nuclear energy and makes no mention of a specific right to enrichment or reprocessing. We think that the efforts of the international community to strengthen the constraints on Iran against its acquisition of nuclear weapons are appropriate, and we hope for their success. As physicists who have spent much of our careers in nonproliferation, arms control, and disarmament, we agree with Wilson's point that the physics community should explain the policy implications of nuclear weapons issues. And working on resolving those issues is perhaps even more important.

Has the NPT process helped or hurt global proliferation? Certainly it initially enhanced technology transfer of plutonium manufacture, but it also gave the world a starting place to establish nonproliferation criteria and institutions to carry out inspections under the NPT and the IAEA. Further progress will make it easier to obtain nuclear technology, will lower the technical barrier to the bomb over time, and will increase the need for strong NPT and IAEA safeguards. And starting with the Carter administration in 1977, the US has worked mightily to constrain enrichment and reprocessing in non-nuclear-weapon states. A major concern is that the NPT is silent on the issue of ownership of the nuclear materials in states that withdraw from the NPT—North Korea, for example—and what to do about it. Problems are well known, but specific, viable solutions are needed.

Reference

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Shock waves and history in free fall

As I read with interest "Dynamics of a skydiver's epic free fall," the Quick Study by José Colino, Antonio Barbero, and Francisco Tapiador (Physics Today, April 2014, page 64), I encountered several important errors from the aerodynamic standpoint that need to be clarified.

First, in the paragraph just above the subhead "A closer look at Baumgartner's jump," the authors state that "since the [shock] wave propagates at the speed of sound, the diver will eventually cross that disruptive shock." Shock waves always propagate faster than the upstream speed of sound. In fact, what we call a detached shock wave, which forms upstream of a blunt body flying at supersonic speeds, travels at roughly the same velocity as the blunt body itself.

Second, the authors state that "shock waves form where subsonic and supersonic flows meet." That is true only when downstream boundary conditions require that a supersonic flow slow to subsonic speeds. When a subsonic flow accelerates to a supersonic flow, the region where the flow is sonic is not a shock wave but a sonic line or sheet. Accordingly, the thin regions marked in blue in panel b of the figure are sonic sheets, not "shock waves" as the authors state. The sheets delimit the subsonic region between the shock and the diver's head, and the supersonic region around the chest and the rest of the diver's body.

Unlike shock waves, sonic sheets are isentropic. Of course, even though it is supersonic, the flow formed downstream of the sonic sheets marked in blue is slower than the incoming flow. Nevertheless, the unsteady and complex boundary layers formed around the chest and backpack wrapped in fluttering fabrics create a forest of small, low-intensity shock waves that eventually accommodate the air speed to that of the object in contact with it.

Furthermore, in describing panel b of the figure, the authors say the detached shock wave at the diver's front is positioned "downstream" of him. That turns the established language of fluid dynamics upside down: "Upstream" is in the opposite direction to the incoming flow relative to the object (or to the axes used to describe the motion), and "downstream" is behind the object, in the direction of the flow.

My above comments aside, I truly congratulate Colino and coauthors for their illuminating study on the free fall of a diver; I will surely use it in my undergraduate classes.

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■ **The lead-in paragraph** to the interesting Quick Study on Felix Baumgartner's free fall misstates history when it says that Baumgartner fell faster than anyone before him. In 1966 an SR-71 reconnaissance aircraft experienced an in-flight breakup while traveling faster than Mach 3. The event resulted in an involuntary free fall that in all probability began at a speed much greater than Mach 1. The pilot, Bill Weaver, survived his high-speed free fall; his reconnaissance system officer, Jim Zwayer, did not.

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■ **The discussion** about Felix Baumgartner's fall to Earth gives an interesting analysis of a hair-raising event. A similar historical feat that few may know about involves the return of the early Soviet cosmonauts.

In the race into space, the Soviets sent Yuri Gagarin and his colleagues in the Vostok program into orbit without having confidence they could bring them back in one piece. Their solution, which they kept secret for many years, was to have the cosmonauts eject from their reentering capsule at an altitude of 7 km and parachute to the ground. Valentina Tereshkova, the first woman in space and part of the Vostok program, was chosen for the job in part because she was a member of a parachuting club.

So while Baumgartner started his jump essentially at rest, Gagarin and colleagues started with a big initial velocity. Stories about the 2012 jump got me wondering just how fast the cosmonauts were going. I've posted my analysis at http://allthingsnuclear.org/skydiving-from-a-reentering-spaceship.

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■ **Colino, Barbero, and Tapiador reply:** We thank Alfonso Gañán-Calvo, Alan Spero, and David Wright for their careful, detailed comments on our Quick Study. Gañán-Calvo's point about sonic sheets is pertinent; it shows that the topic is too subtle to be judiciously covered in the limited space of a Quick Study. We thank him for expanding on it for Physics Today readers. Also, because the real flow structure was unknown, we simplified the plots: The offending panel b of the figure, for which "downstream" is incorrectly used instead of "upstream," is obviously not a precise depiction of the aerodynamics but a sketch intended for a wide audience. For a discussion of such issues as low-intensity shock waves around the suit and the complex flow patterns that expansion waves, shocks, and turbulence form past a body—downstream—at transonic or supersonic regimes, see the more detailed treatment given in references 1–3.

Spero and Wright bring attention to two other free falls that we think can hardly be compared with Baumgartner's. The SR-71 pilot and reconnaissance system officer could have experienced a fall with a presumably horizontal, probably supersonic initial speed. Nevertheless, it is hard to tell without ejection trajectory data, fall dynamics details, or any other information except the tragic outcome.

We also know little about the jumps associated with the Vostok program. Neither example can be compared with the jump by Baumgartner—or even the one by Joseph Kittinger in 1960—not only because the two jumpers began their descent at nearly zero speed but especially because precise speed and location measurements were available. Indeed, we should thank the Red Bull Stratos project for making such quality data available.

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2. R. A. Granger, *Fluid Mechanics*, Dover (1995), chap. 15.
3. S. F. Hoerner, *Fluid Dynamic Drag: Practical Information on Aerodynamic Drag and Hydrodynamic Resistance*, Hoerner (1958).

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Correction

October 2014, page 12—The first sentence in the second paragraph under the subhead "Cosmic foil" should read, "The team's search turned up 20 impact craters, including the one shown in figure 2." The majority of craters were identified manually. ■