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"It's been really difficult" to prove that drugs or vaccines are safe in pregnancy, says Allison McGeer, an infectious disease specialist at Mount Sinai Hospital in Toronto, who is studying flu vaccines in pregnancy. Although McGeer believes flu vaccines are safe, she hesitates to prescribe antiviral drugs to pregnant women who are mildly ill or as a preventive treatment. "Those of us who don't deal routinely with pregnant women are very afraid to do anything," she says.

One area not addressed by VAMPSS and most other studies is whether medications taken during pregnancy can cause effects in children years later, such as learning difficulties in school. "We need to focus more on the long-term effects," says Lars Pedersen, an epidemiologist and obstetrician at Aarhus University in Denmark, who has studied antidepressants and other drugs in pregnancy. But that is not easy to do.

It's not so much that "drugs are out there causing problems," says Schatz, although some probably are. The bigger challenge, he believes, is the uncertainty: Which drugs are dangerous to a fetus, and which are not?

–JENNIFER COUZIN-FRANKEL

PHYSICS

Century-Long Debate Over Momentum of Light Resolved?

What is the formula for the momentum of light zipping through a transparent material? That may sound like a question on a high-school physics quiz, but physicists have been debating the matter ever since two different formulas were proposed more than 100 years ago. Now Stephen Barnett, a theorist at the University of Strathclyde in Glasgow, U.K., says he has resolved the famed "Abraham-Minkowski dilemma." Both formulas are correct, he says, but they denote different things and apply in different contexts.

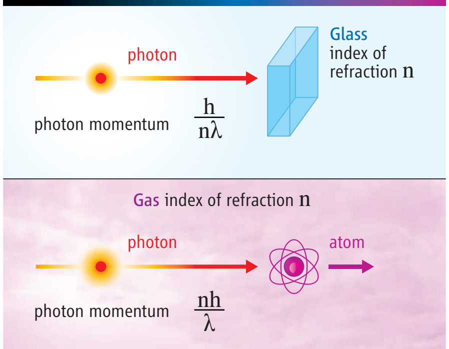
Others had suggested that each formula might be correct in its own way, but Barnett spells out precisely when each is relevant, says Robert Boyd of the University of Rochester in New York state. "Steve tells you how to apply them correctly," Boyd says. "I think [the work] has a good chance of being definitive."

Everyone agrees that the momentum of a photon zinging through empty space is given by a fundamental constant divided by the light's wavelength. When the light enters a medium such as glass or a gas, however, it slows down, which is why a lens bends light. What then happens to the light's momentum? Key to this question is the material's "index of refraction," the ratio of light's speed in a vacuum to its speed in the material, a number typically larger than one. In 1908, German mathematician Hermann Minkowski argued that the momentum of light in a material equals its momentum in the vacuum multiplied by the index of refraction, making it greater than the vacuum momentum. A year later, his compatriot, physicist Max Abraham, argued that the momentum of light in a material equals the vacuum momentum *divided* by the index, making it smaller than the vacuum momentum.

Thought experiments and real-world data can be found to support each formula. For example, imagine a photon speeding toward a block of glass (see diagram). Together, the glass and the photon possess a total mass and energy that flows in the same direction as the photon. According to Newton's laws of motion, that flow should continue unabated as the photon passes through the glass. But within the glass, the photon slows down. So to maintain constant energy flow, the glass has to recoil in the same direction. From this premise, a little algebra leads to Abraham's formula for the photon's momentum in the glass.

On the other hand, imagine firing a photon at an atom in a gas. Suppose the atom can absorb light of a wavelength slightly longer than that of the approaching photon. Then to soak up the photon, the atom must speed away from the light source so that from its perspective the light wavelength stretches—just as a siren's pitch dips if you're in a car rushing away from the siren. The size of that "Doppler shift" is proportional to the gas's index of refraction. Starting from that premise, a little math yields Minkowski's formula.

DEFINING LIGHT'S TOUCH



Riddle me this. Incompatible equations for a photon's momentum have long puzzled physicists.

Actually, Barnett argues in the 19 February issue of *Physical Review Letters*, the two cases describe different kinds of momentum. Abraham's formula gives the "kinetic momentum"—essentially the mechanical punch the photon packs as it hits the glass. Any experiment to measure such a punch will agree with Abraham's formula. Minkowski's formula gives the subtler "canonical momentum"—which, loosely speaking, is tied to the wave nature of light and is higher in a material than in vacuum because the light's wavelength is shorter in the material. Any experiment to probe wave effects will jibe with Minkowski's formula.

More technically, the canonical momentum is a mathematical quantity connected to movements in space. A theorist can write down a quantum "wave function" describing an atom sitting in an electromagnetic field. To move the atom to another spot, the theorist must change the wave function by performing a specific mathematical operation that involves the canonical momentum. That's why in the thought experiment with the moving atom, it's the canonical momentum that counts.

Given the debate's long history, few expect the work to win immediate acceptance. "Various people have taken rather strong views, you might say verging on religious beliefs," says Paul Lett, a physicist at the U.S. National Institute of Standards and Technology in Gaithersburg, Maryland. Barnett says he's game to take on the naysayers, however: "If somebody exposes some flaw, then I suppose I shall have to—Oh, they won't!"

–ADRIAN CHO

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