Introduction Complex Numbers into Basic Growth Functions -(V) Hypothetic Factors Influencing Increase in θ in exp(θ)-

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Introducing Complex Numbers into Basic Growth Functions – (V) Hypothetic Factors Influencing Increase in θ in $\exp(\theta)$ –

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The present trial was designed to investigate hypothetic factors influencing the increase in θ after the appearance of $\exp(\theta)$ from $\exp(\boldsymbol{i}\theta)$. Hypothetic factors used in this trial were related to properties of indefinite integral and Euler's formula. The results obtained were as follows. It was shown hypothetically that '$(-1)+1$' appeared from '0' through indefinite integral of $f(\theta)$ on condition that $f(\theta)=0$, where there was not an increase in θ. The hypothetic breakdown of multiplication form connecting eight complex numbers to construct '-1' left $2\exp(\boldsymbol{i}\theta)$, and one of the two $\exp(\boldsymbol{i}\theta)$ was changed into $\exp(\theta)$ by the product of '$\boldsymbol{i}\theta$' and '$-\boldsymbol{i}$' (clockwise $\pi/2$ rotation of variable). The periodic increase in θ, the different breakdown of multiplication form and changing one of the complex numbers into real number gave $[-\exp(\boldsymbol{i}(\theta+2\pi))-\exp(\theta+2\pi)]$. Consequently it was shown that $\exp(\boldsymbol{i}\theta)$ was offset by $-\exp(\boldsymbol{i}(\theta+2\pi))$, due to the periodic property. However, both $\exp(\theta)$ and $-\exp(\theta+2\pi)$ were left because they were not periodic, where there was an increase in θ if the minus sign was disregarded.

INTRODUCTION

In our recent report (Shimojo *et al.*, 2004e) we tried to investigate, under hypotheses, the appearance of exponential function with base e from the complex representation of '$0=(-1)+1$', namely how $\exp(\theta)$ came from $\exp(\boldsymbol{i}\theta)$ and how θ was increased. This kind of study is based on speculation and requires a lot of trial and error.

This second trial was designed to investigate hypothetic factors influencing the increase in θ after the appearance of $\exp(\theta)$ from $\exp(\boldsymbol{i}\theta)$.

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HYPOTHESES FOR APPEARACNE OF $\exp(\theta)$ FROM $\exp(\boldsymbol{i}\theta)$ AND INCREASE IN θ

Hypothetic factors influencing the complex representation of '0=(−1)+1'

The following equation (1) is an example of complex representation of '$0=(-1)+1$' shown by Shimojo *et al.* (2004a, c, d, e),

$$\begin{aligned}0&=(-1)+1\\&=[\exp(\boldsymbol{i}\theta)\cdot\boldsymbol{i}\exp(-\boldsymbol{i}\theta)\cdot\boldsymbol{i}\exp(\boldsymbol{i}\theta)\cdot(-\exp(-\boldsymbol{i}\theta))\\&\quad\cdot\{-(-\exp(\boldsymbol{i}\theta))\}\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot\exp(-\boldsymbol{i}\theta)]\\&\quad+[\exp(\boldsymbol{i}\theta)\cdot\boldsymbol{i}\exp(-\boldsymbol{i}\theta)\cdot\boldsymbol{i}\exp(\boldsymbol{i}\theta)\cdot(-\exp(-\boldsymbol{i}\theta))\\&\quad\cdot(-\exp(\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot\exp(-\boldsymbol{i}\theta)].\end{aligned}\tag{1}$$

Shimojo *et al.* (2004c, e) also showed that there was a fluctuation between '0' and '$(-1)+1$' whenever the increase is calculated using the definite integral of $\exp(\theta)$. It is known that the differentiation of constant gives zero, and in reverse the constant is considered to appear from zero by an indefinite integral when there is a function, for example $f(\theta)$. This suggests a kind of hypothetic relationship between '$0=(-1)+1$' and the indefinite integral of $f(\theta)$ on condition that $f(\theta)=0$. Thus,

$$\int f(\theta)d\theta=C,\tag{2}$$

where C=integration constant.

There is not an increase in θ in the calculation (2). Any value can be taken for C, and '$0=(-1)+1$' is only an example of C. However, the following relations might give one of the reasons why '$0=(-1)+1$' is taken for C.

$$\exp(\boldsymbol{i}\pi)=-1,\quad \exp(\boldsymbol{i}\pi)+1=0,\quad \exp(\boldsymbol{i}\pi)=\sum_{n=0}^{\infty}\frac{(\boldsymbol{i}\pi)^n}{n!},\tag{3}$$

where e=Napierian constant, $\boldsymbol{i}$=imaginary unit, π=circular constant.

