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Tracing from the 1,000-foot radiotelescope shows Pulsar One intensity changing every 1.3372795 seconds.

## Thinning the crop of pulsar theories

**Latest observations of strange sources indicate natural cause; pulsing neutron star ruled out**

Theories to account for pulsars, a new type of astronomical object, have blossomed since the first report of their discovery in late February (SN: 3/16, p. 255). The field was narrowed down when the first results of U.S. observations—the most intensive yet—were reported at the spring meeting of the International Scientific Radio Union in Washington, D. C.

The 1,000-foot dish at Arecibo is the instrument best-suited for listening to regularly varying radio waves being broadcast by the four known pulsars. It can tune in on several frequencies at one time, thus giving the radio spectrum, which is an index of the total power being radiated and the physical phenomenon causing the broadcasts.

The evidence so far is "very strong that this (radiation) is a natural phenomenon and not the result of intelligence," says Dr. Frank Drake, director of Cornell University's Arecibo Ionospheric Observatory in Puerto Rico. He cites two reasons:

- The spectrum is quite different

from what would be expected from an intentional signal; it covers a broad frequency range, as does that from a natural object. Equally important, the energy peak is in the low frequency range, where it is masked by the background noise of radiation from the Milky Way. Scientists quip on this: "Not an intelligent but a stupid civilization."

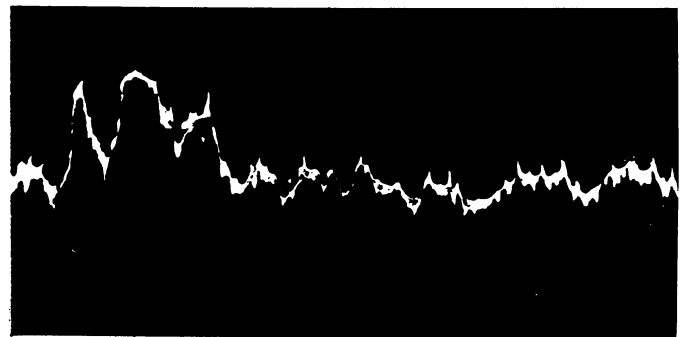
- The total power output in the radio frequency range is  $10^{22}$  watts—10 billion times higher than the total power production of the entire earth. "Even allowing for great advances over our present technology," Dr. Drake says, this power level "seems much too high to be a plausible manifestation of advanced technology."

The observations by Dr. Drake and his co-workers also show that the regularly varying radiation bursts are not the results of pulsations of a neutron star, since they would be much shorter than the observed pulse period. The observations also "are strong evidence against" a binary star consisting of two

neutron or white dwarf components as a source, or the gravitational lens effect (SN: 4/20, p. 374).

This leaves still in the running the theory that pulsars could be the result of pulsations of a white dwarf star (SN: 4/6 p. 326), or the rotation of a neutron star. The latter is the theory favored by Dr. Thomas Gold of Cornell who suggests that when a normal star conserves angular momentum while contracting to the dimensions of a neutron star, rotation periods on the order of one second would result. This short rotation period would maintain a fixed value in the radiation to a very high precision, thus reproducing the most striking characteristics of a pulsar—its short period and invariant pattern.

Another striking characteristic, first shown by the Arecibo recordings, is that three of the four known pulsars emit not a single burst but three pips closely spaced in time, each about 12 milliseconds apart and lasting from 30 to 40 milliseconds. These triplets vary from one pulse to another in a random



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Triplets within pulsar pip at 111 megacycles.

manner, an observation Dr. Drake calls "as hard to explain as the periodicity."

The pulses also differ in time of arrival at different frequencies, indicating a plasma cloud between earth and the radiating object. Although the initial radio emission at the pulsar occurs simultaneously on all frequencies, the intervening electrons slow down the radio waves, with the drag effect being greater at low frequencies.

On this basis, calculations show that three of the pulsars are roughly 300 light years away, although the distance is known only approximately and could be one-half or twice that, Dr. Drake says. These three lie very close to the plane of the Milky Way. The fourth, known as Pulsating Radio Source Number Three, shows only one pulse and no internal structure; it is about 100 light years away and is inclined nearly 60 degrees to the plane of the Milky Way.

The three pulsars with periods ranging from 1.18 to 1.33 seconds have diameters no larger than 12,000 kilometers, about the size of earth. The singly pulsed pulsar, with a period of one-fourth of a second, would have a

diameter no larger than 4,200 kilometers; but that could be the size of a radiation source on a larger object.

Measurements of the delay in arrival time of a pulsar's radiation at different frequencies give a measure of the electron density in interstellar space, the speed of their travel being the same as that of light. This gives, for the first time, a method to determine the number of electrons in the line of sight between earth and another object without making any assumptions as to estimated factors, such as electron temperature. Any variation in the intervening electron density can be measured day-to-day, Dr. Drake noted, and this is now being done.

