Successful Wiggler for SLAC

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 synchrotron radiation, but to increase the control and luminosity.

The synchrotron radiation people get a

Stanford Univ.

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

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