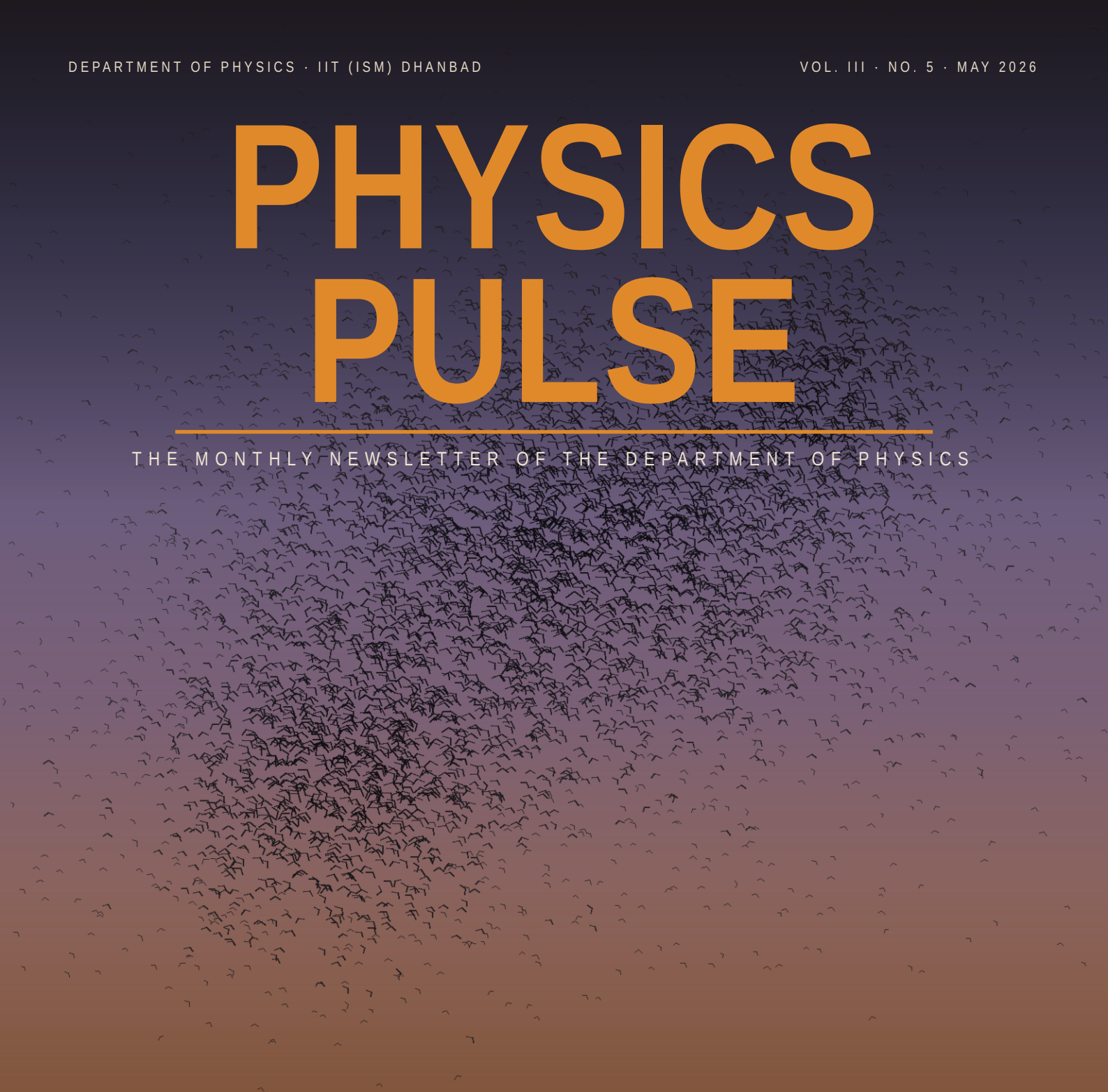
DEPARTMENT OF PHYSICS · IIT (ISM) DHANBAD

VOL. III · NO. 5 · MAY 2026

PHYSICS PULSE

THE MONTHLY NEWSLETTER OF THE DEPARTMENT OF PHYSICS



EMERGENCE · THE PHYSICS OF THE COLLECTIVE

More Is Different

Fifty years on, P. W. Anderson's 1972 essay on emergence still frames how physicists think about complexity — from single atoms to the whole of nature.