It is generally known that relations (3) belong to beautiful mathematical phenomena, where some basic numbers and state, namely e, $\boldsymbol{i}$, π, 0, −1, 1, other natural numbers and ∞, are related simply.

Thus, equation (2) and relations (3) will hypothetically lead to the occurrence of equation (1), where '$0=(-1)+1$' is considered a significant example of C composed of functions of complex numbers.

Hypothetic factors influencing the appearance of exp(θ) from exp(iθ)

The hypothetic breakdown of multiplication form connecting eight components to construct '1' vanishes '1', as shown by Shimojo *et al.* (2004a, b, c, d, e). Thus,

$$\begin{aligned}1&=\exp(\boldsymbol{i}\theta)\cdot\boldsymbol{i}\exp(-\boldsymbol{i}\theta)\cdot\boldsymbol{i}\exp(\boldsymbol{i}\theta)\cdot(-\exp(-\boldsymbol{i}\theta))\\&\quad\cdot(-\exp(\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot\exp(-\boldsymbol{i}\theta),\end{aligned}\tag{4}$$

$$\exp(\boldsymbol{i}\theta)+\boldsymbol{i}\exp(-\boldsymbol{i}\theta)+\boldsymbol{i}\exp(\boldsymbol{i}\theta)+(-\exp(-\boldsymbol{i}\theta))$$
$$+(-\exp(\boldsymbol{i}\theta))+(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))+(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))+\exp(-\boldsymbol{i}\theta)=0. \tag{5}$$

However, this does not apply to the case of '–1' (Shimojo *et al.*, 2004a, b, c, d, e). Thus,

$$-1=\exp(\boldsymbol{i}\theta)\cdot\boldsymbol{i}\exp(-\boldsymbol{i}\theta)\cdot\boldsymbol{i}\exp(\boldsymbol{i}\theta)\cdot(-\exp(-\boldsymbol{i}\theta))$$
$$\cdot(-(-\exp(\boldsymbol{i}\theta)))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot\exp(-\boldsymbol{i}\theta), \tag{6}$$

$$\exp(\boldsymbol{i}\theta)+\boldsymbol{i}\exp(-\boldsymbol{i}\theta)+\boldsymbol{i}\exp(\boldsymbol{i}\theta)+(-\exp(-\boldsymbol{i}\theta))$$
$$+(-(-\exp(\boldsymbol{i}\theta)))+(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))+(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))+\exp(-\boldsymbol{i}\theta)=2\exp(\boldsymbol{i}\theta). \tag{7}$$

Equation (7) shows hypothetically that $\exp(\boldsymbol{i}\theta)$ is derived from '–1' that, together with '1', has appeared from '0', the seeming nothing.

Equations (6) and (7) show that there are a set of four $\exp(\boldsymbol{i}\theta)$ and half of them are multiplied by '$\boldsymbol{i}$' (anti–clockwise $\pi/2$ rotation) or '$-\boldsymbol{i}$' (clockwise $\pi/2$ rotation). If '$\boldsymbol{i}\theta$', as well as $\exp(\boldsymbol{i}\theta)$, namely not only the function but also the variable, is multiplied by '$\boldsymbol{i}$' or '$-\boldsymbol{i}$', then applying this to one of the two $\exp(\boldsymbol{i}\theta)$ in equation (7) gives an example of changes,

$$2\exp(\boldsymbol{i}\theta)\rightarrow\exp(\boldsymbol{i}\theta)+\exp(-\boldsymbol{i}(\boldsymbol{i}\theta))$$
$$=\exp(\boldsymbol{i}\theta)+\exp(\theta). \tag{8}$$

The change (8) seems to show a hypothetic appearance of $\exp(\theta)$ from $\exp(\boldsymbol{i}\theta)$.

Hypothetic factors influencing the increase in θ in $\exp(\boldsymbol{i}\theta)$

The following equation,

$$\exp(\boldsymbol{i}\theta)=\cos(\theta)+\boldsymbol{i}\sin(\theta), \tag{9}$$

is Euler's formula that beautifully relates exponential function with base e and trigonometric functions in the world of complex numbers, a formula that is at the back of beautiful relations (3). The right hand–side, $\cos(\theta)+\boldsymbol{i}\sin(\theta)$, is periodic at in interval of 2π. This periodic property is related to the increase in θ, which is associated with a definite integral. The hypothetic appearance of $2\exp(\boldsymbol{i}\theta)$ from '0' shown in equations (1)～(7) will be offset if this is followed by equations (10) and (11), a different complex representation of '–1' under the periodic property at an interval of 2π. Thus,

