SCIENCE NEWS OF THE WEEK

Successful Wiggler for SLAC

Stanford Univ.

Recently installed four-foot wiggler yields six-fold boost in radiation intensity.

Synchrotron radiation is one of those things that people thought was useless until somebody did something with it. Synchrotron radiation is generated whenever an electrically charged particle undergoes a sharp bend in its trajectory. It is electromagnetic radiation that in principle can range over the spectrum from gamma rays through light to radio, but in the range of most practical interest now it is X-rays or ultraviolet. It has been a nuisance to the designers of high-energy electron accelerators and storage rings ever since synchrotrons were invented in the late 1940s because it drains the electrons of energy almost as fast as the accelerator can put it in.

Yet synchrotron radiation is very useful. Given a source of highly collimated, intense X-rays or ultraviolet that is variable in wavelength (changing the energy of the electrons changes the wavelength of the radiation), a biologist, a surface chemist or a solid state physicist can think of many things to do with it. The radiation is so useful for the study of structure in those fields that suddenly investigators are clamoring for it, and countries all over the world are establishing new centers or altering old ones to provide it. For the efficient operation of such centers, a device called a wiggler magnet will be necessary. At the 1979 Particle Accelerator Conference in San Francisco last week, Martin Berndt of the Stanford Linear Accelerator Center and eight others from SLAC and the Stanford Synchrotron Radiation Laboratory reported the first successful operation of a wiggler.

A wiggler is something that everybody is sure will work, says Herman Winick, deputy director of SSRL, and so plans all over the world are based on them. Ed M. Rowe of the University of Wisconsin, who was chairman of the session at which Berndt made the report, remarked, "No wiggler has ever been installed in a storage ring. People say glibly, 'We'll have wigglers.' At last there is a wiggler."

What a wiggler does is use high-field magnets to produce sharp back-and-forth twists in the path of the moving electrons. This increases the intensity of the synchrotron radiation and tends to extend the spectrum of the radiation toward harder (higher-energy) X-rays, which are of particular use to materials scientists. The wavelengths radiated depend both on the energy of the electrons in the beam and the sharpness of the twist (which in turn depends on the magnetic field strength).

Such kinks represent a reversal of the traditional attitude of designers of electron accelerators and storage rings, who have opted for weak magnetic fields and the gentlest, most sweeping curves the geometry of their locations would allow so as to minimize the synchrotron radiation and to make control of the accelerated electron beams as easy as possible. The Stanford wiggler is called a "three lambda" wiggler, because it makes the electrons go through three complete wiggle oscillations before it returns them to their original orbit. The wiggler has proved no disturbance to the SPEAR storage ring, in which it is inserted to provide synchrotron radiation for the Stanford Synchrotron Radiation Laboratory. It returns the electrons to the orbit that the storage ring people want well enough to quiet their previously quite lively fears on the subject.

Furthermore, the storage ring people get a bonus. What the wiggler does to the electrons increases their current density and thus the factor called luminosity by which the storage ring people measure the effectiveness of the apparatus for their purpose — the collision of electrons with positrons (antielectrons) for the study of the most fundamental kind of particle physics. Luminosity measures how efficiently a given storage ring produces such collisions, and the insertion of a wiggler in SPEAR increases it. The storage ring physicists are now planning to insert wigglers into the more energetic PEP ring they are now building, not to provide synchrontron radiation, but to increase the control and luminosity.

The synchrotron radiation people get a bonus, too. Berndt points out that the standard wiggler can also be operated as an undulator. An undulator would have generally more undulations and operate with lower magnetic field strength. The large number of undulations produces what Winick describes as a kind of diffraction grating effect. It makes the radiated energy concentrate in a narrow sharp peak over a very short base of wavelengths. The peak can be hundreds of times as intense as the continuous spectrum would otherwise be.

Winick says work on undulators has been done in the Soviet Union but is mostly proof-of-principle experiments, not practical demonstrations. He would like to get an undulator project going at Stanford. A combination of wigglers and undulators would make SPEAR a more versatile source of synchrotron radiation, providing an intense broad spectrum ranging well into the hard X-rays, combined with sharp highly energetic peaks. It will also give the storage ring better control and high collision efficiency, especially at lower energies than it has been practical for SPEAR to work before. □

Shortwave listening for space messages

Barring literally astronomical luck, the chances of success at detecting a radio message from some intelligent extraterrestrial source are likely to be a matter of strategy. There is simply too much sky to cover, and too many possible wavelengths to monitor, for the shotgun approach to be promising with existing technology and resources. Present facilities are not capable of anything approaching the full-time, all-sky, all-wavelength search that would be desirable, although proposals to build such equipment have been made.

