sembling the arrangement of atoms in a crystal. These colloidal crystals display a variety of optical effects, becoming transparent at some wavelengths and beautifully iridescent at others (see photo).

The Brown team used short pulses of yellow laser light to excite dye molecules distributed among the colloidal crystal's spheres. Ordinarily, the laser-excited dye molecules would spontaneously emit red light. But measurements of the number of molecules still excited after a given time period suggest that the presence of the polystyrene-sphere lattice delays photon emission in certain directions for this particular wavelength of light.

"The dye molecules are not giving off their photons as quickly," Lawandy says. "The [vacuum field] isn't there to tickle the dye molecules to radiate."

Although the results look promising, "it's a weak effect," says theorist K. Ming Leung of Polytechnic University in Brooklyn, N.Y. "One would like to achieve complete suppression regardless of the direction of travel of the photon."

That goal may now lie within reach. In the last few months, Leung and other theorists have developed ways to extend to photons the kind of calculations researchers conventionally use for modeling the behavior of electrons in materials.

"This field has really heated up in the past couple of months," says Eli Yablonovitch of Bell Communications Research in Red Bank, N.J. "The theorists can now tell us which structures to make, and we're making those structures. We already have evidence that they're going to work out beautifully."

Yablonovitch and his colleagues create these structures by drilling patterns of spherical hollows on the surfaces of flat, electrically insulating plates, which the researchers stack and bolt together to produce an array of air-filled spheres. They then study what happens to microwaves traveling through the arrays.

"Right now we are just trying to test the theory to see if it is sound," Leung says. "It's all done in microwaves because the longer wavelength allows one to fabricate the crystal in the lab just by drilling. But everything's to scale, and if it works, it should also work for visible light."

Achieving control of spontaneous emission in atoms holds the promise of improved laser performance and greater control of certain types of chemical reactions. Physicists would also have at their disposal a volume of space quite unlike any they have yet probed.

"This would actually be a volume of space that is quieter, or in a sense emptier, than the vacuum," Yablonovitch says. "If you were an atom inside this structure, you would be living in an unfamiliar world." *— I. Peterson*

Migraines linked to childhood anxiety

About 20 percent of migraine sufferers endure a triple whammy of disorders as they age, according to a new long-term study. During childhood, excessive worrying and other anxiety symptoms appear; by early adolescence, migraine headaches begin; and bouts of severe depression kick in after another three or four years.

This evolving pattern represents a distinct syndrome, or group of related symptoms, reports a team led by psychiatrist Kathleen R. Merikangas of Yale University School of Medicine. Anxiety apparently does not cause the migraines, and the migraines do not cause the depression, the researchers point out.

However, shared neurochemical mechanisms may lie at the heart of the anxiety-migraine-depression triad, they maintain. For example, recent investigations revealed that migraine headaches sometimes respond to antidepressants, and that reserpine — a drug that depletes dopamine and other chemical messengers in the brain — elicits both depression and migraines in some people.

But until now, researchers lacked evidence of a strong relationship between migraines and anxiety, and thus did not seek physiological links between the two, Merikangas and her co-workers note in the September ARCHIVES OF GENERAL PSYCHIATRY. Moreover, previous reports of an association between depression and migraines — which led to speculation that depression may lead to migraines — were based on single assessments of migraine patients who sought medical treatment.

Merikangas' team recruited 457 people living in Zurich, Switzerland. The sample was not completely random, since two-thirds of the volunteers were selected based on elevated scores on a checklist of psychiatric symptoms. Researchers interviewed participants in 1978, 1981 and 1986, and had them fill out questionnaires on headaches and psychiatric symptoms twice a year. By the third interview, participants were 27 to 28 years old.

About 13 percent had at some time experienced common migraine headaches (without preceding visual or neurological sensations known as auras). Migraines occurred substantially more often in women and in participants with elevated psychiatric symptom scores, the researchers found.

Retrospective self-reports showed that, for about one in five migraine sufferers, excessive anxiety and fears of public situations emerged at about age 12, followed by the onset of migraines at age 14 and severe depression at age 17 to 18.

The investigators plan to chart the psychiatric course of the Zurich migraine sufferers as they proceed through adulthood. *— B. Bower*

A hard step toward diamond circuitry

Standard microelectronic chips work fine for everyday PC tasks such as word processing. But more demanding jobs — such as regulating lots of current, operating in hot engines or computing at ever-faster speeds — would reduce these silicon wonders of miniaturization to melted jumbles of atoms. That's why scientists have been eyeing melt-resistant synthetic diamond as a semiconducting material that could go where no silicon chip has gone before.

Amidst some skepticism, Ken Okano of Tokai University in Japan claimed this week that his team has taken a long-awaited step toward that goal. The step involves making "n-type" semiconducting diamond, in which impurities such as phosphorus ions carry current through a microscopic electronic gate.

In the past, researchers have synthesized thin films of only "p-type" diamond, which carries current via positively charged "holes" created by inserting atomic impurities, such as boron ions. These ions readily assemble within a growing diamond lattice. In principle, circuit makers could use such boron-doped diamond for making novel types of electronics devices. But since standard silicon-based components comprise thin layers of both n- and p-type silicon, diamond chips featuring both types of materials are preferred.

At the Second International Conference on the New Diamond and Technology, held in Crystal City, Va., Okano outlined his group's method for depositing 10-micron layers of n- and p-type semiconducting diamond onto a silicon base. The team uses a technique called chemical vapor deposition, in which a heat source such as a hot metal filament breaks hydrocarbon gas molecules into fragments. Liberated carbon atoms then systematically rearrange into diamond films as they deposit on materials such as silicon placed nearby within the deposition chamber (SN: 8/4/90, p.72).

By including certain boron or phosphorus compounds in the gas, the researchers were able to lay down both the p- and n-type diamond layers on silicon, Okano says. Moreover, their data suggest that the triple-layer sandwich behaved as a rudimentary electronic gate.

Some scientists argue that this behavior could arise from crystal imperfections, such as tiny lattice voids, rather than from the controlled implantation of phosphorus ions, which has proved so elusive in the past. And diamond isn't the only candidate for heat-resistant chips, they note. Other experimental semiconducting materials, such as boron nitride or silicon carbide, could sneak into the same market niches. *— I. Amato*