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Physical Information Cognitive Computing and Its System Analysis in Data Science: Take the Particle Wave as an Example

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Abstract. It aims to further understand the third cognitive sublimation of wave-particle duality by top experts through computer AI cognitive computing and system analysis in Data Science. The method: 1 Review the three cognitive processes of human experts on wave-particle duality; 2 Use the computing for formal information processing; 3 Build a human-machine collaborative smart system to show how to form chemically understand the advanced knowledge of the frontiers of physics. It is characterized in that it combines the physical facts recorded by the three formulas to analyze with the help of computer formal understanding and interdisciplinary expert understanding, and highlights the verifiability and easy repeatability of cognitive computing in Data Science. The result is that it is not only conducive to popularizing the knowledge of experts for the three cognitive sublimation of wave-particle duality, but also can be demonstrated through the AI cognitive computing process and its intelligent system, so as to be recognized by the international academic and higher education circles 's practice. Its significance lies in revealing the advanced knowledge of quantum physics and information physics, which is transmitted between the three formulas, from the three aspects of physical quality, energy and information quantity through human-machine cooperation. It is particularly worth mentioning that the previous knowledge accumulation is only desirable material here, and then the creative triple-jump method is used to re-analyze the cognitive process and expert system of wave-particle duality top experts from a new academic perspective in Data Science. The cognitive computing approach provides an example for the inheritance of advanced knowledge and further innovation.

Keywords: Cognitive Computing, Human-Machine System, System Analysis, Information Processing, Formal Understanding, Wave-Particle Duality, Quantum Physics Information Physics, Interdisciplinary Expert Understanding.

1 Introduction

1.1 Purpose

It aims to further understand the third cognitive sublimation of wave-particle duality by top experts through computer AI cognitive computing and system analysis in Data Science.

1.2 Background

Standing on the shoulders of giants is Newton's famous saying. This research is first based on the first type of wave-particle duality - revealed by Einstein in 1905 and verified by Milligan in 1916, and the two won the Nobel Prize in 1921 and 1923 respectively; then, based on the second type of wave-particle duality - de Broglie revealed in 1923, Davidson and Thomson verified in 1927, and won the Nobel Prize in 1929 and 1937 respectively; further, based on the first two steps plus the enlightenment of the research results of Schrödinger and Dirac who won the Nobel Prize in 1933, Yongchao Gan in 1994 revealed the third type of wave-particle duality-, a substantial advance from 2018 to 2022, further straightening out the relationship between the three types of wave-particle dualities, and revealing the " π -type triple wave-particle duality" combining the three types of wave-particle duality with corresponding formal methods can better reveal the profound philosophical and basic scientific mechanisms they contain.

On a heuristic point of view concerning the production and transformation of light (Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt)[1]

Albert Einstein's light-quantum paper was the only one of his great papers of 1905 that he himself called "very revolutionary". I sketch his arguments for light quanta, his analysis of the photoelectric effect, and his introduction of the wave-particle duality into physics in 1909. [2]

In 1905, Albert Einstein submitted five papers for publication in Annalen der Physik, covering three topics: the photoelectric effect, brownian motion, and the special theory of relativity.[3]

de Broglie"made one of the greatest discoveries of the 20th century: the wavelike nature of all matter. His formula $\lambda = (h/p)$ stands on a par with Planck's $E = hv$ and Einstein's $E=mc^2$."[4]

2 Method

The method: 1 Review the three cognitive processes of human experts on wave-particle duality; 2 Use the AI cognitive computing for formal information processing; 3 Build a human-machine collaborative smart system to show how to form chemically understand the advanced knowledge of the frontiers of physics. It is characterized in that it combines the physical facts recorded by the three formulas to analyze with the help of computer formal understanding and interdisciplinary expert understanding, and highlights the verifiability and easy repeatability of cognitive computing.

2.1 Review the three kinds of wave-particle duality

The three types of wave-particle duality and the cognitive processes of various top experts involved here:



Fig. 1. The physicists who reviewed the first two discoveries and inspired the third discovery of the profound principle of wave-particle duality.

As can be seen from Figure 1, the physicists who reviewed the first two discoveries and inspired the third discovery of the profound principle of wave-particle duality, how hard they explored in those days, and how they relied on their own major achievements in scientific exploration, won the Nobel Prize. Its scientific exploration spirit and cognitive thinking characteristics are worth studying and summarizing seriously.

