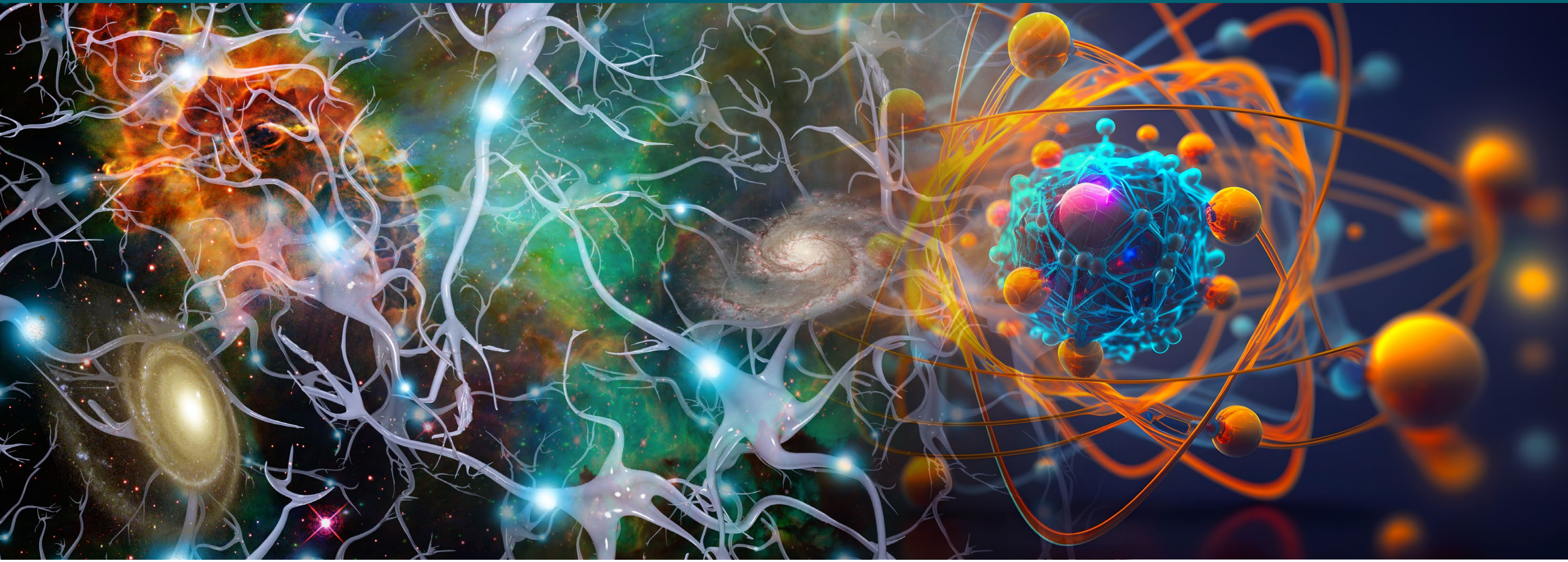

How particle breakups could connect phenomena from biology to cosmology

- Numerous areas of science are wrestling with problems whose solutions have eluded them for decades.
- Professor Ken Naitoh at Waseda University in Tokyo, Japan, argues that these mysteries persist because scientists haven't fully considered the deeper underlying connections between their fields.
- Through his research, Naitoh shows how numerous natural processes involve particles breaking up in distinctive universal patterns.
- His discoveries could lead to new advances in areas ranging from cosmology to mental health.

Decades-long mysteries persist across virtually every branch of science. On subatomic scales, they are found in quantum entanglement – where the fates of two or more particles can be intrinsically intertwined. In biology, mysteries emerge in the intricate connections which form between neurons in our brains, and the cell-to-cell mechanisms which allow cancer to spread so quickly. On cosmological scales, the nature and abundance of dark matter continues to elude astronomers and experimental physicists alike.

In each of these widely varying cases, solutions remain elusive despite decades of dedicated research. According to Professor Ken Naitoh at Waseda University in Tokyo, Japan, the main reason why all of these mysteries continue to persist is that we simply haven't been searching for the universal laws which connect them.