PHYSICS PULSE

DEPARTMENT OF PHYSICS · IIT (ISM) DHANBAD · VOL. III · NO. 5 · MAY 2026

IN THIS ISSUE

FROM THE EDITORS

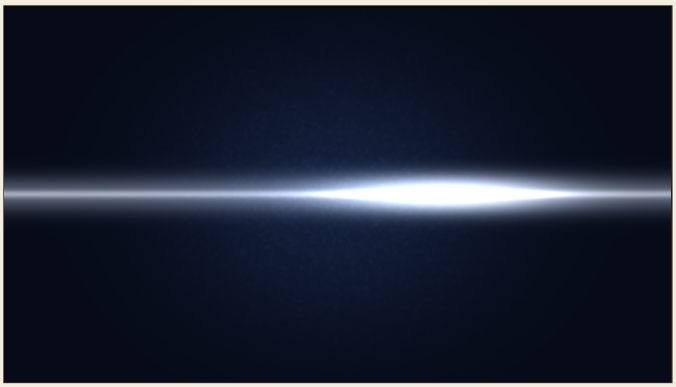
Welcome to this edition of Physics Pulse. Inside you will find the latest from the world of physics, a revisit of a classic essay on emergence, notable dates in physics history, and a round-up of departmental research and academic activity. We hope you enjoy reading.

PHYSICS NEWS

QUANTUM OPTICS

“Negative Time” Observed in a Lab

SUBMITTED BY ARINDAM CHAKRABORTY · 22 MAY 2026



A light pulse traverses a cloud of ultracold rubidium atoms — and appears to leave before it has fully arrived.

A recent experiment at the University of Toronto has measured a phenomenon known as *“negative dwell time.”* The team shot photons through a cloud of ultracold rubidium atoms. Normally, a photon entering such a medium briefly excites the atoms before being re-emitted — a duration called dwell time.

Under specific conditions, transmitted photons exited the cloud **earlier** than if they had travelled through a vacuum, yielding a negative value. Similar effects were seen in 1993 but were not taken seriously at the time.

To confirm the result, Steinberg’s team used a non-disruptive continuous probing method that bypasses the Quantum Zeno effect. The atoms recorded a negative excitation time — as if they had re-emitted the energy before the pulse had fully entered.

Importantly, this is **not** time travel: no information travels faster than light, so Einstein’s relativity is not violated. The result is a striking illustration of how deeply counter-intuitive the quantum world can be, even when its underlying rules stay firmly intact.

READ MORE: PHYSICAL REVIEW (APS)

MACHINE LEARNING MEETS PLASMA

AI Uncovers Hidden Physics in the Fourth State of Matter

Glowing filaments in a plasma — where AI has now revealed hidden, one-way forces between charged grains.

Researchers at Emory University have used artificial intelligence, combined with precise three-dimensional tracking of particles in a **dusty plasma**, to reveal patterns in how those particles interact — patterns that had escaped physicists for decades.

Plasma, often called the fourth state of matter, is a hot, ionised gas whose charged grains push and pull on one another in surprisingly complex ways. The team's machine-learning model captured these interactions — including subtle *non-reciprocal*, one-way forces — with over 99% accuracy.

