Sky Survey print. In the same issue of *Nature* a group (J. G. Davies, P. W. Horton, A. G. Lyne, B. J. Rickett and F. G. Smith) at Jodrell Bank reported that random fine structure, with periods at least as short as 1 msec, is present in the pulses.

Observations of the original source are being made also at Arecibo, and all the findings of the British groups have been confirmed.

Signals have been received by these four groups at a total of six different frequencies, from 81.5 to 1407 MHz. Short pulses are detected because the emission frequency sweeps downward on each cycle and registers as a pulse whenever the frequency passes through the receiver's passband. Dispersion of a wide-band signal in the interstellar medium could produce this effect, just as radio "whistlers" are dispersed during propagation in the earth's atmosphere—higher frequencies travel faster. The pulse amplitude changes irregularly, but with a four-minute pattern; signals are only received during about one minute in four. Amplitude variations of longer time scale show up in records covering six months.

Because there is no detectable parallax as the earth moves in its orbit we know that the radio source is more than 1000 AU away, well outside the solar system. If the frequency sweep is indeed a result of dispersion during transmission we can put an upper limit on the distance at 65 parsec. The size of the emitter can be estimated, from the rapidity of pulses, to be not greater than 5000 km.

**Neutron star?** Stable oscillations of white-dwarf stars or neutron stars are a possible explanation for these signals. White dwarfs are elderly stars that have exhausted their energy resources and have collapsed to small sizes and high densities; neutron stars were postulated as an alternative development where greater densities force protons and electrons together as neutrons. A. G. W. Cameron (Yeshiva University) suggested that neutron stars may also arise as supernova remnants, when pulsation is likely. But the observed period of 1 sec is too slow for the densities expected in a neutron star and too fast for the fundamental frequency of a white dwarf. The Cambridge astronomers find agreement between their observations and the predictions if they assume a neutron star with a density $10^{13}$ g/cm$^3$, but Kip Thorne (U. of Chicago) argues in the April *Astrophys. J. Letters* that this density corresponds to an energetically-unbound neutron star that could probably not be formed by the natural process of stellar evolution. Thorne believes that unstable nuclear burning in the envelope of a white dwarf excites harmonic modes rather than the fundamental, and these harmonics have periods between 0.2 and 20 sec.

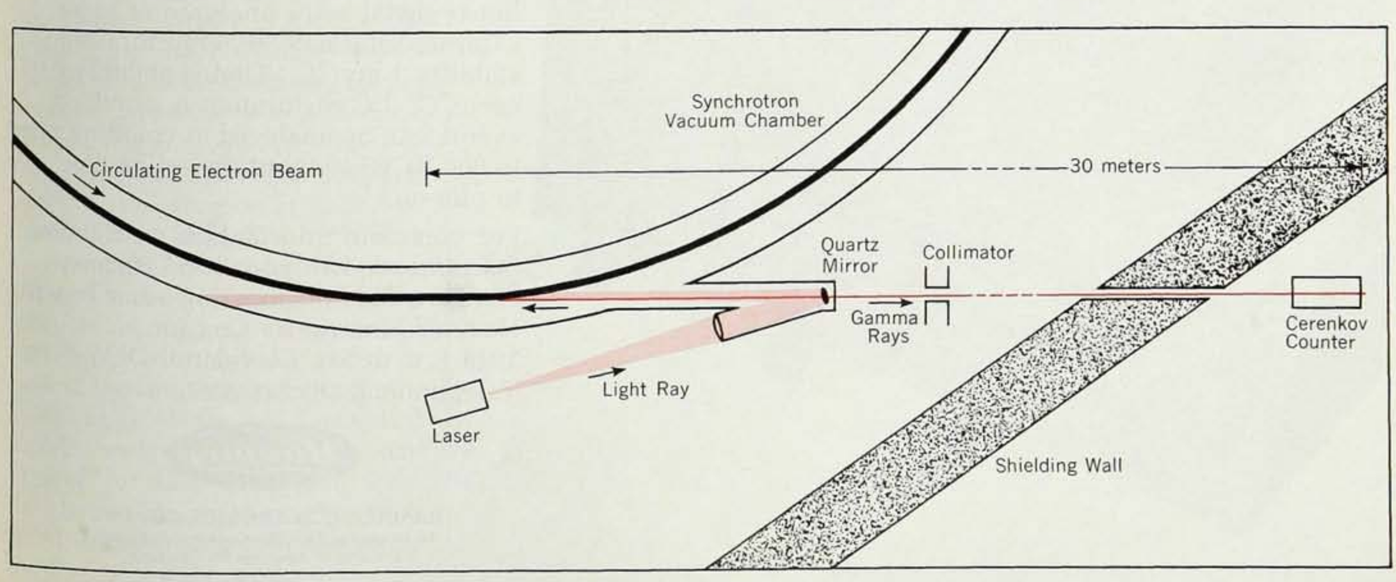
## *Polarized Gamma Rays Made by Compton Scattering*

