PHYSICAL REALITY OF COMPLEX NUMBERS

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Abstract

Evidence of the physical reality of imaginary and complex numbers is presented. It is explained that they correspond to a different conception of the structure of Universe and Multiverse than currently held.

Keywords: complex numbers • imaginary numbers • hidden extra dimensions • parallel Universes • Multiverse

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Introduction

Imaginary numbers were discovered (Hladkyy, 2000) by S. del Ferro (1465 – 1526), N. Tartaglia (1499 – 1557), G. Cardano (1501 – 1576), L. Ferrari (1522 – 1565) and R. Bombelli (1526 – 1672), or may be even earlier (Beckmann, 1976) by P. Valmes (m. 1486), who was sentenced to death at the stake by Spanish inquisitor F. Torquemada for making this discovery. Even I. Newton (1642 – 1727) had to take into account the opinion of the inquisition on the issue, and did not dare to use imaginary numbers in his works.

By now, due to efforts of prominent mathematicians A. de Moivre (1667 – 1754), L. Euler (1707 – 1783), J. d'Alembert (1717 – 1783), C. Wessel (1745 – 1818), P.-S. Laplace (1749 – 1827), J.-R. Argand (1768 – 1822), K. F. Gauss (1777 – 1855), A. Cauchy (1789 – 1857), K. Weierstrass (1815 – 1897), W. R. Hamilton (1805 – 1865), G. Riemann (1826 – 1866), O. Heaviside (1850 – 1925) and others, a consistent theory of the function of complex variable has been developed; nevertheless, the physical reality of complex numbers is still denied.

However, at present, it is not denied by the inquisition; it is denied by the special theory of relativity (the STR) developed by J. Larmor (1857 – 1942), H. A. Lorentz (1853 – 1928), A. Poincare (1854 – 1912) and A. Einstein (1879 – 1955). The theory states that if physical objects (e.g., the elementary particles) move at speeds approaching the velocity of light, relativistic effects – time dilation, mass increase, etc. – will be observed. Moreover, according to the formulae describing these relativist effects, the corresponding physical quantities – time, mass and so on – at superluminal speeds will take values measured with imaginary numbers. Being unable to explain the physical meaning of imaginary numbers, the current interpretation of the STR thus alleges that they have no real physical meaning.

Nevertheless, not all scientists agreed with the suggested interpretation of the STR. The STR was from the very beginning criticized by O. Heaviside (1850–1925), N. Tesla (1856 – 1943), Nobel Prize winner J. J. Thomson (1856 – 1940), Nobel Prize winner S. Arrhenius (1859 – 1927), Nobel Prize winner W. Nernst (1864 – 1941), Nobel Prize winner E. Rutherford, (1871 – 1937), Nobel Prize winner F. Soddy (1877 – 1956), Nobel Prize winner P. Bridgman (1882 – 1961), L. Brillouin (1889 – 1969) and many other outstanding scientists. Over 800 articles and monographs criticizing the STR have already been published; Refs. (Recami et al., 2000; Kalinin,

2003; Artekha, 2007; Albert and Galchen, 2009; Hill and Cox, 2012) can be cited among the most recent ones.

In the recent years, the confrontation between the opponents and the adherents of the STR has shifted from the theoretical field into the experimental one – the results of the MINOS, OPERA and ICARUS experiments were published. In these experiments, some scientists attempted to prove, while others tried to disprove the possibility of a neutrino moving at superluminal speed. Thus, in fact, they tried to prove or disprove the physical reality of imaginary numbers, or even disprove the validity of the relativistic formulae as such.

Nevertheless, regardless of which of the experiments is correct, the current interpretation of the STR is erroneous, which was proven by other experiments (described below) performed before the MINOS, OPERA and ICARUS. These experiments can be performed by anyone. These experiments also prove the physical reality of imaginary and complex numbers.

1. Evidence of the physical reality of complex numbers

The physical reality of complex numbers can be proved in a variety of ways (Antonov and Bazhev, 1974; Antonov, 2008; 2009; 2010a,b,c; 2011a). Let us consider the simplest one (Antonov 2010a,b; 1011a).