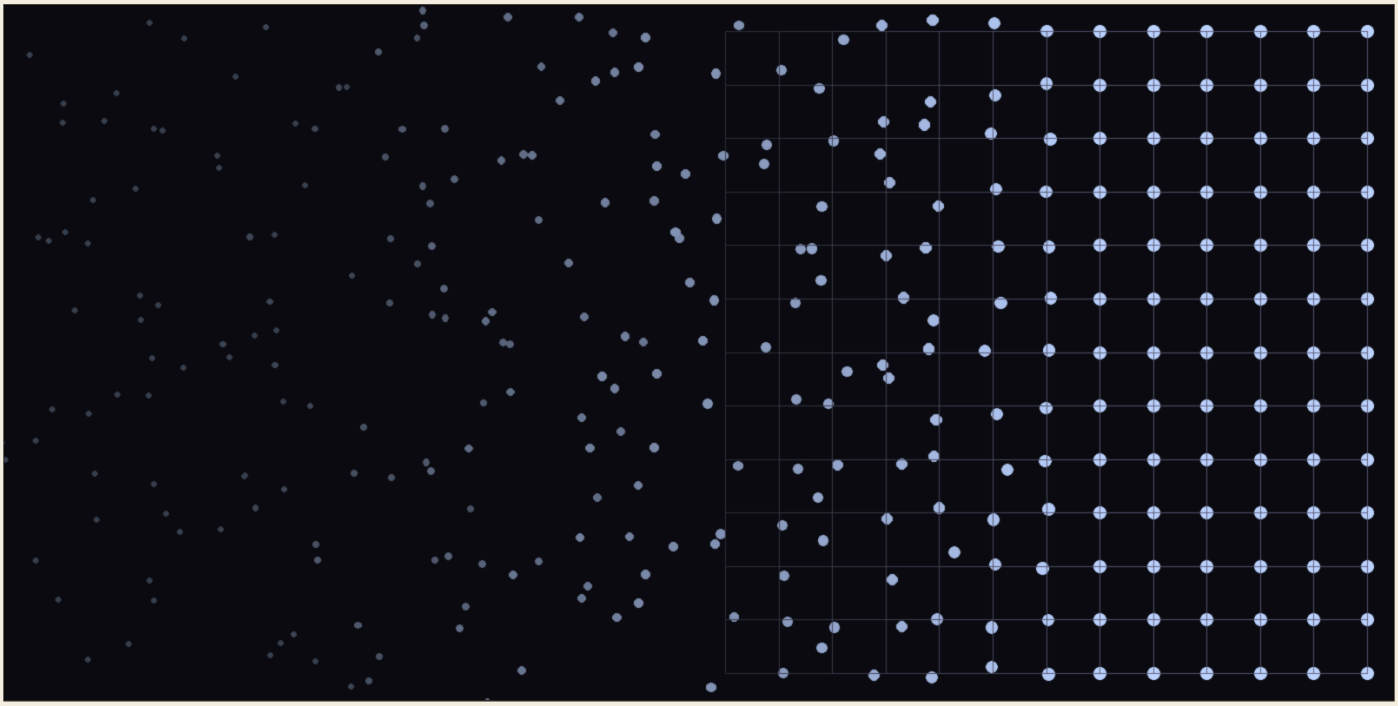
Strikingly, the results overturned a long-held assumption that such forces obey simple, symmetric rules. The work is a vivid example of how data-driven methods are becoming genuine partners to theory and experiment in the physicist's toolkit.

READ MORE: SCIENCEDAILY · EMORY UNIVERSITY

PHYSICS EXPLAINED

MORE IS DIFFERENT

By Physics Pulse Desk



From disorder to order: as many particles act together, entirely new laws emerge that no single particle obeys.

In 1972, the physicist Philip W. Anderson published a short essay in *Science* with a deceptively simple title: *"More Is Different."* Half a century later, it remains one of the most quoted arguments in all of physics — a manifesto for why the study of complex systems is every bit as fundamental as the search for the ultimate constituents of matter.

