

# Complex Numbers Explain Why in Chinese Tradition, 4 Is Bad But 8 Is Good

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**Abstract** In the traditional Chinese culture, 4 is considered to be an unlucky number, while the number 8 is considered to be very lucky. In this paper, we show that both “badness” and “goodness” can be explained if we take into account the role of complex numbers in the analysis of general dynamical systems.

## 1 Formulation of the Problem

**Cultural fact.** In the traditional Chinese culture, 4 is considered to be an unlucky number, to the extent that in hotels, there is often no 4th floor – just like in many European and American hotels, there is no 13th floor. On the other hand, in this culture, number 8 is considered to be very lucky; see, e.g., [3].

**Usual explanation.** The usual explanation for the above fact is that in Chinese, the pronunciation of number 4 is similar to the word “death”, while the pronunciation of number 8 is similar to the verb “to prosper”.

**Our idea.** It is known that sometimes ancient traditions – which at first may seem completely arbitrary – later turn out to make some sense. Because of this, we decided to see if there can be a more serious explanation for the attitude towards 4 and

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8 – and we found it. Our explanation – based on complex numbers – is described in this paper.

## 2 Our Explanation

**Dynamical systems: brief reminder.** The attitude towards numbers 4 and 8 is also applied to time periods. In view of this, let us consider systems changing with time, i.e., dynamical systems.

In general, at each moment of time, the state of a dynamical system can be described by values of several quantities  $x_1, \dots, x_n$ . The values of these quantities in the next moment of time  $t + \Delta t$  are determined by their current values:

$$x_i(t + \Delta t) = f_i(x_1(t), \dots, x_n(t)). \quad (1)$$

**Possibility of linearization.** In many practical situations, the changes in the state are relatively small. This means that the value of each quantity  $x_i$  describing the system's state are close to the average value  $\bar{x}_i$  of this quantity, so that the differences  $\Delta x_i \stackrel{\text{def}}{=} x_i(t) - \bar{x}_i$  are small. In terms of these differences, the equation (1) takes the form

$$\Delta x_i(t + \Delta t) = F_i(\Delta x_1(t), \dots, \Delta x_n(t)), \quad (2)$$

where we denoted

$$F_i(\Delta x_1, \dots, \Delta x_n) \stackrel{\text{def}}{=} f_i(\bar{x}_1 + \Delta x_1, \dots, \bar{x}_n + \Delta x_n).$$

Since the values  $\Delta x_i$  are relatively small, terms which are quadratic in  $\Delta x_i$  (or of higher order) can be safely ignored. Thus, we can expand the right-hand side of the equation (2) in Taylor series and keep only linear terms in this expansion. This is a usual idea in physics (see, e.g., [1, 2]). In our case, it leads to the system of linear equations:

$$\Delta x_i(t + \Delta t) = a_i + \sum_{j=1}^n c_{ij} \cdot \Delta x_j(t). \quad (3)$$

**Generic solution to the resulting linear system: reminder.** A general solution to a linear system (3) is well-known: in the generic case, in each solution  $\Delta x_i(t + k \cdot \Delta t)$  to this system, each quantity  $\Delta x_i$  is a linear combination of the expressions  $\lambda_j^k$ , where each  $\lambda_j$  is an eigenvalue (in general, complex) of the matrix  $c_{ij}$ :

$$x_i(t + k \cdot \Delta t) = C_i + \sum_{j=1}^n C_{ij} \cdot \lambda_j^k,$$

for some coefficients  $C_i$  and  $C_{ij}$ .

For each term  $T \stackrel{\text{def}}{=} C_{ij} \cdot \lambda_j^k$ , its value at the next moment of time  $t + (k+1) \cdot \Delta t$  can be obtained from its value at the previous moment of time  $t + k \cdot \Delta t$  by multiplying by  $\lambda_j$ :

$$T(t + (k+1) \cdot \Delta t) = \lambda_j \cdot T(t + k \cdot \Delta t).$$

In general, we have

$$T(t + k \cdot \Delta t) = \lambda_j^k \cdot T(t).$$

**What is good and what is not good: an example.** An example when it is clear what is good and what is not good is economics:

- if it grows, it is usually good (although if it grows too fast, it may be dangerous in the long run), while
- if it shrinks, this is usually not good.

