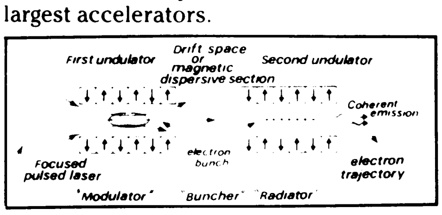
An OK for coherent ultraviolet light

If investigators in various departments of physics, materials science, chemistry and biology had coherent ultraviolet light, they could do many things better than they do now and some things they can't do now. However, few lasers operate in the ultraviolet, especially in the range called the vacuum ultraviolet, which is so called because air absorbs it and experimentation with it must be done in vacuum.

Now a group of physicists working at the Laboratory for the Utilization of Electromagnetic Radiation at the University of Paris-South in Orsay, France, report that they have developed a source of coherent radiation for the vacuum ultraviolet range (wavelengths less than 2,000 angstroms). It is called an optical klystron (OK). They report that at a wavelength of 3,350 angstroms it produced an enhancement of 100 to 1,000 times its ordinary spontaneous emission (B. Girard and eight others in the Dec. 17 PHYSICAL REVIEW LETTERS).

An ordinary klystron is an electron tube that produces or amplifies radio waves. As an amplifier, a klystron takes energy from electrons energized by an electric field to increase the power of an incoming radio wave. The influence of the incoming wave makes the electrons in the klystron form bunches of a size corresponding to its wavelength, and then a magnetic field makes the electron radiate in synchrony with the incoming wave, thus strengthening it. One important scientific application of klystrons is producing the radio waves that accelerate particles in the world's largest accelerators.



Schematic of optical klystron's operation

The OK works in roughly the same way. It takes electrons from a storage ring (the ACO ring at Orsay) because for visible or ultraviolet light they have to have much higher energy than they could get from electrostatic forces in a large vacuum tube. The electrons enter the first stage of the OK, which is the field of an undulator magnet called the "modulator." This undulator is a magnet whose field reverses direction every 78 millimeters. There are seven such reversals altogether. In the undulator the electrons encounter the focused beam of a laser. In combination with the undulating magnetic field the laser beam modulates the energy of the electrons in a way that resonates with its own wavelength.

The electrons then enter the second stage, the "buncher." This can be either a magnetically shielded drift tube or a steady magnetic field. Here the energy modulation of the electrons converts itself to a spatial bunching, whose dimensions match the wavelength of the laser (in the experiment 10.6 micrometers).

The bunched electrons then enter another undulator field, which induces them to radiate not only at the fundamental frequency of the laser but also at higher harmonics (integral multiples) of it. The experiment used electrons with 166 million electron-volts to produce the coherent radiation at 3,550 angstroms. The OK yielded a maximum of 600,000 coherent photons per 12-nanosecond laser pulse.

Theory predicts 4 million photons per pulse. The experimenters attribute the difference to the experimental setup not being optimum for this purpose. They chose to work with the visible wavelength, 3,550 angstroms, for ease of recording. The principle, they say, is easily applicable to wavelengths as short as a few hundred angstroms, by increasing the energy of the electrons. Under optimum conditions it should yield 10 billion to a trillion photons per pulse. —*D. E. Thomsen*

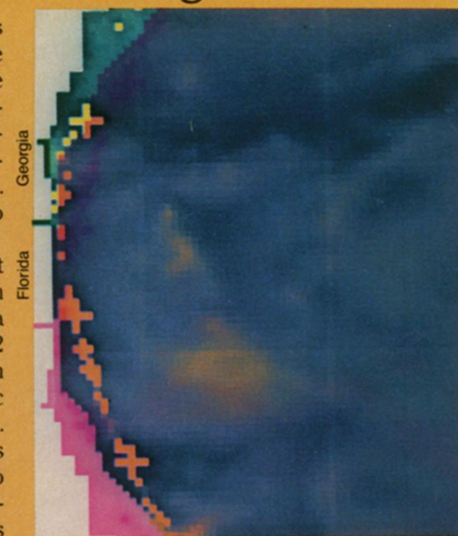
Whales and dolphins use magnetic 'roads'

The beaching of whales and dolphins is a tragic mystery. But records of the strandings are yielding clues about the paths these animals take when they migrate. In particular, the beachings indicate that whales and dolphins, like bacteria, bees, fish and birds (SN: 1/10/81, p. 24), use the earth's magnetic field to navigate.

Joseph L. Kirschvink, a geobiologist at the California Institute of Technology in Pasadena, and co-workers correlated a Smithsonian Institution map of 212 beaching events along the eastern United States with a map of the magnetic landscape of that area made by the U.S. Geological Survey. The researchers found that the strandings tended to occur at magnetic lows, or minima—regions where the earth's magnetic field is locally diminished by the opposing field in rocks that solidified when the earth's field reversed direction.

The magnetic lows on the coastline lie at the ends of a number of long, continuous channels of magnetic minima that mark the ocean floor. Kirschvink believes that the whales and dolphins were tracking these magnetic "lowways" when they were stranded. He does not know, however, why the animals approaching the continents "didn't see the stop sign." Ocean currents, temperature and topography are not correlated with beaching sites. And even whales that use sonar have been stranded, although less often.

According to Kirschvink, who presented the group's findings in San Francisco at the recent meeting of the American Geophysical Union, the difference between the magnetic minima and maxima is at most 4 percent of the background magnetic field strength, and directional variations of the field are too small to be measured with a compass. Therefore, whatever mechanism the whales and dolphins have to detect the magnetic lowways must be extremely sensitive, he says. In both types of animals, as in their insect, bird and fish cousins, a strongly magnetic iron-oxide compound called magnetite has been found. But its distribution within the bodies of whales and dolphins is too widespread for researchers to pinpoint a specific magnetic sensory organ.



Kirschvink/Cal Tech

Computer map of whale and dolphin beachings along Atlantic Coast. Large red crosses denote strandings of more than 30 animals; smaller crosses are for 3 to 30 animals; dots represent 1 or 2 animals. Dark blue areas are magnetic lows; yellow regions magnetic highs.

Kirschvink has recently obtained a new set of observations of whales and dolphins in the open sea, not just at the coast. Here, too, he says, most species appear to stay away from magnetic highs in favor of lows. One reason for this may be that lows are easier to track over large distances, since they are more continuous and far reaching than high regions, which are often formed by discrete clusters of seamounts. However, when whales are not migrating, Kirschvink suspects — and has found with one species — that they tend to stay around highs as a kind of anchor point.

Since many of the regions that are now highs may have been lows when the earth's magnetic field reversed in the past, Kirschvink hopes to fortify his results by finding corresponding changes in the fossil record of strandings along the coast. — *S. Weisburd*