In selecting a wavelength, most such strategies have concentrated on two areas: technical and psychological. The technical question is to find a wavelength at which a signal can cross astronomical distances without being absorbed, distorted or otherwise rendered useless by passage through the interstellar medium. The psychological issue has generally been defined as narrowing down the candidate wavelengths to ones with some possible rationale for their selection. In both cases, the assumption is made that extraterrestrial civilizations advanced enough to send such messages might have pursued similar logic in deciding upon their transmissions.

Perhaps the most oft-suggested wavelength has been 21 centimeters. This would be a natural choice, the argument goes, because (1) it is the wavelength of the spectral line of atomic hydrogen, the most abundant element, which might be noted by the sender as relevant symbolism, and (2) it is near the region where the intensity of the cosmic radio background "noise" is at a minimum.

A problem with the 21-cm band, however, was pointed out in 1977 by Frank Drake and George Helou of the National Astronomy and Ionospheric Center. Ionized clouds in the galaxy, they noted, refract such wavelengths slightly and cause them to "twinkle" by introducing small Doppler shifts in the received signal. The result is a "frequency-smeared" signal that would spread the transmitted power (already extremely weakened by the time it reached a receiver across interstellar space) over a wider bandwidth. This, in turn, would make the signal seem "noisier" at any given part of the band, making it difficult to extract a possible message without unreasonably long monitoring times to "integrate" the signal into a cleaner picture. A better bet, the researchers suggested, would be millimeter wavelengths, which would be less refracted by the ionized clouds, and thus less Doppler-shifted and smeared at the receiver. A wavelength of about 4 mm, says Drake, would be an optimum balance between low noise and narrow bandwidth.

But what about some symbolic significance that might prompt the sender to choose a given particular wavelength? The constraints on differing wavelengths are matters of degree, so there would seem to be some room for choice.

One candidate has now been suggested by N. S. Kardashev of the Soviet Space Research Institute in Moscow, writing in the March 1 NATURE. His proposal is the wavelength of 1.47 mm, corresponding to a frequency recently calculated to be 203.3849 gigahertz. This, says Kardashev, represents a spectral line that could be seen as even more fundamental than the 21-cm hydrogen line. It corresponds to the splitting of the ground state of what Kardashev calls "the lightest atom" — positronium. "Positronium," he says, "forms by recombination of an electron and a positron, and is about 1,000 times lighter than a hydrogen atom. Laboratory investigation of positronium provided some of the basic evidence for the validity of quantum electrodynamics." Furthermore, he adds, "the lifetime of this atom is very short because of the annihilation process, so a high concentration could hardly be expected in natural cosmic conditions."

Besides singling out a specific candidate wavelength, Kardashev adds other reasons for liking the millimeter region in general. First, he says, it represents a spectral region of minimum brightness temperature. "For lower frequencies [the longer wavelengths]," he says, "the temperature increases due to synchrotron radiation, [and] for higher frequencies, due to radiation of dust and stars." Second, he adds, it is a spectral region of minimum absorption and scattering. This would be of advantage to senders hoping to make the most of their transmitter power by sending in a narrow beam.

Some equipment already exists that is capable of searching for millimeter-range signals, Kardashev points out. However, such searches have been on limited scales at *any* wavelengths, and the National Aeronautics and Space Administration's proposal for a coordinated facility to do the work was cut from the FY 1979 budget by Congress and does not appear in the FY 1980 plan. Without some such all-sky, all-wavelength approach, strategies like those of Kardashev and others are likely to play a significant role in guiding the ears of earth. □

New therapies, new forms of an old vitamin

The sunshine vitamin, turned hormone, is offering dramatic results in therapies for bone-destroying diseases. Vitamin D and its derivatives produced in the body are a new endocrine system based on an old vitamin, Hector F. DeLuca told a science writers' seminar in New York sponsored by the Endocrine Society. In his laboratory at the University of Wisconsin, DeLuca and collaborators have just discovered three new vitamin D metabolites, and clinicians around the world are investigating therapeutic uses of previously identified metabolites.