The Nobel Prize in Physics 1921 was awarded to Albert Einstein "for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect"[5]

The Nobel Prize in Physics 1923 was awarded to Robert Andrews Millikan "for his work on the elementary charge of electricity and on the photoelectric effect"[6]

The Nobel Prize in Physics 1929 was awarded to Prince Louis-Victor Pierre Raymond de Broglie "for his discovery of the wave nature of electrons"[7]

The Nobel Prize in Physics 1937 was awarded jointly to Clinton Joseph Davisson and George Paget Thomson "for their experimental discovery of the diffraction of electrons by crystals"[8]

The Nobel Prize in Physics 1933 was awarded jointly to Erwin Schrödinger and Paul Adrien Maurice Dirac "for the discovery of new productive forms of atomic theory"[9] Revealed the third wave-particle duality; and unified the three wave-particle duality revealed by Einstein 1905, De Broglie 1923 and Gan 1995 respectively, revealing the microscopic object π -type triple wave particle duality.[10]

If you read a randomly selected nontechnical account of quantum entanglement, you will likely be told that measuring a particle in one place can instantly change another particle elsewhere, no matter the distance between the two. [11]

The idea of quantum entanglement and wave-particle duality is the most mysterious and illuminating view of physics. Therefore, physics has to be sublimated from the four elements of mass, energy, time and space to further research or thinking about the amount of information.

2.2 Use the AI cognitive computing for formal information processing

First, the acquisition of expert knowledge of three types of wave-particle duality is realized in a tabular manner, and then starting from mathematical and physical formulas, with structured data that can be understood both by humans and machines, highlighting the formal expression of expert knowledge, and finally using the combination of words, formulas, diagrams and tables realizes comprehensive pattern recognition of knowledge information data in rich media and structured aspects.

Table 1. Expert Knowledge Acquisition of Three Types of Wave-Particle Duality

Type	Analyze wave-particle duality	Virtual and Real	Time	Prize
1 st -Type	Essential wave; simple particles	Real wave & real particle	1905	1921
2 nd -Type	De Broglie wave; general particles	Virtual wave; real particle	1923	1929
3 rd -Type	Real wave; imagined particles	Real wave; virtual particle	1995	

From Table 1, it can be seen that the basic characteristics of the three types of wave-particle duality are: 1. The key subject is the difference between physicists and their characteristics; 2. The relationship between particles and waves is different, namely: a. The characteristics of one type, particles and waves are real, but cannot be observed at the same time, b. The characteristics of the second type, the waves are virtual, the particles are real, c. The characteristics of the third type, the waves are real, the particles are virtual; 3. The time when each was discovered and proposed is different, the three are 1905, 1923, 1995 respectively; 4. The influence of the three is different, the first two won the Nobel Prize in 1921 and 1929 respectively, and the third of the three are still in the process of promoting cognition, popularizing teaching and even trying related applications.

Table 2. Expert Knowledge Formal Expression

Type	Physicist	Physics Formula	Time	Prize
1 st -Types of Wave-Particle Duality	Albert Einstein	$e V = \hbar \omega - A$	1905	1921
2 nd -Types of Wave-Particle Duality	De Broglie	$p = h / \lambda = \hbar k$	1923	1929
3 rd -Types of Wave-Particle Duality	Yongchao Gan	$\begin{bmatrix} \varepsilon \\ p \end{bmatrix} = \begin{bmatrix} \hbar & 0 \\ 0 & \hbar \end{bmatrix} \begin{bmatrix} \omega \\ k \end{bmatrix}$ $P = G W$	1995	

It can be seen from Table 2 that the basic characteristics of the mathematical and physical formulas of the three types of wave-particle duality are that human cognition and AI human-computer cognitive computing and system analysis can be in-depth and continuous, and can be structured, formalized, and digitalized in a targeted manner. Repeatedly invoked (that is, such cognitive outcomes are easily shared by both humans and machines).

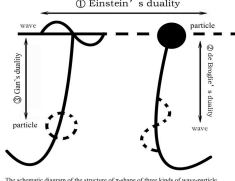
2.3 Build a human-machine collaborative smart system

How to help natural language processing and formal understanding of three types of wave-particle duality more effectively through formulas, graphs and tables?

The π -type structural relationship between the three wave-particle dualities: the virtual and real of the wave and the particle are expressed by the dotted and solid lines.

