$$L_\pm = L_\pm S(x)(\cdot)(v) = \int_0^\infty e^{\pm x} S(x)dx, L = L_-,$$

$$F_\pm^0 = F_\pm^0 S(x)(\cdot)(v) = \int_0^\infty e^{\pm ixv} S(x)dx,$$

L is the transform of Laplace,

$$LF_\pm^0 = LF_\pm^0 S(x)(\cdot)(v) = \int_0^\infty e^{-vt}dt \int_0^\infty e^{\pm ixt} S(x)dx,$$

$$L_+F_\pm^0 = L_+F_\pm^0 S(x)(\cdot)(v) = \int_0^\infty e^{vt}dt \int_0^\infty e^{\pm ixt} S(x)dx,$$

$$F_\pm = F_\pm S(x)(\cdot)(v) = \int_{-\infty}^\infty e^{\pm ixv} S(x)dx = F_\pm S(x)(\cdot)(v),$$

$v \in (-\infty,\infty)$. We use the Y1 condition: the $S(p)$ function is regular in J without some the $p_1 ... p_n$ points,

$$p_k \notin (-\infty,\infty) \cap p_k \notin (-i\infty, i\infty), k = 0,1,...n,$$

(the $S(p)$ function can be regular in J), $S(0) = 0,$

$$|S(p)||p|^{2+\delta} \to 0, |p| \to \infty$$

for come $\delta > 0, \delta = const.$

We can consider the functions

$$L_{right}^0(p) = LF_+^0 = LF_+^0 S(x)(\cdot)(p), Re\, p \ge 0,$$

$$L_{left}^0 = L_+F_+^0 = L_+F_+^0 S(x)(\cdot)(p), Re\, p \le 0.$$

Lemma 1.

The $L_{right}^0(p)$ function is regular in J , if the Y1 condition takes place.

Proof.

The $\pm L_{left}^0 = \pm L_+F_+^0 S(x)(\cdot)(p)$ function is the odd or even reflection of the

$$L_{right}^0(p) = LF_+^0 S(x)(\cdot)(p)$$

function from the right part of the plane in the left part of the plane in relation to the center of co-ordinates.

Let us $S(-p) = -S(p)$ in the area of the definition. For the $+L_{left}^0$ function we consider the

$$L_\Sigma(p) = L_{right}^0(p) + L_{left}^0(p)$$

sum for the $+L_{left}^0$ function. The $L_\Sigma(p)$ sum is equal to its reflection from the right part of the plane in the left part of the plane, and we obtain

$$L_\Sigma(p) = L_\Sigma(-p)$$

for all p from the area of the definition of the $L_\Sigma(p)$ function.

From the definition

$$L_{right}^0(iy) + L_{left}^0(iy) = 2C^0[C^0 S(x)(\cdot)(v)](\cdot)(y) +$$

$$+ i2C^0[S^0 S(x)(\cdot)(v)](\cdot)(y) =$$

$$= \pi S(y) + iC^0[S^0 S(x)(\cdot)(v)](\cdot)(y) = L_\Sigma(iy),$$

$y \in (-\infty,\infty)$. As the $C^0[S^0 S(x)(\cdot)(v)](\cdot)(y)$ function so as the $S(p)$ function are regular in J without some $n < \infty$ points, and we obtain, (it is well known [1=4]) , and we obtain, that the $L_\Sigma(p)$ function is regular in the same area, (in J without some $n < \infty$ points). We get, that $L_\Sigma(-p) = L(p),$

and the $L_\Sigma(p)$ function is regular in J without some

$n<\infty$ points, if $S(-p)=-S(p)$.

To prove the lemma 1 we can write

$$\lim_{p\to -x, Im\, p>0} L_\Sigma(p) = \lim_{p\to -x, Im\, p<0} L_\Sigma(p),$$

and

$$\lim_{p\to -x, Im\, p>0} L^0_{right}(p) = \lim_{p\to -x, Im\, p<0} L^0_{right}(p).$$

$p = x \in (-\infty, 0]$

The facts about the continuity of the functions on the full complex axis, and the $L^0_{right}(p), L^0_{left}(p)$ regularity is well-known, if

$$p \neq iy \cap y \notin (0,+\infty) \text{ for } L^0_{right}(p),$$

$$p \neq iy \cap y \notin (-\infty,0) \text{ for } L^0_{right}(p),$$

and $S(0)=0$.

