Synchronystic rowing for speed

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LETTERS

Effect of seasons on greenhouse warming

Michael Gerver cites the planet Venus as a caution about runaway greenhouse warming (Physics Today, September 2017, page 11). Apart from Venus's being much closer to the Sun and having a very dense carbon dioxide atmosphere, another critical difference between Earth and Venus is highly relevant to our greenhouse effect but rarely mentioned: Earth has seasons; Venus does not.

The importance of seasons struck me when I was puzzling how IR radiation can escape from the tropopause into outer space.

In the troposphere, heat is transported upward by convection. First-year undergraduates are taught how to calculate the lapse rate—the temperature drop with altitude—by considering gas thermodynamics alone. But at the tropopause, the temperature ceases to fall with altitude and begins to rise again. The cause is UV heating from above.

Above the tropopause, convection is no longer a viable mechanism for vertical heat transport, and that is why the stratosphere is stratified. If heat is to escape into space from the tropopause, it is going to be by IR radiation. But there is a problem: greenhouse gases, such as CO_2, which provide the IR. The CO_2 concentration makes the mean free path quite short for a photon at the center of the molecule's IR resonance. And with the temperature now rising, the net IR flux at that frequency is actually downward.

Nevertheless, IR radiation can cross the stratosphere at frequencies with a smaller CO_2 cross section. Raymond T. Pierrehumbert alluded to that in an excellent feature article he wrote for Physics Today (January 2011, page 33). However, the restriction to off-resonance frequencies severely limits the amount of heat that can be shed into space.

In the case of Venus, the options essentially end there. Any extra heating at the surface will cause thermal runaway until some new mode of heat shedding is activated. For Venus, it would appear that the surface is hot enough for the temperature to fall monotonically with altitude all the way up.

Earth, however, has another savior: its shadow, which in winter shields the stratosphere near the poles and thus prevents UV heating from above. The temperature continues to fall with altitude, and IR radiation, even at the center of the CO_2 resonance, can cross the stratosphere.

What is surprising is that the seasonal heat shedding receives so little attention.

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Synchronystic rowing for speed

The Quick Study about rowing (Physics Today, June 2017, page 82) by Jean-Philippe Boucher, Romain Labbé, and Christophe Clanet was interesting, but I think the authors missed the real answer to their question. To understand why rowing in sync is faster than rowing asynchronously, consider the authors' plot of velocity versus time. As the boat speed increases, the exertion of a given force by the rowers becomes increasingly difficult and the stroke time decreases; as a result, the per-stroke momentum imparted to the boat decreases. By reducing the boat speed during most of the stroke, synchronized rowing increases the effective power output of the rowers and thus raises the average speed.

I experienced the phenomenon during my brief time with the freshman crew at MIT in 1969: The faster the boat is going, the harder it is to pull effectively on the oar and the shorter the duration of the power stroke.

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▶ **Boucher, Labbé, and Clanet reply:** Eric Firing gives an interesting comment on our Quick Study. We reported the observation, with a model robotic rowing boat, that being synchronized goes faster than being asynchronized. Our explanation of the difference was that in the synchronized configuration, the motion of the rowers with respect to the boat during the recovery stroke had a propulsive effect, but that effect was canceled out in the asynchronous case.

With further experiments on our model boat, we confirmed that effect as we observed that when the rowers were synchronized, the higher the mass of the rowers, the higher the speed of the boat. However, after further investigations and as Firing suggests, we think the phase shift between rowers might also affect the efficiency of oar propulsion. Our current study on oar propulsion will surely clarify that point.

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"Necessary and sufficient"— and classic

The letter by Robert Hirsch and the response by Steven Cowley (Physics Today, October 2017, page 11) discuss a classic issue related to fusion research. In 1991, as chairman of the American Physical Society's division of plasma physics, I met with US secretary of energy James Watkins and pointed out the problems a deuterium–tritium fusion reactor has with tritium fuel storage and with radioactive waste created by neutron-damaged reactor structure.

The debate between Hirsch and Cowley demonstrates that no progress has been made on the issue in the past quarter century. Hirsch advocates using an alternative advanced fuel, such as proton–boron, which produces no neutrons. Although p–B fuel in theory could be ideal, the excessively higher temperature and the necessary plasma confinement time make its use unworkable. In meeting with the energy secretary, I proposed deuterium–helium-3 fuel, which also produces no neutrons (although subsidiary deuterium–deuterium fusion produces neutrons but with much less energy and quantity than D–T reaction).

The D–^{3}He reactor requires a container that can withstand an order-of-magnitude higher pressure than D–T requires, but still in a more feasible range than p–B. I also recommended the magnetic dipole container that allows much higher pressure than ITER standards for D–^{3}He fuel.

I agree with Hirsch that the research goal of a fusion reactor should be based on what he calls the sufficient condition of being economically and environmentally acceptable. If the goal is right, the physics problem will eventually be solved.

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Rosenfeld's work on Fermi compilation

The obituary honoring Arthur Rosenfeld (Physics Today, September 2017, page 72) did not mention the very important contribution that he, together with Jay Orear and R. A. Schluter, made to the education of my generation of physicists. The trio compiled Enrico Fermi's 1949 physics lectures from the University of Chicago into the book *Nuclear Physics*, originally published in 1949–50. Students at the time universally referred to it as Fermi's Notes.

A dense compilation of just about all the nuclear physics understood at the time—including a chapter each on nuclear reactors and cosmic rays—this modest and reasonably priced volume sparkles with the kind of physical insight said to be characteristic of Fermi's style as a teacher.

I remember one of its sample problems: An American car was shown to be tunneling quantum mechanically through a one-foot-high bump in the road. Would this be a solution to our crumbling roads? Not quite. The probability of that happening is not zero, but it is infinitesimally small!

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Correction

February 2018, page 55—Although Jill Tarter was the only woman in her engineering class at Cornell University in 1965, she was not the first woman to receive an engineering degree from the university. That benchmark belongs to Nora Stanton Blatch Barney, who received a civil engineering degree in 1905. PT