Classifying breakups

Naitoh began his career studying the behaviour of liquid fuel droplets in combustion engines. Specifically, he examined how breakups and collisions between droplets can be predicted using models of fluid dynamics. As he explored these behaviours, he began to realise that the relevance of his discoveries stretched far beyond his own field of research.

This understanding stemmed from the fact that all systems in nature are composed of particles in some form – whether they are quarks, atoms, molecules, droplets, cells, stars, galaxies, neural networks, or social groups. As they break up and fuse together, these particles adopt asymmetrical or symmetrical, 'gourd-like' shapes, featuring a pair of connected lumps of differing or identical size.

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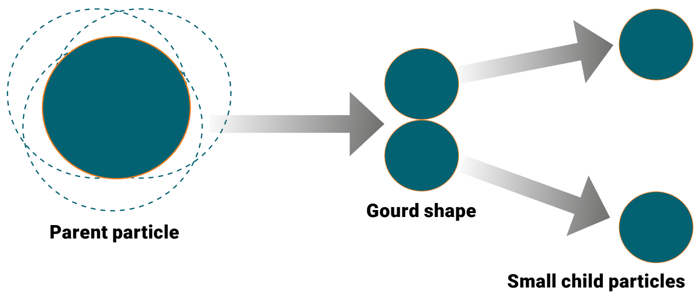
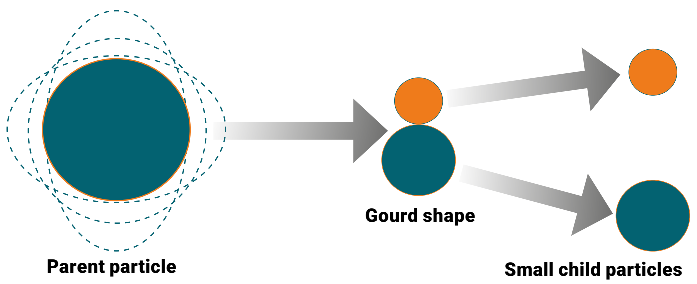
Previously, researchers have mainly studied these breakups by considering simple structures such as spheres and strings. In contrast, Naitoh's observations clearly showed that gourds offer a far more accurate description. As they break apart, these gourds exist in a state of 'quasi-stability', meaning they break up slowly enough to be considered stable in the short term, but nonetheless break up in the longer term, releasing energy in the process. With this principle in mind, Naitoh proposes that all particle breakups can be classified into three possible modes.

The first of these quasi-stable modes is named 'breakup-collision'. According to Naitoh, it underlies processes including the aggregation of protons and neutrons into atomic nuclei, the formation of complex biomolecules like DNA and proteins, and even the breakup of stars during supernovae. Secondly, the 'expansion-compression' mode is relevant to describing objects which develop inside a larger object, such as an unborn baby growing inside a mother, or organs like the brain, which change in structure as we age. Finally, the 'excitatory-inhibitory' mode can relate to self-replication behaviour, such as the growth of living cells, as well as economic and social systems, and networks of neurons in the brain.

Symmetic breakup of parent particle



Asymmetric breakup of parent particle



In biological and abiological systems, translational motion disturbance entering parent particle (circles with blue dots) brings symmetrical division of child particles, whereas deformation disturbance entering parent particle (spheroid circles with blue dots) leads to left-right asymmetric size ratio of child particles after gourd shape.

Missing universal connections

Each of these modes is characterised by patterns of kinks in the sections of the gourds separating both lumps, which will appear at different stages of the quasi-stable breakup process. While also considering indeterminacy, the masses, sizes, and overall diversity of these lumps can be predicted using 'fractal' patterns: intricate geometric shapes defined by simple mathematical and dynamical constraints of quasi-stability.

Drawing from this concept, Naitoh has now made a case for explaining why so many pressing scientific questions have gone unresolved so far. Today, many key scientific principles apply only to specific fields of research: first devised by brilliant scientists like Newton for classical gravity; Schrödinger for quantum mechanics; and Boltzmann for thermodynamics.

A closer consideration of this universality could help researchers to answer some of their most long-standing questions.