If $S(-p)=S(p)$, we can consider the

$$L_-(p) = L^0_{right}(p) - L^0_{left}(p)$$

function with help of the $L_-(-p) = -L_-(p)$ equality.

The lemma 1 is proved.

As result of the proof the lemma 1 we obtain, that the $C^0[C^0S(x)(\cdot)(v)](\cdot)(t)$ function is regular in J without some $n<\infty$ points with the

$$C^0[C^0S(x)(\cdot)(v)](\cdot)(t) = C^0[C^0S(x)(\cdot)(v)](\cdot)(-t)$$

equality for all $t\in(-\infty,+\infty)$, if

$$S(-t) = -S(t), t\in(-\infty,+\infty).$$

From the lemma 1 we obtain, that the $LLS(x)(\cdot)(p)$ is regular function too, while

$$-(1/i)LLS(x)(\cdot)(p) = L\_F_+^0 S(x)(\cdot)(p/i).$$

for all $p \neq -y \cap y \in (0,+\infty)$. The fact conflict with well-known equalities

$$l_-(iy) = -\pi s(y) + i\,\mathrm{Im}\, l_-(iy), l_-(p) = L\_F_+^0 S(x)(\cdot)(p), \mathrm{Re}\, p \le 0,$$

$$l_+(iy) = \pi s(y) + i\,\mathrm{Im}\, l_+(iy), l_+(p) = L\_F_+^0 S(x)(\cdot)(p), \mathrm{Re}\, p \ge 0,$$

$$l_+(p) = l_-(p), p \neq iy, y\in(0,+\infty),$$

where $l_+(iy) \neq l_-(iy), y\in(0,+\infty)$, (see about the fact in the works of I.I. Privalov). A similar paradox we consider in conclusion.

With help of the consideration of lemma 1 we can prove, that for the

$$L_c(p) = 2C^0[LS(x)(\cdot)(v)](\cdot)(iy) = LLS(x)(\cdot)(iy) + \\ + LLS(x)(\cdot)(-iy)$$

functions takes place the $L_c(-p) = L_c(p)$ equality, and for the

$$L_s(p) = 2S^0[LS(x)(\cdot)(v)](\cdot)(p) = LLS(x)(\cdot)(iy) - \\ - LLS(x)(\cdot)(-iy)$$

function takes place the $L_c(-p) = -L_c(p)$ equality.

With help of the wall-known ([2-4])

$$C^0[LS(x)(\cdot)(v)](\cdot)(x) = L[S^0S(x)(\cdot)(v)](\cdot)(x)$$

and

$$S^0[LS(x)(\cdot)(v)](\cdot)(x) = L[C^0S(x)(\cdot)(v)](\cdot)(x)$$

equalities we get, that the transform of Laplace is odd and even, if the $S(p)$ function is even and odd in the Y1 condition of the lemma 1.

V. Conclusion

The methods of the first theme (related to new co-ordinates) result in many new surprising facts, for instance: the $z=g(a-s)$ and $z=f(-a-p)$ is the result of reflection of the M set of points of the $f(p)$ function in relation to the $(-A/2,0)$ points **in the primary system of co-ordinates** (with the p variable) and in **the “left” system of co-ordinates** with the $(-A,0)$ center (with the **s** variable and the $z=g(s)$ equation in the “left” system); (the $(-A/2,0)$ and $(-A,0)$ coordinates we consider in the primary system with the (0,0) center); but the $z=f(-a-p)$ equation in the form

$$z = f(P-a) = g(P)|_{P=-s} = g(-s)| : z = g(-s)$$

is not equal to the $z=g(a-s)$ equation of the same reflection [2].

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