

A lost detail in D-T fusion history

In the summer of 1942, at J. Robert Oppenheimer's "luminaries" meetings, Emil Konopinski proposed the introduction of tritium into deuterium fuel to enhance the feasibility of a fusion-driven super bomb. Several histories and memoirs by Manhattan Project scientists mention Konopinski's insight, but none that we could find explain where it came from. In one interview, Konopinski stated, "I happened to know from pre-war work that the reaction of deuterium with hydrogen-3 produces much more energy and has a larger cross section, so to speak—happens more easily—than deuterium with deuterium."¹ The recent ignition of a D-T mixture at the National Ignition Facility by inertial-confinement fusion (see "National Ignition Facility surpasses long-awaited fusion milestone," *PHYSICS TODAY* online, 13 December 2022) prompts the question: How did Konopinski, and perhaps other physicists, know about the unexpectedly high D-T reaction rate?

Enter Arthur Ruhlig, who did graduate work at the University of Michigan in the 1930s with H. Richard Crane. They studied electron and positron propagation through lead.² In the same year that Ruhlig submitted his dissertation, he published a letter in *Physical Review* assessing whether ^3He possesses excited states.

Ruhlig did not detect any excited-state signal, consistent with present understanding. But the title of the letter, "Search for gamma-rays from the deuteron-deuteron reaction," cloaks the tectonic finding of its penultimate paragraph: The reaction $^3\text{H} + ^2\text{H} \rightarrow ^4\text{He} + n + 17.6 \text{ MeV}$ "must be an exceedingly probable one."³ Ruhlig deduced the presence of energetic neutrons, correctly ascribing their production to secondary, in-flight D-T fusion reactions following the $^2\text{H} + ^2\text{H} \rightarrow ^3\text{H} + ^1\text{H}$ primary reactions and quantifying the

EMIL KONOPINSKI in Ann Arbor, Michigan. (Photograph by Samuel Goudsmit, courtesy of the AIP Emilio Segrè Visual Archives, Goudsmit Collection.)



rate of the D–T reaction relative to that of D–D. That remarkable observation had never been explicitly cited before.

While working at Michigan on his doctoral degree with George Uhlenbeck, Konopinski overlapped with Ruhlig. (Uhlenbeck is warmly cited in Ruhlig's thesis acknowledgments.) Ruhlig's proximity to Konopinski at Michigan and his inclusion in reference 3 of a citation to a private communication from Hans Bethe—who worked with Konopinski at Cornell University—afford possible conduits for the key piece of surprising information on D–T fusion. A follow-up measurement confirmed the large cross section.⁴

As the story of nuclear-reaction physics continues to unfold, we hope to uncover more of its historical details,⁵ hopefully with input from readers of *PHYSICS TODAY*.

References

1. A. B. Carr, "Physicist Emil Konopinski discusses hydrogen reactions," <https://www.youtube.com/watch?v=z5cQgu5xCnc>.
2. A. J. Ruhlig, "The passage of fast electrons and positrons through lead," PhD thesis, U. Michigan (1938).
3. A. J. Ruhlig, *Phys. Rev.* **54**, 308 (1938).
4. C. P. Baker et al., *The Cross Section for the Reaction $D(T,\alpha)n$* , AECD-2226, US Atomic Energy Commission (17 September 1943); reprint, <http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-00011-MS>.
5. M. B. Chadwick et al., "The earliest DT nuclear fusion discoveries," *Nuclear News*, 13 April 2023.

Mark W. Paris
(mparis@lanl.gov)

Mark B. Chadwick
(mbchadwick@lanl.gov)

*Los Alamos National Laboratory
Los Alamos, New Mexico*

Plutonium pits and moral principles

I commend David Kramer for his Issues & Events piece "Despite unknowns, NNSA plunges ahead on plutonium pits" (*PHYSICS TODAY*, April 2023, page 22). But it is missing a discussion of the morality of possessing nuclear weapons in the first place.

Both rightness and truth are important. Many US citizens, including those with

and without physics backgrounds, do not want their federal taxes to pay for nuclear weapons—and therefore National Nuclear Security Administration facilities that aim to make, certify, or store them. And voters' decisions in national elections can be flawed if based on misinformation.

The public also needs information from the National Nuclear Security Administration regarding the stability of plutonium pits, especially given the conundrum of the element's instability from the mutually interacting effects of self-irradiation and its multiple phases—to say nothing about the other properties of plutonium (for example, that it is pyrophoric when in contact with air).

Everyone needs to be included in devising solutions to the problem of nuclear weapons. If those with moral reservations are excluded from that work, the results will be flawed.

Harold M. Frost III
Sheffield, Vermont

Shorten the solar-geoengineering timeline?

In his article on climate tipping points, Michael Edgeworth McIntyre highlights how the various synergies among contributing factors mean there are multiple possible pathways toward unpredictable adverse climate impacts (*PHYSICS TODAY*, March 2023, page 44). Only a subset of those pathways need to be self-reinforcing in an adverse way to produce more severe or more abrupt harmful outcomes than models predict.

In that context, it can be useful to reconsider the role of solar-radiation management (SRM), also known as solar geoengineering—a strategy that involves reflecting some of the Sun's energy back into space as a means of combating climate change. Proposed SRM strategies include the injection of aerosols into the atmosphere, the brightening of marine clouds via sea-salt injection, and even the creation of floating mirrors in space.

The well-known potential drawbacks of those strategies should be viewed in

the context of growing indications that climate degradation will outpace decarbonization. McIntyre's survey of climate contingencies serves as a reminder that the decision of whether to implement SRM is a choice between the lesser of two problematic scenarios.

In that regard, two points are pertinent. First, the choice is not binary. A limited deployment of SRM that fractionally slows the global-temperature increase over several decades might yield benefits that greatly outweigh the associated risks. Second, the possible rapid onset of extreme climate scenarios could accentuate the need for timely SRM deployment, which raises the question of how quickly that need could be met. The present approach, which holds more-concrete steps in abeyance pending the outcome of ongoing studies of SRM effectiveness and drawbacks and the clarification of governance, could mean that we wouldn't see any tangible mitigation benefits for decades. Aerosol dispersal, for one, will eventually require the design and construction of aircraft, among other large-scale industrial tasks.

The adverse impacts of that lag could be enormous. Parallel efforts, analogous to the COVID-19 vaccine development strategy, therefore merit consideration. That would involve initiating long-lead-time substantive preparations for deployment concurrently with scientific evaluation, but not committing to full operational deployment of SRM capability until it has been adequately assessed with regard to its effectiveness and risks. By that or other means, the prioritization of SRM should be aligned with its unique precautionary role.

Alan Kerstein
(alan.kerstein@gmail.com)
Danville, California 

CONTACT PHYSICS TODAY

Letters and commentary are encouraged and should be sent by email to ptletters@aip.org (using your surname as the Subject line), or by standard mail to Letters, *PHYSICS TODAY*, American Institute of Physics, One Physics

Ellipse, College Park, MD 20740-3842. Please include your name, work affiliation, mailing address, email address, and daytime phone number on your letter and attachments. You can also contact us online at <https://contact.physicstoday.org>. We reserve the right to edit submissions.