Perhaps the most important current clinical investigations are trials of a vitamin D derivative as a treatment for the bone breakdown disease osteoporosis. Promising early results suggest that the vitamin D compound may replace estrogen as treatment for the disease, suffered by more than 20 million persons in the United States.

Vitamin D, either produced in the skin by sunlight or acquired from food, is required in the calcification of bones. In children, a deficiency of the vitamin interferes with bone growth, and in adults deficiency prevents the continual bone remodeling that mends "microfractures." However, simply adding vitamin D to the diet does not cure all bone disease. The body must convert the vitamin to its active forms, and some diseases result from defective processing. In addition, a hormone from the parathyroid gland, together with a vitamin D metabolite, governs release of calcium from bone. By administering laboratory-synthesized vitamin D metabolites, clinicians are bypassing problems of hormonal deficiencies and defective metabolite production.

The Food and Drug Administration has recently approved the use of 1,25-vitamin D (1,25-dihydroxyvitamin D) to promote bone growth and maintenance in patients with bone disease due to kidney failure. In healthy persons, that metabolite results from two processing steps in the body. Vitamin D is first converted in the liver to 25-hydroxyvitamin D, the form that circulates in the blood. Then the kidney changes that compound into the active hormone 1,25-vitamin D. Thus, vitamin D by itself cannot help the 200,000 Americans with chronic kidney failure; but long-term oral therapy with 1,25-vitamin D can have a dramatic effect. In children with kidney failure, the treatment tripled their growth rate (SN: 2/25/78, p. 123).

The 1,25-vitamin D is also being examined in two double-blind clinical trials on older patients with osteoporosis. With age, ability to absorb calcium decreases, as do the blood levels of 1,25-vitamin D. Researchers find, in addition, that post-menopausal women who have small bone fractures have lower blood levels of the hormone than those with intact bones. In the clinical trials, small doses of 1,25-vitamin D improved the calcium absorption and balance in post-menopausal women with small fractures. A new treatment for osteoporosis is particularly welcome because the current treatment, estrogen therapy, has been associated with an increased uterine cancer risk (SN: 12/2/78, p. 389).

Premature infants, as well as elderly women, may benefit from therapy with 1,25-vitamin D. Such babies are born with immature systems for calcium absorption, and they generally show low calcium levels and slow bone growth. Although the result has not yet been firmly established, DeLuca says, two studies show 1,25-vitamin D effective in promoting bone growth in premature infants.

Other patients who eventually may be helped by the metabolite are those taking glucocorticoid hormones for various diseases and patients on blood dialysis. Both treatments can decrease calcium absorption leading to thin bones. Glucocorticoids lower 1,25-vitamin D levels in the blood, and in a trial now underway the vitamin D derivative is being administered to patients taking glucocorticoid hormones.

Israeli researchers led by Shmuel Edelstein of the Weizmann Institute report another metabolite, 24,25-dihydroxyvitamin D is also required for bone formation. They believe that metabolite may be useful in promoting healing in elderly fracture patients. However, DeLuca contests their conclusions, saying they have not clearly demonstrated an effect separate from that of 1,25-vitamin D.

The researchers continue to look for other vitamin D metabolites and actions. Among the latest findings are a lactone of vitamin D, made from the circulating blood form. That lactone was found during vitamin D intoxication and may be an excretory product. Other recently discovered compounds are carboxylic acids, one (24-carboxylic acid vitamin D) made in the kidney and the other (1-alpha-hydroxy, 23-carboxylic acid vitamin D) in the liver and intestine. The latter compound has now been synthesized in DeLuca's laboratory, and the biochemists are beginning tests to find its biological function.

When rickets was prevented by vitamin D fortification of foods more than 50 years ago, scientists thought they knew everything concerning the vitamin, DeLuca says. But the more recent work reveals a complex system, interrelating with other hormone systems. DeLuca explains, "We are just beginning to learn in which disease states the vitamin D system is disturbed and in which disease states the judicious administration of the synthetic sources of the active hormone 1,25-vitamin D or its precursor 25-vitamin D could be beneficial." □