Anderson took aim at what he called the **reductionist hypothesis**: the widely held view that everything in the universe can, in principle, be reduced to a small set of fundamental laws governing particles and forces. He did not dispute this. What he rejected was the tempting corollary — that if we know those fundamental laws, we can reconstruct the entire universe from them. "The ability to reduce everything to simple fundamental laws," he wrote, "does not imply the ability to start from those laws and reconstruct the universe."

The reason is **emergence**. At each level of complexity — from atoms to molecules, from molecules to cells, from cells to organisms — entirely new properties appear that are not obvious from, and cannot easily be predicted by, the level beneath. Understanding water's wetness, a crystal's rigidity, or a magnet's field requires new concepts and new laws that are just as "fundamental" as the equations of particle physics. As Anderson put it, the behaviour of large and complex aggregates of elementary particles is not to be understood in terms of a simple extrapolation of the properties of a few particles.

MORE IS DIFFERENT — CONTINUED

His favourite illustration was **broken symmetry**. The laws of physics are, for the most part, perfectly symmetric — they look the same in every direction and at every point in space. Yet the world they produce is full of structure: crystals pick out particular directions, magnets choose a particular pole, and the arrow of time points one way. Collective behaviour spontaneously breaks the underlying symmetry, and in doing so it creates something genuinely new. More particles do not merely mean more of the same; they mean *different*.

This is why Anderson argued that the science of the very complex is not simply "applied" particle physics. Chemistry is not merely many-body physics; biology is not merely applied chemistry. Each field confronts phenomena — superconductivity, phase transitions, life itself — whose organising principles must be discovered on their own terms. A hierarchy of sciences does not imply a hierarchy of importance.

For a department like ours, where condensed-matter physicists, optical scientists and quantum theorists work side by side, Anderson's message is a quietly radical one. The frontier of physics is not only smaller and smaller, but also larger and more intricate. The next fundamental discovery may lie not inside a proton, but in the astonishing ways that ordinary things, when there are enough of them, conspire to become something more.

> *About this piece: "More Is Different" by P. W. Anderson appeared in Science, Vol. 177, No. 4047 (4 August 1972). This explainer revisits its central argument for readers of Physics Pulse.*

THIS MONTH IN PHYSICS HISTORY

11 MAY 1998

Pokhran-II Nuclear Tests

On 11 May 1998, India conducted three underground nuclear tests at Pokhran, Rajasthan, followed by two more on 13 May, under **Operation Pokhran-II**. The tests involved both fission and thermonuclear devices.

Led by scientists from the Bhabha Atomic Research Centre (BARC) and the Defence Research and Development Organisation (DRDO), the tests demonstrated India's capabilities and declared it a nuclear weapons state.

14 MAY 1973

Launch of Skylab

On 14 May 1973, NASA launched **Skylab**, the first space station of the United States. Designed to study long-duration spaceflight, it conducted experiments in solar physics, microgravity, and Earth observation.

Despite damage to its micrometeoroid shield and a solar panel during launch, astronauts repaired the station in orbit — an early achievement in space engineering and orbital maintenance.

25 MAY 1961

Kennedy Announces the Moon Mission

On 25 May 1961, U.S. President John F. Kennedy addressed Congress and announced the goal of sending a man to the Moon and returning him safely before the decade's end.

This vision gave rise to the **Apollo programme**, which achieved the historic Apollo 11 Moon landing in 1969.

DEPARTMENT NEWS

STUDENT RESEARCH

Ph.D. Pre-Submission Seminar — Sujeet Kumar

13 MAY 2026 · GUIDE: PROF. P. M. SARUN

Mr. Sujeet Kumar (19DR0159) of the **Functional Ceramics Laboratory** successfully conducted his Ph.D. pre-submission seminar on 13 May 2026 under the supervision of Prof. P. M. Sarun.

His thesis, *"Investigations on Rare-Earth (Nd, Pr, Eu) Doping Effects on the Structural, Ferroelectric, Dielectric, and Impedance Properties of Bismuth Ferrite Multiferroic Ceramics Across 50–500 °C,"* studies how rare-earth substitution in $BiFeO_3$ ceramics modifies the structural framework, enhances ferroelectric characteristics, and tunes dielectric and impedance responses across a wide temperature range — offering insights into the multifunctional behaviour of multiferroic materials.