Two laboratories, at Tufts University and the Lebedev Institute in Moscow, have simultaneously developed a novel production mechanism for very high-energy gamma rays. Photons in a laser beam are Compton scattered off relativistic electrons in an accelerator. The method is likely to be of particular value because the gamma rays are produced with the same polarization properties as the incident laser light, and nearly 100% plane- and circular-polarized beams will be available for tests of T invariance in electromagnetic interactions and other high-energy physics experiments.

In a head-on electron–photon collision the photon energy, say 2 eV, is Doppler shifted into the x-ray region from the point of view of an electron travelling at close to the velocity of light. Back-scattered photons must be Doppler shifted again to yet higher energy when observed in laboratory coördinates, and the combined effect is that laser photons become gammas of MeV and GeV energies. The output energy varies approximately as the square of electron energy.

At the Cambridge Electron Accelerator Richard Milburn (Tufts University) has used a small 0.2-joule

**SOURCE OF HIGH-ENERGY GAMMA RAYS at the Cambridge Electron Accelerator. Light from a ruby laser is reflected at a quartz mirror to meet 6-GeV electrons in a straight section of the machine. Backscattered gammas pass through the mirror and are counted in a total-absorption Cerenkov counter.**



ruby laser with 6-GeV electrons (see figure). Photons from the laser are reflected along a tangent to the circulating electron orbit, and back-scattered gammas come out through the mirror into a Cerenkov counter. About eight photons are detected for each laser pulse; about $10^4$ photons per sec are expected with an improved 15-joule laser system.

M. N. Yakimenko at the Lebedev Institute in Moscow used a 0.5-joule ruby laser and 550-MeV electrons to produce a few 7-MeV gammas, and then a bigger, 10-joule laser to get thousands of gammas per laser pulse.

At the Stanford 20-GeV linear accelerator (SLAC) Joseph Murray and Paul Klein (Stanford) and Charles Sinclair (Tufts) are building a well collimated high-resolution back-scattered 7-GeV gamma beam for the 2-meter bubble chamber; they hope to have it ready by the end of this year.

In addition there is a proposal at Frascati to incorporate an entire straight section of the ADONE storage ring into the 12-meter cavity of an argon-ion laser. Gammas of 83 MeV energy and 100% polarization are expected at an intensity of $2.5 \times 10^5$ photons per second.

### *Experimenters See Plasma-Wave Echoes*

Two waves in a plasma, of different frequencies, can combine to produce a third wave or "echo" after the original waves have apparently died away by collisionless damping. The effect is very sensitive to collisions between particles in the plasma.

A wave set up in a plasma will die away, either spatially or temporally, as a result of the distribution of particle velocities about the mean; mixing of phases in the wave soon destroys the macroscopic periodic motion. This effect, called Landau damping, occurs in the absence of collisions. Last year Roy Gould (Cal Tech) and Tom M. O'Neil and John Malmberg (General Atomic) proposed that the wave would reappear if a second periodic disturbance were added to the first, but later in space or in time.

The figure shows how individual particles retain the phase information required for echo production even though the phases become so well mixed that macroscopically the waves