In terms of eigenvalues:

- grows corresponds to  $\lambda_j > 1$ , while
- a crisis corresponds to  $0 < \lambda_j < 1$ .

**How complex numbers affect the result.** Suppose that we start with an ideal good case, when  $\lambda_j$  is a positive real number larger than 1:  $\lambda_j = r > 1$ . In this case, the corresponding term in the description of economy grows:

$$T(t + k \cdot \Delta t) = r^k \cdot T(t).$$

What happens when we take into account that eigenvalues are, in general, complex numbers? This means that, in general, the eigenvalues have the form

$$\lambda_j = r + m \cdot i,$$

where  $m$  is a real number, and  $i \stackrel{\text{def}}{=} \sqrt{-1}$ .

When the imaginary part  $m$  is small, i.e., when its absolute value much smaller than the real part  $r$ , the effect of this part is also small, so the situation continues to be good. We therefore need to start being careful when the imaginary part becomes comparable with the real one. To analyze this case, let us consider the situation when the imaginary part is of exactly the same size as the real one, i.e., when  $|m| = r$  and thus,  $m = \pm r$ . In this case,

$$\lambda_j = r \pm r \cdot i = r \cdot (1 \pm i).$$

We start at some moment  $t_0$  (e.g., in Year 0) with some value  $T(t_0) = T_0 > 0$ . Then, at the next moment of time  $t_0 + \Delta t$ , we get

$$T(t_0 + \Delta t) = r \cdot (1 + i) \cdot T_0.$$

Since this value contains both real and imaginary parts, it is not clear how it will affect the expected results, whether it will be good or bad. At Moment 2, i.e., when

$t = t_0 + 2 \cot \Delta$ , we similarly get

$$T(t_0 + 2 \cdot \Delta t) = (r \cdot (1 \pm i))^2 \cdot T_0 = \pm 2 \cdot i \cdot r^2 \cdot T_0.$$

Again, it is not clear where it is good or bad. At the third moment of time  $t = t_0 + 3\Delta$ , we get

$$T(t_0 + 3 \cdot \Delta t) = (r \cdot (1 \pm i))^3 \cdot T_0 = (-2 \pm 2 \cdot i) \cdot r^3 \cdot T_0,$$

still unclear. However, at the 4-th moment of time, we get

$$T(t_0 + 4 \cdot \Delta t) = (r \cdot (1 \pm i))^4 \cdot T_0 = -4 \cdot r^4 \cdot T_0.$$

This time, there is no confusing imaginary part, the value is purely real – and negative. What does that mean? We started with a positive value  $T_0 >$  indicating good.

- If the eigenvalue did not have any imaginary part, at the 4-th moment of time, we would have a positive value  $r^4 \cdot T_0$ .
- However, because the eigenvalue has an imaginary part, the value  $T(t_0 + 4\Delta t)$  is now negative – i.e., bad!

This may explain why 4 is considered a bad number.

What happens after that? At moments 5, 6, and 7 we will have values

$$T(t_0 + k \cdot \Delta t) = r^k \cdot (1 + i)^k \cdot T_0$$

with non-zero imaginary parts, so it is not clear whether it will be good or bad. The first moment when the value  $T(t_0 + k \cdot \Delta t)$  becomes real again is the moment  $k = 8$ . At this moment, we have

$$T(t_0 + 8 \cdot \Delta t) = 16 \cdot r^8 \cdot T_0.$$

This value is not only positive (which is good), but it is even much larger (16 times larger) than the value  $r^8 \cdot T_0$  that we would have gotten if the eigenvalue did not have the imaginary part. No wonder number 8 is considered to be good!

So, indeed, both “badness” of 4 and “goodness” of 8 are indeed explained by complex numbers!

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## References

1. R. Feynman, R. Leighton, and M. Sands, *The Feynman Lectures on Physics*, Addison Wesley, Boston, Massachusetts, 2005.
2. K. S. Thorne and R. D. Blandford, *Modern Classical Physics: Optics, Fluids, Plasmas, Elasticity, Relativity, and Statistical Physics*, Princeton University Press, Princeton, New Jersey, 2021.
3. Wikipedia, Chinese Numerology, [https://en.wikipedia.org/wiki/Chinese\\_numerology](https://en.wikipedia.org/wiki/Chinese_numerology), downloaded on April 5, 2023