OFFICIAL VISIT · 13 APRIL 2026

Inauguration of the Manekshaw Centre, IIIT Delhi

Prof. Sumit Kumar attended the inauguration of the Manekshaw Centre at IIIT Delhi on 13 April 2026, representing the Department of Physics at the official engagement.

OFFICIAL VISIT · 20 APRIL 2026

CMB-Bharat Meeting, Raman Research Institute

Prof. Sumit Kumar took part in the *CMB-Bharat* meeting at the Raman Research Institute on 20 April 2026, an engagement linked to external funding received for the initiative.

JOB OPPORTUNITIES

Junior Research Fellowship (JRF)

Combat Vehicles R&D Establishment (CVRDE), DRDO · Chennai

LAST DATE · 15 July 2026

https://drdo.gov.in/drdo/en/offerings/vacancies/cvrde-chennai-invites-applications-post-junior-research-fellowship-jrf-2026

Scientific Officer

Homi Bhabha Centre for Science Education (HBCSE), TIFR

LAST DATE · 11 July 2026

https://www.hbcse.tifr.res.in/get-involved/work-at-hbcse/permanent-recruitment-advt_02-2026.pdf

Postdoctoral Researcher — Investigation of Quantum Magnets

Helmholtz-Zentrum Berlin, Germany

LAST DATE · 26 July 2026

https://recruitingapp-5181.de.umantis.com/Vacancies/2827/Description/2

Postdoctoral Researcher — Self-Driving Lab for the Discovery of Novel Catalyst Materials

Helmholtz-Zentrum Berlin, Germany

LAST DATE · 12 July 2026

https://recruitingapp-5181.de.umantis.com/Vacancies/2838/Description/2

RESEARCH PUBLICATIONS

1 **Manika Dandapat, Priyadarshi Sahoo, and Umakanta Tripathy**

Detecting toxic species in the aggregation of amyloid beta in real time

Journal of Physics: Photonics, 8, 025017 (2026) · DOI: 10.1088/2515-7647/ae65f1

4 August 1972, Volume 177, Number 4047

SCIENCE

PHYSICS PULSE

More Is Different

Broken symmetry and the nature of the hierarchical structure of science.

P. W. Anderson

The reductionist hypothesis may still be a topic for controversy among philosophers, but among the great majority of active scientists I think it is accepted without question. The workings of our minds and bodies, and of all the animate or inanimate matter of which we have any detailed knowledge, are assumed to be controlled by the same set of fundamental laws, which except under certain extreme conditions we feel we know pretty well.

It seems to me that one may array the sciences roughly linearly in a hierarchy, according to the idea: The elementary entities of science X obey the laws of science Y.

X	Y
solid state or many-body physics	elementary particle physics
chemistry	many-body physics
molecular biology	chemistry
cell biology	molecular biology
•	•
•	•
•	•
social sciences	psychology

But this hierarchy does not imply that science X is "just applied Y." At each stage entirely new laws, concepts, and generalizations are necessary, requiring inspiration and creativity to just as large as in the previous one. Psychology is not applied biology, nor is biology applied chemistry.

In my own field of many-body physics, we are, perhaps, closer to our fundamental, intensive underpinnings than in any other science in which nontrivial complexities occur, and as a result we have begun to formulate a general theory of just how this shift from quantitative to qualitative differentiation takes place. This formulation, called the theory of "broken symmetry," is generally clear the breakdown of the constructionist converse of reductionism. I will give an elementary and incomplete explanation of these ideas, and then go on to some more general speculative comments about analogies at

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> *The ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe.*
>
> P. W. ANDERSON · "MORE IS DIFFERENT," 1972

The opening page of P. W. Anderson's 1972 essay "More Is Different," as it appeared in Science.