The course of algebra teaching quadratic equations

$$ax^2 + bx + c = 0 \quad (1)$$

suggests two different algorithms of their solution:

- on the set of real numbers, in accordance with which, depending on the value of coefficients a,b,c, the equation may have two, or one, or none solutions;
- on the set of complex numbers, according to which, irrespective of the values of coefficients a,b,c, there are always two solutions.

Let us try to clarify the issue. According to psychologists, people think with visual images, so let us resort to these visual images. To this end, let us solve the algebraic equation (1) graphically, rewriting it in the form

$$\begin{cases} y = ax^2 + bx + c \\ y = 0 \end{cases}$$

(2)

As can be seen (figure 1), in this case, different number of solutions of these combined equations, equivalent to the initial equation (1), on the set of real numbers is defined by the different location of the parabola with respect to the ***X***-axis. It is quite clear that, indeed, the parabola can cross the ***X***-axis at two points, at one point (the tangency point) or at no point. It is so obvious that this figure may seem to prove that the only true solution exists only on the set of real numbers.

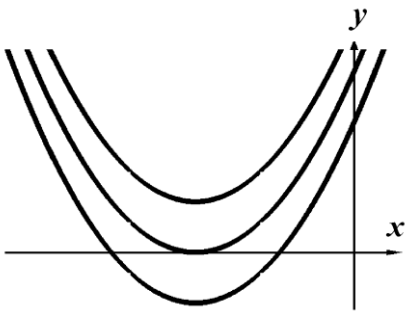

Figure 1. Graphical solution of the quadratic equation on the set of real numbers

However, it is not as simple as that. The solution of the quadratic equation on the set of complex numbers can be supported with graphical evidence which is not less convincing. To this end, let us rewrite the algebraic equation (1) in the form

$$\begin{cases} |y| = \left| a(\sigma + i\omega)^2 + b(\sigma + i\omega) + c \right| \\ y = 0 \end{cases}$$

(3)

Its solutions for the same particular cases as in figure 1 are plotted in figure 2. Figure 2a corresponds to the positive discriminant, figure 2b – to the zero discriminant, figure 2c – to the negative discriminant. As can be seen, the plane of the complex argument $\sigma, i\omega$ always has two tangency points with the surface which corresponds to the absolute value $|y|$ (in figure 2b this point is twofold).

Thus, indeed, both variants of the graphical solution of the algebraic equation (1) turned out to be equally convincing and, therefore, do not allow preferring one of them and rejecting the other.

Then, seemingly, we may try to resort to the general scientific criterion referred to as the "Occam's razor", which reads that the concept or theory suggesting a simpler explanation must be held true (e.g., in astronomy, Copernic's heliocentric system was recognized as true, and Ptolemy's geocentric system was found to be false). According to this criterion, the second algorithm would most probably be held true, sooner or later. However, if this choice is to be made, then the physical meaning of complex numbers will have to be explained.

Physics gives no answer to this question. What is worse, instead of admitting it, it alleges that imaginary (and, consequently, complex numbers, as well) have no physical meaning. Thus, the authority of the STR basically prevents such an important problem from being explored. This point of view is even reflected in scientific terminology, since one of the components of complex numbers is referred to as imaginary (i.e., allegedly, non-existent) numbers.

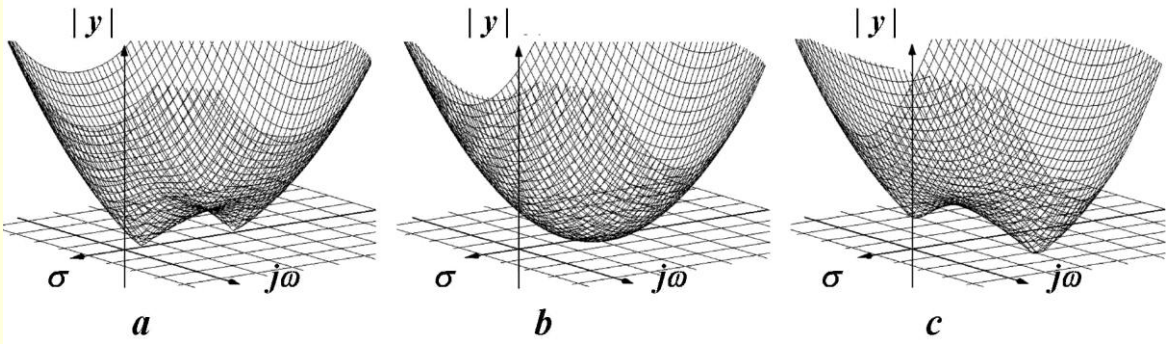

Figure. 2. Graphical solution of the quadratic equation on the set of complex numbers equations.

