Solitons, numerical experiments, and that mysterious lady

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letters

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The interesting article by Thierry Dauxois on "Fermi, Pasta, Ulam, and a Mysterious Lady" (PHYSICS TODAY, January 2008, page 55) relates the subject of solitons to that of the Fermi-Pasta-Ulam (FPU) problem. The term "soliton" was introduced by Norman Zabusky and Martin Kruskal[1] in 1965 because the nonlinear waves studied did not lose their identity after colliding. In a sense, they resembled particles. The study by Zabusky and Kruskal was a numerical one of the Korteweg–de Vries equation, but the motivation was to study the propagation of waves in a collisionless plasma containing a magnetic field. Fifty years ago John Adlam and I studied that problem[2] and found an analytical solution for strong, collision-free hydromagnetic solitary waves for Alfvén Mach numbers less than 2. The solution was not valid for faster, stronger waves. Further work in 1960 dealt with the excitation of a train of such waves;[3] that time the equations were solved numerically. The work with Adlam seems to have been largely overlooked until recently,[4] presumably because it predated the term "soliton."

References

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Rediscovering Mary Tsingou's role in the Fermi-Pasta-Ulam problem is laudable. However, Thierry Dauxois is incorrect in calling the FPU problem "the first-ever numerical experiment" that marked the beginning of "computer simulations of scientific problems."

Lewis F. Richardson's landmark 1922 work on numerical weather prediction predated the FPU problem by more than three decades and far surpasses it in complexity.[1] The first successful numerical weather forecast was performed on the ENIAC computer in 1950 by a team of scientists that included John von Neumann.[2] Both of those numerical experiments were highly nonlinear in character and involved approximations of the Navier–Stokes equation. Dauxois's oversight confirms the statement that "meteorologists . . . are the Rodney Dangerfields of science. They get no respect from . . . physics and chemistry."[3]

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Dauxois replies: I did not attempt to present a complete history of the soliton concept, so all possibly relevant papers were not cited. However, I think the paper by Norman Zabusky and Martin Kruskal (J. E. Allen's reference 1) ought to be emphasized for several reasons. First, it dealt directly with the understanding of the puzzling observation made by Enrico Fermi, John Pasta, Stanislaw Ulam, and Mary Tsingou. Second, it highlighted the soliton, a concept of general interest[1] that goes beyond the observation of "collision free" wave interactions. Third, the suffix "-on" in the name emphasizes that those waves have properties of particles.

I know that using a computer to solve an equation was done before FPU-Tsingou. (Working in physical oceanography and having a wife in fluid mechanics, I do respect meteorologists!) Solving equations, with or without approximations, is different from conducting a numerical experiment, which asks the computer a physical question. One studies a system simpler than the real one in order to use the computer to test theories that could not have been tested with real experiments, affected as they are by uncontrollable effects and noise (see the epistemological paper in reference 2). I am not aware of any previous use of computers in that way, nor, apparently, was Ulam.[3]

References

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Water in trees

The Quick Study by Missy Holbrook and Maciej Zwieniecki (PHYSICS TODAY, January 2008, page 76), on the physics of transporting water to the tops of trees, invites an immediate agricultural query: Since, as the article describes, the extreme amounts of water that plants require are due to the low concentration of carbon dioxide in the atmosphere, why have we not developed enclosed growing systems with dramatically higher CO_2 concentrations?

For example, capturing coal-plant CO_2 effluent for use in adjacent growth enclosures—which requires almost no net energy consumption—would simultaneously reduce emissions and water consumption and provide abundant supplies of CO_2 for crops. Of course, that might require genetic reconfiguration of plants that have adapted to the low current CO_2 concentrations, but unlike other genetic modifications, those plants could pose no threat other than economic to normal crops, since they would not