Despite applying to different branches of science, these theories all hinge on the conservation of properties including mass, momentum, and energy. All the same, Naitoh believes that researchers still don't fully appreciate just how deeply these fields are connected, and how a closer consideration of this universality could help them to answer some of their most long-standing questions.

Considering breakup timings

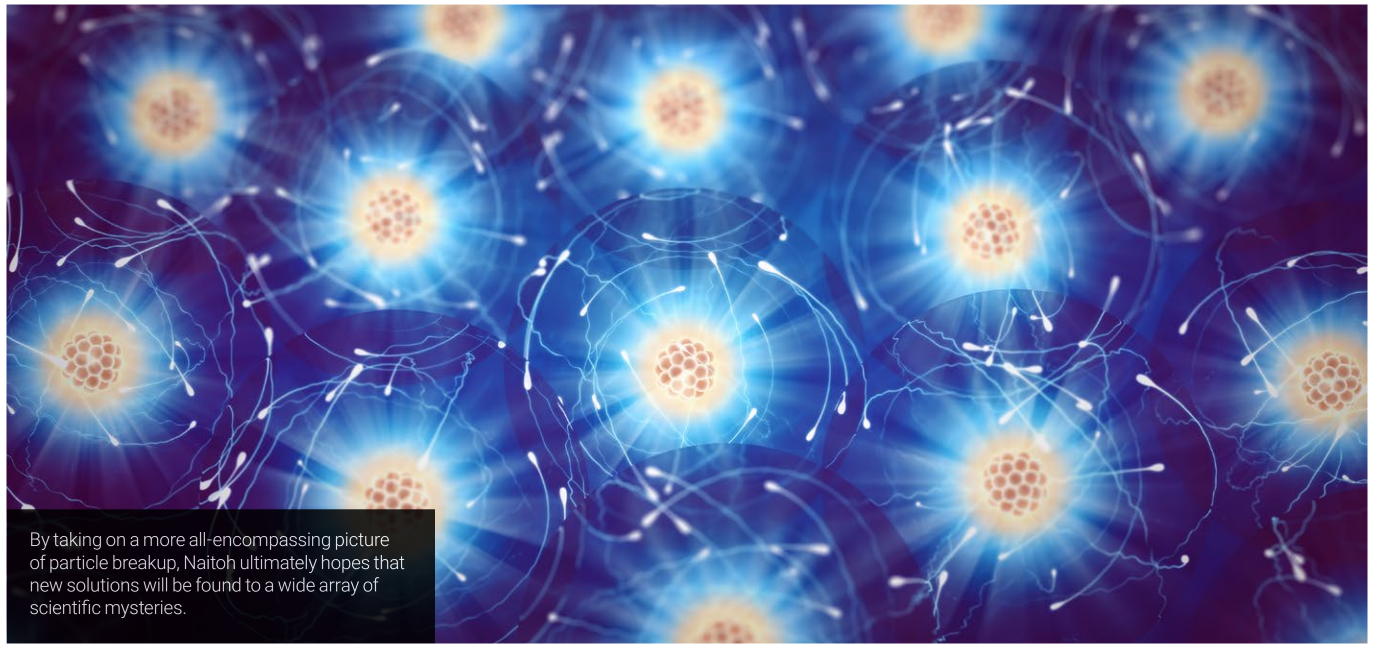
Through his research, Naitoh argues that these difficulties persist because researchers today mainly focus on orderly durations before and after the breakups of the various particles they study – although sizes of child particles, ie, the resulting particles after breakups, are determined at breakup timing as the rate-controlling step. As a result, the theories available today can only a reveal a narrow range of certain universal quantities like mass, momentum, or energy.

In fact, a far more realistic picture can be gained by considering the breakup of quasi-stable gourd structures, and the difference or sameness in size between each lump – while considering whether each breakup should be classified as breakup-collision, expansion-compression, or excitatory-inhibitory.

From cutting-edge science to everyday life

By taking on a more all-encompassing picture of particle breakup, Naitoh ultimately hopes that new solutions will be found to a wide array of scientific mysteries which have stood firm for decades. In one study, Naitoh describes how a more complete picture of the behaviours of atomic nuclei could lead to new breakthroughs in cold fusion. This would enable nuclei to fuse together at temperatures and pressures achievable in ordinary industrial settings on Earth – providing a practically limitless source of clean energy.