Let us try to clarify the issue ourselves, using just common sense. First of all, let us specify the criterion of truth, i.e., let us try to understand the meaning of such phrases as "the solution exists" and "the solution does not exist". Where does it exist? On paper? In a computer? On a blackboard in a university classroom? May be. However, the most correct answer would be – in nature, in the physical world we live in. Consequently, we are speaking of the solution as physical reality. Thus, it is quite logical to conclude that, in order to answer the question, we must resort to a physical experiment.

Which one? It turns out that these experiments have been known in engineering sciences for ages. These are the so called oscillation transient processes, or, in other words, shock oscillations. They are used in a piano and a kid's swing, they cause tsunami and earthquakes, and they account for a weather phenomenon referred to as the Indian summer. All these transient

processes mathematically correspond to the so-called free component of solutions of the corresponding differential equations.

In order to determine the parameters of transient processes, engineers solve the so-called characteristic algebraic equations, which correspond to the initial differential equations. Moreover – and this is very important – characteristic equations are always solved by engineers only on the set of complex numbers.

Engineers never use the first algorithm, which looks for solutions on the set of real numbers, to solve characteristic equations. The reason is that, if they used this algorithm, they would have to state that oscillation transient processes do not exist in nature, because the corresponding solutions of characteristic algebraic equations at the negative discriminant do not exist.

However, shock oscillations do exist in nature! Thus, they prove the physical reality of complex frequencies $\sigma \pm i\omega$ of shock oscillations, which are the solutions of these characteristic equations.

There is other evidence, including experimental, of the physical reality of complex numbers, using resonant oscillation processes (Antonov & Bazhev 1974; Antonov 2008; 2009; 2010c).

2. Explanation of the physical reality of complex numbers

In accordance with the foregoing, there is an inevitable question: how do we understand imaginary numbers? Can we see them, touch them or somehow feel them?

The answer to this question is simple – everything is possible. However, this is not easy. And the explanation will not be simple.

First of all, let us note that imaginary numbers, just as real numbers, in everyday life serve to measure something. However, if real numbers, such as 5 meters, 10 kilos, 2 cars, $ 50 are understandable, what do imaginary numbers measure?

To answer this question, let us resort to the Euler formula

$$e^{ix} = \cos x + i \sin x \tag{4}$$

which can be easily transformed into

$$e^{(-\sigma \pm j\omega)t} = e^{-\sigma t}(\cos\omega t \pm j \sin\omega t)$$

(5)

As can be seen, the exponent of the left part of the formula (5) contains complex frequency $-\sigma \pm i\omega$, the physical reality of which was proven above. Consequently, the whole left-hand part of the formula (5) is also physically real. Therefore, its right-hand part is physically real, as well, including both the real and the imaginary components. The real component can always be registered – it can be seen, heard, felt, and detected by various devices. Consequently, we can simultaneously make sure the imaginary component exists, as well. Similarly, when we see someone's shadow, we know the person exists, even if they are hiding. Therefore, the imaginary component can be referred to as the hidden extra dimension (Antonov 2011b,c), similar to the hidden extra dimensions of the microcosm described in (Randall 2005).

We will demonstrate below that the hidden extra dimensions are such if we, from our world, measure what is going on in other parallel worlds. If we get into these worlds, these dimensions will become quite real, and we will be able to see, hear and touch everything there is.

However, let us go back to the STR. If we have disproved the current interpretation of the STR, which denies the physical reality of complex and imaginary numbers, we have to explain the new situation. We suggest the following explanation of imaginary mass, imaginary time and other physical quantities describing relativistic effects (Antonov 2011d; 2012a,b,c).

In physics, elementary particles moving at superluminal speeds are usually referred to as tachyons, contrary to the particles moving at subluminal speeds, which are usually referred to as tardyons (or bradyons). Tachyons cannot be registered from our tardyon Universe. Therefore, it is acceptable to assume that imaginary values of mass, time and other physical quantities mean their absence in our tardyon Universe and transition into the tachyon Universe (or the tachyon Antiverse).