The value for the electron density obtained by pairing the lag in arrival times for widely differing frequencies is about a million times that typical for the earth's daytime ionosphere, thus ruling out a planetary ionosphere as the location of the retarding plasma.

Dr. Drake's co-workers include H. D. Craft Jr., D. L. Jauncey, J. M. Comella, G. A. Zeissig, E. J. Gundermann and B. S. Tanenbaum.

## LSD vs. I.Q.

### Trippers can't follow maps

LSD is one of the most potent drugs affecting perception. Despite that fact, little effort has been made to understand whether continuous LSD use alters vision, hearing or any other sensory function, leaving permanent changes in an individual's view of the world.

A leading authority on LSD has now found such a change in visual perception among 30 heavy drug users in Los Angeles who had trouble following directions on a road map test.

The test is given to measure spatial orientation. With map in hand, the subject must walk out a route, often complex, between cities marked as dots on the floor. Drug users would turn east when they should have turned west; north instead of south. None were on drugs during the tests, but the LSD users nevertheless did considerably worse than a non-drug group used as controls, report Drs. Sidney Cohen and Allan E. Edwards of the Veterans Administration Center in Los Angeles.

Curiously enough, drug users did as well as anyone else with a wooden map marked in braille relief. "The trouble has something to do with visual space," says Dr. Edwards. Normally such spatial impairment would be attributed to brain damage, but the drug users were not deficient in any other intellectual or perceptual function tested. Consequently, the investigators believe LSD causes a learned perceptual change. "If

you take enough trips on LSD, you learn to look at space differently," comments Dr. Edwards.

Apparently because of this visual change, the heaviest drugs users—those who had taken LSD more than 100 times—also did worse on I.Q. tests. Intelligence scores were inversely related to the number of trips, says Dr. Edwards. There was roughly a 10-point drop between the 50-trip drug users and those who had used LSD up to 500 times. The heaviest users clustered below the drug group's mean I.Q., which was fairly high in any case.

Users and non-users alike came from an above-average social-economic class and included professors and lawyers. The groups were matched as closely as possible for age, sex, race and years of education.

Since the investigators do not have original I.Q.'s on their drug users, they cannot prove LSD caused the intelligence drop. But the other alternative—that less intelligent people take more LSD—does not stand up well. Everyone in the drug group had used LSD at least 50 times and often a variety of other drugs, including marijuana, psilocybin, dimethyltryptamine, barbiturates, amphetamines, methedrine, opiates and cocaine.

None of these drugs, unlike LSD, showed any correlation with altered visual perception or intelligence.

## DUGWAY

### Dead sheep and sick men

Amid the horror of thousands of dead sheep, apparently poisoned by a nerve chemical blown over their range from the Army's nearby Dugway Proving Ground (SN: 4/6, p. 327), there appeared to be at least some grounds for relief. No other animals were affected, said reports, though the pastures harbored many other species. Best of all was the news that no people had been affected.

Now there are signs that both of those optimistic beliefs may have been wrong.

**Some 18 days** after the first sheep deaths, a columnist reported that two veterinarians who had performed autopsies on the sheep had subsequently experienced nausea, headaches, dizziness and diarrhea. Such symptoms could be those of anticholinesterase poisoning, typical of the nerve chemical.

Several researchers involved in the sheep investigation branded the report "sensationalistic," and "without any foundation." The veterinarians had driven 140 miles and then worked all day long without rest, said one investigation. "It was snowing, it was raining, it was nasty and it was muddy. When they came in that night, they apparently said they were tired. That's all."

However, one of the doctors mentioned in the column, Dr. Lynn James of Utah State Agricultural College, admitted that he had had those symptoms, but said that they could just as easily be the result of the flu as nerve gas. "I could guess either way and be wrong," he said.

All this time the Army had been denying, although increasingly weakly, that its chemicals could definitely be blamed for the disaster. Soon afterward, however, Utah's Democratic Senator Frank E. Moss announced "proof positive" that the Army testing was responsible. Comparative tests by the U.S. Department of Agriculture, he said, had revealed that a chemical found in sheep tissue and in forage from the grazing site was the same nerve agent used by the Army in its experiments. The Public Health Service turned up identical traces in snow from the area, after examining samples at its Communicable Disease Center in Atlanta, Ga.

**The Army**, meanwhile, continued to raise the question of why anticholinesterase symptoms were found only in sheep, when there were horses, cattle and many other creatures in the same area. The main counter-response has been that sheep were the only chronic snow-eaters in the area, and that they took in the chemical that way. Such an