

brates, they are exploiting the implications of quantum mechanics, in which the ball-and-spring picture of a molecule dissolves into a set of overlapping mathematical waves. "If you think of a molecule as jiggling and wiggling, then it's that wiggling which is described by the wave function," explains Brumer. He and Shapiro design their laser pulse to interfere with those waves, changing the wave pattern—and consequently the

molecular motion—in some predictable and controlled way. "You want to get the wiggling coalesced in one part of the molecule and minimize it elsewhere," explains Brumer.

Says Wisconsin's Crim, who is trying to extend his passive technique to other reactions, including one between hydrogen cyanide and chlorine, "We are looking in the windows of the house, and these folks are trying to find new passages in." One way or

another, he thinks, after 30 years of trying, "someone is going to make this work."

—Faye Flam

Additional Reading

Yu-hui Chiu, Hungshin Fu, Jui-tsen Huang, and Scott L. Anderson, "Large, Mode-selective Vibrational Effect on the Reaction of $C_2H_2^+$ with Methane," *Journal of Chemical Physics* **101**, 5410 (1994).

ENVIRONMENT

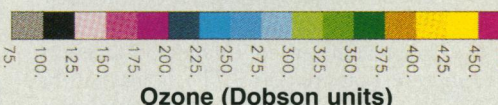
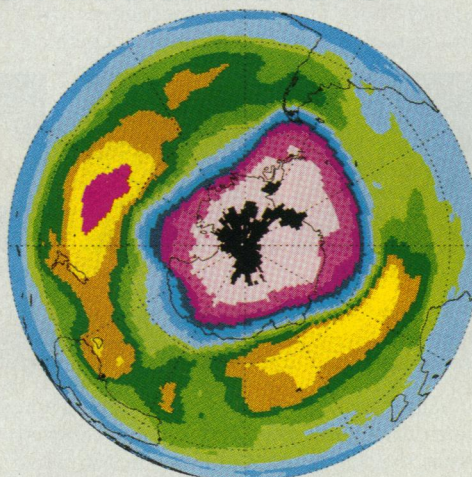
Antarctic Ozone Hole Fails to Recover

This was supposed to be a better year for ozone over Antarctica. Not a great one, of course, given that the synthetic chemicals that attack the ozone layer each year at this time as the sun hits the Antarctic stratosphere are still there. But researchers expected that last year's record ozone loss wouldn't be repeated. The reason for their optimism was that the volcanic debris spewed by Mount Pinatubo in 1991, which enhanced the chemical destruction of ozone, is nearly gone. But instead of recovering this year, the ozone hole is nearly as deep and wide as ever. For Antarctic ozone, it's been four bad years in a row.

"It's a little bit of puzzle as to why [ozone] values are as low as they are," says Samuel Oltmans of the National Oceanic and Atmospheric Administration in Boulder, Colorado, who monitors ozone above the South Pole using balloon-borne instruments. The most discouraging possibility is that the ozone hole has recovered as much as it can from Pinatubo, but the hole is being deepened and enlarged by the steady increase of chlorine and bromine from synthetic chemicals. Notes Arlin Krueger of the Goddard Space Flight Center (GSFC) in Greenbelt, Maryland: "Maybe the hole has returned to normal; 'normal' may be a progressively deepening ozone hole."

That's not what many researchers had expected a few months ago. They assumed that last year's record low of 91 Dobson units (DU) of ozone was largely due to the heavy blanket of debris lofted into the stratosphere by Pinatubo. The microscopic debris particles, they knew, provide hospitable sites for the chemical reactions that help destroy ozone. Now that most of the debris has settled out, it seemed, ozone should not drop much lower than 125 DU, the typical annual minimum just before the eruption. Although chlorine and bromine levels have increased since then, most researchers thought that their effect might not have grown much, as the regions of the stratosphere where conditions are most favorable to ozone destruction were already suffering almost total loss.

But as of last week, this year's total ozone losses over Antarctica had nearly kept pace



Ozone (Dobson units)

Another bad hole. This year's ozone hole, seen by the TOMS instrument in space, nearly matches last year's in depth and size, continuing a 15-year worsening trend (right).

with last year's. So far, Oltmans has measured ozone levels over the South Pole as low as 102 DU—comparable to 1992's 105 DU and 1991's 108 DU—and they could have dipped lower before the recovery begins this week. All these figures are a far cry from the measurements of the late 1970s, before the hole began to form, when ozone values were about 280 DU at this time of year.

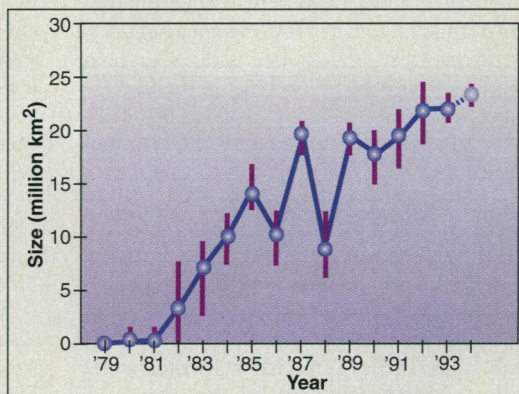
The Total Ozone Mapping Spectrometer (TOMS) aboard the Russian Meteor-3 spacecraft, meanwhile, showed that this year's hole covers about 24 million square kilometers, just shy of the 1992 record, according to Paul Newman of GSFC.

Researchers see three factors that, alone or in concert, might explain the continuing near-record severity. One is the temperature 15 to 20 kilometers up in the stratosphere, where most of the ozone is lost. The colder it is there, the more effectively chlorine and bromine destroy ozone. This year, the Antarctic stratosphere is a couple of degrees colder than normal, says James Miller of the

National Weather Service's Climate Analysis Center in Camp Springs, Maryland. But unusual cold alone probably can't explain the continuing bad news; in 1987, when it was even colder over Antarctica, ozone fell no lower than 121 DU.

In spite of expectations, the Pinatubo debris may also be contributing to the size of the ozone hole. Of the 20 million tons that were originally lofted into the stratosphere, perhaps 3 million still linger, according to Lamont Poole of the Langley Research Center in Hampton, Virginia. And that may be all that's needed for a significant effect on Antarctic ozone, say researchers; the reaction-speeding effect of the aerosol may saturate as its amount increases, and so decreasing the amount wouldn't lead to a proportional improvement in ozone levels.

If unusual cold or lingering volcanic aerosol explains this year's heavy ozone losses, another year could bring some relief. Not so



if the increasing amount of chlorine and bromine in the stratosphere is to blame. International controls on chlorofluorocarbons and bromine compounds are expected to halt the increase by 1998 (*Science*, 23 September, p. 1806), but in recent years stratospheric chlorine levels have been rising at the rate of a couple of percent per year. That may have been enough to extend ozone destruction beyond the thin layer where major losses were confined before Pinatubo. If those bounds have been breached, it might take several years before researchers monitoring Antarctic ozone finally see bottom.

—Richard A. Kerr