Transition from the tardyon Universe into the tachyon Universe by overcoming the light barrier, in accordance with the Lorentz-Einstein formula, is impossible, because it requires infinitely large energy. However, it is possible in a different way, in accordance with the Euler formula. Similarly, it is impossible to move from one room of our home into another through the wall separating them, but it is quite possible to go through the door.

Indeed, if a phase shift, e.g. $\pi/2$, is somehow provided for the oscillations described with the Euler formula, we get

$$e^{i(x+\pi/2)} = i\cos x - \sin x \quad (6)$$

As can be seen, in the latter formula the real (i.e. $\cos x$) and the imaginary (i.e. $\sin x$) components of the initial oscillations have interchanged. This means that transition from our tardyon Universe into the tachyon Universe and vice versa is possible in a similar way. Similarly, for the phase shift $-\pi/2$, transition from our Universe into the tachyon Antiverse (or the anti-tachyon universe) can be made, and for the phase shift $\pm\pi$ transition into the tardyon Antiverse (or the anti-tardyon Universe) can be made. All these parallel Universes combine to form the Mutiverse. However, contrary to other hypotheses of the Multiverse described in (Linde, 1990; Deutsch, 2002; Tegmark, 2003; Ellis, 2004; Carr, 2909; Greene, 2011), which can never be verified experimentally, and, thus, parallel Universes they include cannot be visited by people (Ellis, 2011), the structure of the Multiverse presented herein allows for mutual visits of inhabitants of parallel Universes.

Moreover, in accordance with the principle of physical reality of complex numbers, all intermediate implementations of parallel Universes corresponding to phase shifts in the Euler formula different from $\pm\pi/2$ and $\pm\pi$, are also physically real. This circumstance makes it physically, chemically and physiologically possible for people to visit other parallel Universes through portals. This will be similar to a smooth transition from air into water and backwards during sea bathing.

Now, we only have to understand what kind of oscillations determine the type of Universe we live in and what portals actually are. Certainly, this issue requires serious research. However, we can assume that these are, most likely, infra-low-frequency spatiotemporal oscillations caused by the rotation of the Earth around its axis and the revolution of the Moon about the Earth. The Philadelphia electromagnetic experiment with Destroyer Eldridge seems to confirm the assumption. As for portals, they are most likely to occur on our planet due to certain geotectonic processes causing the corresponding shock oscillations, which change the phase of resultant oscillations.

However, portals are invisible. Thus, having got into a portal, people most often do not understand the situation and start wandering around, trying to find the way out, and move away from the portal entrance. When the portal closes, they stay in that other Universe forever.

Moreover, in different parallel Universes time flows in different directions. In the tardyon and anti-tardyon universes, for instance, for a relative outside observer, time flows in opposite directions. In the tachyon and anti-tachyon Universes, for an outside observer from our Universe, time flows in perpendicular directions. For an inside inhabitant of any of the parallel Universes, wherever they are, time always flows from the past to the future.

This is why travelling in parallel Universes is very dangerous. Not only there is a risk of never coming back; it is possible to find oneself in a different time upon return. On the other hand, these journeys may enrich people with new knowledge. For instance, having understood the mechanism of portal formation, people would be able to create artificial portals, including time machines. These artificial portals are most likely present on board of UFOs, which allows them to vanish after transition into adjacent parallel Universes.

As for movement of UFO in space, there is an assumption in (Menshikov and Dedkov, 2007) that it is based on the inertioids principle. However, the Russian Academy of Sciences Commission on Pseudoscience and Falsification of Scientific Research (Kruglyakov, 2011) denies their possible existence because it, allegedly, contradicts the laws of physics. Nevertheless, a successfully operating inertioid is, apparently, a kid's swing, which is swung by a kid's body motions. Motion of a swing-inertioid can be described with parametric differential equations (Kharkevych, 1956). Consequently, inertioids do exist and are parametric systems in which motion of a working medium is in resonance with their oscillation systems.

3. Conclusions

Thus, proof of the general scientific principle of physical reality of imaginary and complex numbers eventually allowed developing the concept of the Multiverse which can already be experimentally verified by means of people visiting adjacent parallel Universes through portals.

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