$$-1=(-\exp(\boldsymbol{i}(\theta+2\pi)))\cdot\boldsymbol{i}\exp(-\boldsymbol{i}(\theta+2\pi))\cdot\boldsymbol{i}\exp(\boldsymbol{i}(\theta+2\pi))\cdot(-\exp(-\boldsymbol{i}(\theta+2\pi)))$$
$$\cdot(-\exp(\boldsymbol{i}(\theta+2\pi)))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}(\theta+2\pi)))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}(\theta+2\pi)))\cdot\exp(-\boldsymbol{i}(\theta+2\pi)), \tag{10}$$

$$(-\exp(\boldsymbol{i}(\theta+2\pi)))+\boldsymbol{i}\exp(-\boldsymbol{i}(\theta+2\pi))+\boldsymbol{i}\exp(\boldsymbol{i}(\theta+2\pi))+(-\exp(-\boldsymbol{i}(\theta+2\pi)))$$

$$+(-\exp(\boldsymbol{i}(\theta+2\pi)))+(-\boldsymbol{i}\exp(-\boldsymbol{i}(\theta+2\pi)))+(-\boldsymbol{i}\exp(\boldsymbol{i}(\theta+2\pi)))+\exp(-\boldsymbol{i}(\theta+2\pi))$$
$$=-2\exp(\boldsymbol{i}(\theta+2\pi)). \tag{11}$$

Combining equations (7) and (11) shows that $2\exp(\boldsymbol{i}\theta)$ is offset by $-2\exp(\boldsymbol{i}(\theta+2\pi))$ due to the periodic property. This offset effect is considered reasonable from the concept that complex numbers borrowed from '0' are returned again to '0'.

However, as shown in (8), if one of the two complex numbers in equation (11) is changed into real number, then

$$-2\exp(\boldsymbol{i}(\theta+2\pi)) \rightarrow -\exp(\boldsymbol{i}(\theta+2\pi))-\exp(-\boldsymbol{i}(\boldsymbol{i}(\theta+2\pi)))$$

$$=-\exp(\boldsymbol{i}(\theta+2\pi))-\exp(\theta+2\pi). \tag{12}$$

Combining changes (8) and (12) leads to

$$\exp(\boldsymbol{i}\theta)+\exp(\theta)-\exp(\boldsymbol{i}(\theta+2\pi))-\exp(\theta+2\pi)$$

$$=\exp(\theta)-\exp(\theta+2\pi). \tag{13}$$

Equation (13) shows that $\exp(\boldsymbol{i}\theta)$ is offset by $-\exp(\boldsymbol{i}(\theta+2\pi))$ due to the periodic property, but both $\exp(\theta)$ and $-\exp(\theta+2\pi)$ are left because they are not periodic. This means that $\exp(\theta)$ and $-\exp(\theta+2\pi)$ cannot be returned to '0' in contrast to the sum of $\exp(\boldsymbol{i}\theta)$ and $-\exp(\boldsymbol{i}(\theta+2\pi))$.

If this process continues by some hypothetic factors related to periodic property of Euler's formula, then the following will be given,

$$\exp(\theta)-\exp(\theta+2\pi)+\exp(\theta+4\pi)-\exp(\theta+6\pi), \tag{14}$$

and thus,

$$\exp(\theta)-\exp(\theta+2\pi)+\exp(\theta+4\pi)-\exp(\theta+6\pi)$$

$$+\exp(\theta+8\pi)-\exp(\theta+10\pi)+\cdots\cdots+\exp(\theta+4n\pi)-\exp(\theta+(4n+2)\pi)+\cdots\cdots. \tag{15}$$

where $n=0, 1, 2, \cdots\cdot$.
The interval 2π is long, and reducing the interval length will be given by the following description,

$$\sum_{h=0}^{m}\left[\sum_{k=0}^{n}\{\exp(\theta_h+4k\pi)-\exp(\theta_h+(4k+2)\pi)\}\right]. \tag{16}$$

where $0<\theta_0<\theta_1<\theta_2<\cdots<\theta_h<\cdots<\theta_m<2\pi$.
The description (16) might show a continuous increase in θ in $\exp(\theta)$, if m and n are very large and the minus sign is disregarded. The concept of the present trial is partly

different from that of our previous trial (Shimojo *et al.*, 2004e).

Conclusions and suggestions from this study

The present trial suggested hypothetic factors influencing the appearance of '(−1)+1' from '0', that of exp(θ) from exp($\boldsymbol{i}\theta$), and the increase in θ in exp(θ). These hypothetic factors were related to properties of indefinite integral and Euler's formula. The present study might also be associated with an abstract concept of 'existence and nothing', through the complex representation, using Euler's formula, of '(−1)+1' appearing hypothetically from '0'.

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