Elsewhere, Naitoh's principles could also lead to a better understanding of how our mental health is linked to patterns in the neural networks in our brains – potentially leading to new treatments for conditions including depression and more. Ultimately, Naitoh hopes his work will help us to deepen our understanding of how the universe works, while helping us to lead happier, healthier lives.



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Personal response

How did you transition from studying combustion engines to your current field of research?

In my mind, there is no transition. When I was a child, I watched the launch of the Apollo 11 mission on TV, which reached the stratosphere with the help of extremely large fuel tanks. Even then, I felt that our technologies were in their infancy, and that we needed higher-power engines so we could freely travel to outer space. Then when I was about seven years old, I caught a severe cold. I was prescribed medicine, but it didn't help me recover for over a week. With that experience, I felt that human beings have no 'medicine', only supportive care. I thought that we could develop all-purpose drugs by revealing the essential mechanism that underlies all living beings. At high school, I was very interested in physics as a means of understanding the essential mechanisms in nature. However, my father strongly opposed my hope to become a physicist. He suggested engineering and thus, I chose to study mechanical engineering. Despite this, I still studied applied physics, especially on statistical thermo-fluid dynamics including turbulence and supersonic flows, because lots of machines and living beings use fluid flows of air and water to provide themselves with power. Finally, a professor working on robotics in mechanical engineering posed the philosophical question: 'What is the essential difference between machines and living beings?'. And so, this question became one of my lifeworks.

After finishing my masters, I decided that I'd first like to contribute in the field of automobile engines, which many people use on a regular basis. If I could contribute to automobiles, I thought that these contributions could also be applied in other areas, including aircraft, aerospace, artificial brain, and medicine. As I was actually able to contribute to patents and engine performance improvements, I worked on several of these essential applications after returning to Waseda University.

How can your theories explain the nature of dark matter?

I have used the word 'cosmic' which includes the meanings of 'elementary particles', because the origin of cosmos is deeply related to subatomic particles. Moreover, studies that I and my students have carried out also show possibilities to dynamically clarify the inevitability of sizes for relatively stable elements in periodic table and those for elementary particles such as hadrons, quarks, and leptons. Dark matter and black holes are my targets in the very near future.

Do you think your work could promote closer collaboration between researchers in different fields of science?

Researchers on cold fusion (low energy nuclear reaction; LENR) have previously been interested in my work, just after I published some journal papers reviewed in the *Journal of Condensed Matter Nuclear Science* in 2010. About 15 years ago, I proposed a new compressive reaction engine principle, which could result in very high thermal efficiencies of over 60%, even for small engines. It would also be able to accelerate a weak nuclear reaction with special catalysis, which may have possibility over chemical reaction without radiation, while we also reveal masses of elements generated by LENR.

More recently, I was the chair of the annual conference (JCF23) planned by the Japan CF-research Society (CF: Condensed-matter Fusion, Coherently-induced Fusion, Cold Fusion). The conference was held on March 4 and 5 2023 at Waseda University where I in my role as chair of JCF23 encouraged people to collaborate.

Biomedical research of mine has also gathered attention in bio-complexity research societies. So now, I also work to encourage students in my role as vice-program chair and an executive board member of the International Society of Artificial Life and Robotics (ISAROB).

Many times, I have been invited to give lectures on fusion study of biological and abiological aspects for several societies, including the French Institute of Petroleum, the Research Foundation for Opto-Science and Technology, the Science Council of Japan, and more.

Between 2013 and 2016, our new engine has been reported on NHK news, NIKKEI newspaper, and various other media outlets. Amazing results will be presented at two SAE conferences (SAE AeroTech conference and SAE WCX conference) in March and April, 2023. This year, we will be at the starting point of practical uses in the business sector.

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Bio

Ken Naitoh gained his PhD at Waseda University, Japan in 1992. He held positions as researcher at NISSAN Motor Co., Ltd. (1987–2000) and as Associate Professor at Yamagata University (2000–2005). Since 2005, he has been Professor at Waseda University.

Further reading

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