free from congestion.[1]

The traffic-generated waves Thusen mentions are kinematic waves described by the equation

$$\frac{\partial Q}{\partial t} + C\frac{\partial Q}{\partial x} = B,$$

in which Q represents a volume flux, C the speed of the wave and B a local production term, and t and x denote time and distance, respectively. These waves are essentially different from dynamic waves, such as waves on the ocean surface. Newton's equations of motion do not play a role in kinematic waves (other than, perhaps, by linking the wave speed to the volume flux), as they do in dynamic waves, which exist because of the inertia terms in the equations of motion. Rather, kinematic waves owe their existence to the conservation of volume or mass, when a relation exists between the discharge, concentration and position.

Kinematic wave theory has been used to describe traffic flow on long crowded roads, as well as to characterize flood waves traveling downstream on long rivers and to model the response of glaciers to changes in surface accumulation.

On California freeways and highways elsewhere, kinematic waves are generated by drivers, especially aggressive ones, as they weave in and out of traffic, annoying and cutting off other drivers and thus aggravating unsuspecting people farther back who have to suddenly slow down for no apparent reason. Because the wave velocity is somewhat less than the mean speed of cars, these people can accelerate only gradually as they make their way through the kinematic wave.

Reference

1. M. J. Lighthill, G. B. Whitham, Proc. R. Soc. London Ser. A, **229**, 317 (1955).

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Earth Science Beckons to Physicists Taking Quantitative Approach

In his review of two books on planetary volcanism (PHYSICS TODAY, March, page 77), Don Anderson is absolutely correct in pointing out that much fascinating and important work remains to be done, and that the field "is ripe for exploitation by physicists." Their abilities and interests would greatly compliment the valuable but often relatively nonquantitative contri-

butions of most geologists.

However, I would go further and suggest that physicists interested in dipping their feet in the waters of Earth science would be well advised to start off with more mathematically rigorous textbooks, as well as geophysics journals. *Geodynamics: Applications of Continuum Physics to Geological Problems*, a graduate-level text by Donald L. Turcotte and Gerald Schubert (Wiley, 1982), is a good starting point, although only a handful of pages are specifically devoted to volcanism. Unlike the books reviewed by Anderson, this text certainly does contain "words such as energy, velocity, . . . pressure, thermodynamics [and] conductivity."

A host of other geophysical journals, including the *Journal of Geophysical Research*, can also provide interested physicists with not only a starting point but also a state-of-the-art understanding of the applications of physics to Earth science.

They should be forewarned, however, that, as Anderson points out, "Earth scientists are presented with a completed experiment and must infer what happened." In many instances, geophysics (and Earth science in general) is unavoidably as much art as science.

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A Sum of Scientists Get Science Right by Writing Fiction

Jean Kumagai's article on Alan Lightman's career shift from astrophysics to writing (February, page 50) prompts me to comment briefly on other scientists who also write fiction.

Many nonscientists will not read even a popularized scientific book or article, no matter how well written. Consequently, to reach that audience, scientists have to write speculative fiction, weaving real science into an exciting plot. They also have to meet the challenge posed by the fact that, in such "hard" science fiction (as opposed to fantasies like *Star Wars*), the plot is constrained by the science, which the reader has to be able to understand, or at least follow.

The very few professional scientists who have become full-time writers include such giants in the SF field as Isaac Asimov, a professor of biochemistry whose 500 nonfiction and fiction books included *I, Robot* and other SF classics, and Arthur C. Clarke, a physicist and mathematician by training, whose 60-plus books include *2001: A Space Odyssey* and about 30 other SF novels.

More scientists have been part-time SF writers. Astronomer Fred Hoyle has written a dozen novels, and physicist John Cramer has written two. In addition to turning out many popularized science books, Carl Sagan was the author of the SF novel *Contact*. Earlier, George Gaylord Simpson, the grand master of evolutionary animal structure, wrote a time-travel novel, *The Dechronization of Sam Magruder*; Gerolf Steiner, a University of Heidelberg zoologist writing under the pseudonym Harald Stümpke, described the evolutionary radiation of imaginary animals in a delightful fictional monograph, *The Snouters*; and J. B. S. Haldane, Leo Szilard, Julian Huxley, Norbert Wiener and others wrote an occasional SF story.

Also worth mentioning is Gregory Benford, a working astrophysicist who has won several literary prizes (one was announced in your "We Hear That" section last year). His 19 books include *Timescape*, a non-SF novel widely regarded as our best depiction of real physicists at work.

If scientists don't write realistic science fiction, who will? Unfortunately, we have left it to the scientifically illiterate to produce most of the novels, movies and TV shows that feed the public's appetite for space sagas, UFOs, dinosaurs, asteroid collisions and unexplained phenomena. The unalloyed nonsense that passes for science in the entertainment world is ultimately our own fault, and I believe we owe a debt to all of the writers I've mentioned above for trying to reach an undereducated public.

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Relationship between Natural and Man-Made Elements Is Platonic

In his letter about naming new elements (August, page 80), Greg Root draws a false distinction between anthropogenic and theogenic elements. Such a distinction runs contrary to the Platonic tradition of chemistry, which regards all appearances of new substances as discoveries. Undiscovered but theoretically possible compounds are said to exist in a Platonic sense.[1]

Reference

1. R. C. Tompkins, Am. Scientist **78** (4), 299 (1991).

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Corrections

August, page 18—Earth's age should have been given as 4.5 billion years, not 4.5 million years.

August, page 48—The sentence about the operational design of the National Ignition Facility was garbled. It should have read: DOE proposes to build a 192-beam glass laser system capable of routinely delivering 1.8 MJ of 350 nm light at a power of 500 TW.

June, page 9—The first experimental proof of principle for a superfluid gyroscope was given by the French team of Olivier Avenel and Eric Varoquaux at the 21st International Conference on Low Temperature Physics, held in Prague on 8–14 August 1996 (O. Avenel, E. Varoquaux, *Czech J. Phys.* **48**, suppl. S6, p. 3319, 1996; see also O. Avenel, P. Hakonen, E. Varoquaux, *Phys. Rev. Lett.* **78**, 3602, 1997.) ■