The simultaneous occurrence of the wave and the particle is connected by the solid line, and the alternate appearance of the wave and the particle is connected by the dotted and solid line.

Table 3. Expert Knowledge Expression of visualization and abstraction

Three types of wave-particle duality as π triple visible shape	
1 st -Wave-Particle Duality	$e V = \hbar \omega - A$  <p>The schematic diagram of the structure of π-shape of three kinds of wave-particle</p>
Visualization graphics that arranged figuratively in the structure of π	
2 nd -Wave-Particle Duality	$p = h / \lambda = \hbar k$
3 rd -Wave-Particle Duality	$\begin{bmatrix} \varepsilon \\ p \end{bmatrix} = \begin{bmatrix} \hbar & 0 \\ 0 & \hbar \end{bmatrix} \begin{bmatrix} \omega \\ k \end{bmatrix}$
	$P = G W$

It can be seen both in Table 3 from the visual diagram and the three sets of formula 3 that the triple visible shape drawn and recognized by Professor Gan, his colleagues and students has 7+1 people with relevant top international physicists (who have won the Nobel Prize five times) and it is quite meaningful to link thinking, research and exploration. We can not only visually see the fundamental physical problems revealed by the three types of wave-particle duality, but also from Einstein's photoelectric effect formula (which contains Planck's formula $\varepsilon = h \nu = \hbar \omega$) [12] and from de Broglie's formula ($p = h / \lambda = \hbar k$) [13][14] to comprehend the new principles revealed in Gan's formula and Gan's matrix. Contributions from various aspects are brought together, and it plays a key role in enlightening wisdom, whether it is for the teaching and research of teachers and students, or the exploration and research of cutting-edge scholars, especially the cognitive thinking of experts, and AI cognitive computing and system analysis.

π -type structural relations of three kinds of wave-particle duality: the virtual reality of wave and particle is distinguished by the virtual reality line; Waves and particles appear at the same time and are connected by solid lines, while waves and particles appear alternately and are connected by virtual and real lines. The π -shaped diagram reveals intuitively: the first wave-particle duality-real waves and real particles transform and appear alternately; The second wave-particle duality-real particles, virtual waves, appear at the same time; The third wave-particle duality-real wave, virtual particle, appears at the same time. The first is the wave-particle duality in essence, and the latter two are the wave-particle duality in phenomenon-its characteristic is that "wave and particle are virtual and real at the same time, and

cannot be transformed into each other, just like the real thing and its shadow". The previous wave-particle duality and its relationship have not been clearly revealed, and only after the third one is revealed can the relationship be straightened out and harmonized.

Table 4. Expert Knowledge Expression with Mathematical Physics Formulas

3rd-Wave-Particle Duality	
Dirac	$A(r, t) = \sum_l \sum_\sigma \sqrt{\frac{\hbar}{2\omega_l \varepsilon_0 \tau}} \hat{e}_{l\sigma} \left[a_{l\sigma} e^{i(k_l \bullet r - \omega_l t)} + a_{l\sigma}^* e^{-i(k_l \bullet r - \omega_l t)} \right] = \sum_l \sum_\sigma A_{l\sigma}(r, t)$ $A(r, t) = \sum_l \sum_\sigma \sum_j \sqrt{\frac{\hbar}{2\omega_l \varepsilon_0 \tau}} \hat{e}_{l\sigma} \left[a_{l\sigma_j} e^{i(k_j \bullet r - \omega_j t)} + a_{l\sigma_j}^* e^{-i(k_j \bullet r - \omega_j t)} \right] = \sum_l \sum_\sigma \sum_j A_{l\sigma_j}(r, t)$ $R = n_1 r_1 + n_2 r_2 + \dots + n_i r_i + \dots = \sum_{i=1}^N n_i r_i$
Gan	$\begin{bmatrix} \varepsilon \\ p \end{bmatrix} = \begin{bmatrix} \hbar & 0 \\ 0 & \hbar \end{bmatrix} \begin{bmatrix} \omega \\ k \end{bmatrix}$ <p>P = G W</p>

As can be seen in Table 4, a set of formulations from the paper we previously communicated at the International Conference on Cognitive Systems and Information Processing (Held at Tsinghua University in 2018) and published in Springer-Nature Publishing Group. [15][16] Our readers can get unexpected cognitive enlightenment and ideological harvest by combining it with the content of this article.

Build a human-machine collaborative smart system to show how to form formal understand the advanced knowledge of the frontiers of physics.

