Catching a light ride on a plasma wave

Replace the waves of Waikiki with relativistic waves in an ionized gas, and substitute a bunch of photons for a surfer. The result is a novel method for increasing the frequency of short pulses of laser light. Such a technique, if practicable, could provide an efficient, flexible way of generating coherent X-rays.

The idea of using plasma waves to "accelerate" photons comes from physicist John M. Dawson and graduate student Scott C. Wilks of the University of California, Los Angeles. Their theoretical analysis of how such a photon accelerator would work appears in the May 29 PHYSICAL REVIEW LETTERS.

"Of course, nothing goes faster than the speed of light [in a vacuum]," Dawson says. "But in a plasma, light travels slower than it does in a vacuum, so one can in fact increase its velocity."

When a bunch of electrons, accelerated to nearly the speed of light, whips through an ionized gas, or plasma, it launches a rapidly moving wave in the plasma, much like the wake generated by a speedboat. Injecting into the plasma wave a pulse of laser light, consisting of a group of photons, transfers energy from the wave to the photons. As they ride the wave, the photons increase their frequency substantially and gain a little speed.

Researchers have already observed plasma wakes, and computer simulations indicate that transferring energy from such wakes to photons is possible in principle. "Now we need to demonstrate that the phenomenon exists," Dawson says.

Using plasma waves to accelerate photons may be most useful for generating high-frequency light. "From our studies, we believe [plasma acceleration] should have high efficiency," Dawson says. "It looks like it might be a cheap way to get coherent X-rays. We could convert low-energy [microwave] photons, which are cheap and easy to make, into expensive photons, shifting them into the ultraviolet or X-ray frequencies."

In contrast, synchrotron light sources, which rely on electron acceleration to generate coherent X-rays, convert into light only a small proportion of the total energy required to run the system.

The notion that relativistic plasma waves can modify photon frequencies also has intriguing implications for astrophysics. Such waves could shift the frequency of light coming from pulsars and other astronomical objects, complicating the interpretation of such observations.

Dawson sees the possibility of not only accelerating but also manipulating photons, perhaps using them to make X-ray movies of molecular vibrations. "It's a tremendously rich field," he says. "There are so many possibilities that experimental programs are just barely scratching the surface. Practice is lagging way behind theory." *— I. Peterson*

Bye-bye Alar

Uniroyal Chemical Co. announced last week it would end U.S. sales of daminozide (Alar) for use on food products. While contending the chemical is safe, the Middlebury, Conn.-based company — sole maker of the controversial plant-growth regulator — agreed to voluntarily ban U.S. sales pending the Environmental Protection Agency's decision on whether to permanently prohibit the pesticide's use (SN: 5/20/89, p.311).

EPA initially asked Uniroyal on Feb. 1 to stop marketing the pesticide, citing new animal data suggesting metabolites of the compound may cause cancer. Uniroyal ignored EPA's entreaties until early May, says EPA spokesman Al Heier. By then, public outcry over the chemical's use on apples had grown to a resounding roar, fueled by new reports on its threat to children and prevalence in apple juice (SN: 3/4/89, p.133; 3/11/89, p.155). □

Diverse recipes shine in the sun's corona

"Cosmic abundances" are what many scientists call the list of ingredients in the recipe for the universe. The sun, as part of the universe, presumably contains the same list of elements as the universe as a whole. Yet cosmic abundances do not always match the solar mixture.

In fact, reports Keith T. Strong of Lockheed Palo Alto (Calif.) Research Laboratory, the abundances measured with the Lockheed-built X-ray polychromator (XRP) aboard the Solar Maximum Mission satellite differ in different parts of the sun, sometimes varying even from minute to minute. He described the findings this week at the Johns Hopkins University Applied Physics Laboratory near Laurel, Md., during a meeting of the American Astronomical Society's Solar Physics Division.

"Abundances have always been the 'known' in one's equation," says Joan T. Schmelz of Applied Research Corp. in Landover, Md. For many research questions, "you just go look them up, plug them in and solve for your 'unknown.' "

But as Schmelz notes, a number of "known" abundances exist for the same solar elements, derived by different researchers from different observations. These abundances often stand quite at odds with one another.

Astronomers have published numerous such lists of abundances for the sun's corona, again based on different observations — and few if any match in detail. Some researchers have just taken a standard set by averaging many other sets, says Strong. Typically, he notes, the view has been: "I'll just take this value, and realize that there's an uncertainty associated with it. You have to make an assumption somewhere; otherwise you make no progress."

This has advantages but creates problems as well. For example, complications arise when scientists try to measure solar temperatures by comparing the relative abundances of different elements, all of which have been ionized by the sun's heat. As the temperature rises, Strong says, some elements are ionized more quickly than others. Iron, for example, shows almost the same abundance in two different measurements, while oxygen and neon are more than twice as plentiful in one measurement as in the other.

In numerous spectra measured by the XRP, the relative brightnesses of light emitted by ions of iron-17 and iron-18 are almost the same, while the ratios between iron and neon measured in the same spectra differ widely. In fact, notes Strong, different spectra showing the same amount of iron show the relative abundances of some elements to differ by as much as a factor of 20.

If a scientist uses the relative abundance of iron and something else to calculate the temperature of a certain part of the sun, the "something else" can make a big difference in the answer, Strong says.

The Solar Max satellite has been in a unique position to make this point because the XRP made all the observations. Though spectra similar to those of XRP have been collected from many observatories, numerous differences can affect the results, such as variations among instruments. Strong and his colleagues have rechecked their theoretical analyses, the resulting temperature measurements and other details. Other factors may have been overlooked, but at present, says Strong, the message seems to be that the relative abundances of the elements simply differ from one spectrum to the next. No single list of cosmic abundances, it seems, can describe the whole sun at once.

A major goal for future study is to explain the wide abundance variations at different locales and times. In 1972 and 1973, measurements made from the Skylab space station hinted that such differences might exist, but according to Strong, these clues went unnoticed.

The sun is a place of constant uncertainty. Two weeks ago, researchers estimated the sun's effect on Earth's atmosphere might make Solar Max uncontrollable by early August. Now they estimate early September. *— J. Eberhart*