It is characterized in that it combines the physical facts recorded by the three formulas to analyze with the help of computer formal understanding and interdisciplinary expert understanding, and highlights the verifiability and easy repeatability of cognitive computing.

3 Result

The result is that it is not only conducive to popularizing the knowledge of experts for the three cognitive sublimation of wave-particle duality, but also can be demonstrated through the AI cognitive computing process and its intelligent system, so as to be recognized by the international academic and higher education circles 's practice.

Formulas (For the three cognitive sublimation of wave-particle duality). .

$$e V = \hbar \omega - A \quad (1a)$$

$$\varepsilon = h \nu = \hbar \omega \quad (1b)$$

$$p = h / \lambda = \hbar k \quad (2)$$

$$\begin{bmatrix} \varepsilon \\ p \end{bmatrix} = \begin{bmatrix} \hbar & 0 \\ 0 & \hbar \end{bmatrix} \begin{bmatrix} \omega \\ k \end{bmatrix} \quad (3a)$$

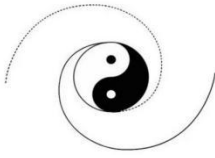
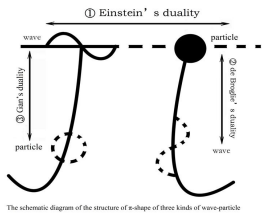
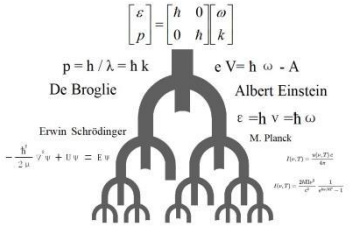
$$P = G W \quad (3b)$$

Gan formula and matrix not only contains Einstein's photoelectric effect equation (which contains Planck's formula) but also contains de Broglie formula.

Visual abstract formulaic representations (For the wave-particle duality).

The pi-shaped diagram intuitively reveals: the first wave-particle duality — real waves and real particles appear alternately; the second wave-particle duality — real particles and virtual waves appear at the same time; the third wave-particle duality - real waves, virtual particles appearing at the same time. The former is essentially wave-particle duality, while the latter two are phenomenal wave-particle duality, which is characterized by "waves and particles appear as virtual and real at the same time", just like objects and their shadows. The wave-particle duality and its relationship have not been so clearly portrayed before. This unified description came only after the third discovery.

Table 5. Visual abstract formulaic representations for the three types of wave-particle duality.

Graphs that visual abstract formulaic representations for the three types of wave-particle duality		
Tai Chi particle wave	Π shaped wave particles	Three types of wave-particle duality
		

From the above chart, we can see how we advance the human cognitive process and the artificial cognitive computing process step by step. The combination of visualization (humanities and arts) and abstract formulation (science and technology), the combination of art and science, systematically demonstrates the characteristics of human cognition and the charm of human-computer interaction, collaboration and even synergistic cognitive computing system analysis, gain a better understanding of fundamental physics and mathematics, as well as the ideological process of artistic creation.

4 Conclusion

Its significance lies in revealing the advanced knowledge of quantum physics and information physics, which is transmitted between the three formulas, from the three aspects of physical quality, energy and information quantity through human-machine cooperation. It is particularly worth mentioning that the previous knowledge accumulation is only desirable material here, and then the creative triple-jump method is used to re-analyze the cognitive process and expert system of wave-particle duality top experts from a new academic perspective. The cognitive computing approach provides an example for the inheritance of advanced knowledge and further innovation.

Comments or suggestions from academic peers (one of the main types of readers) are very important feedback information for our research and exploration. In this paper, we mainly discuss Einstein's photoelectric effect equation $eV = \hbar\omega - A$ and his paper "On a Heuristic Viewpoint Concerning the Generation and Transformation of Light" and Planck's formula $\varepsilon = h\nu = \hbar\omega$ and his paper "Standard Spectrum" Energy Distribution Law" and the de Broglie formula $p = h/\lambda = \hbar k$ and his paper "Waves and Quanta" published in Nature, as well as the research results and papers of Professor Gan and his colleagues and students [17][18] [19][20] (interested readers are invited to read the corresponding references) made some retrospective summaries (although they will inevitably be missed, but after all, they can provide corresponding academic information and research clues). We hope that it can give corresponding inspiration and help to colleagues and interdisciplinary learners who are interested in further research and exploration of the important research results mentioned in our article!

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