

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 2.5×10^5 photons per second.

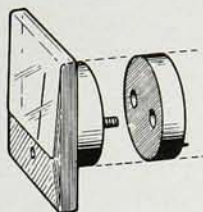
Experimenters See Plasma-Wave Echoes

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

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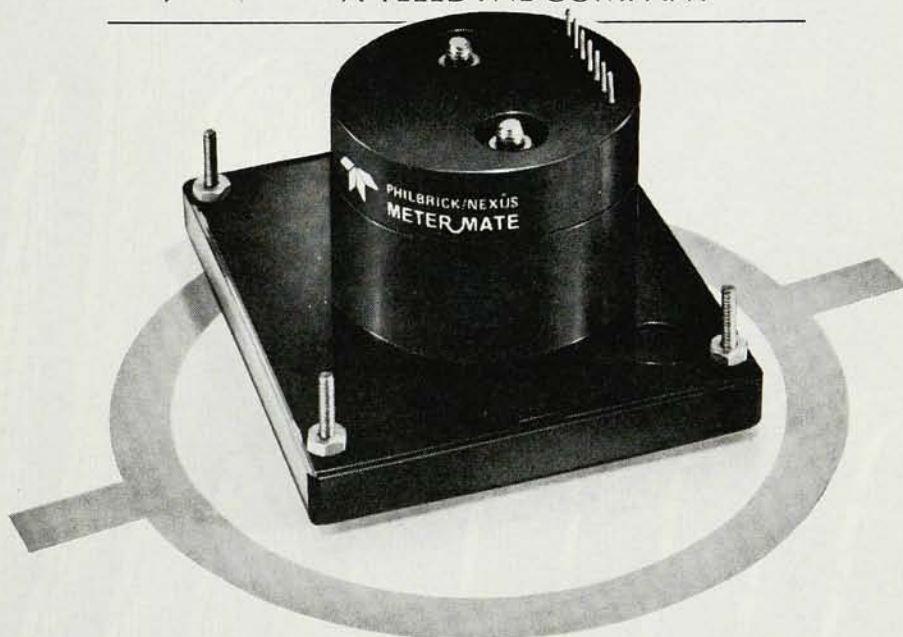
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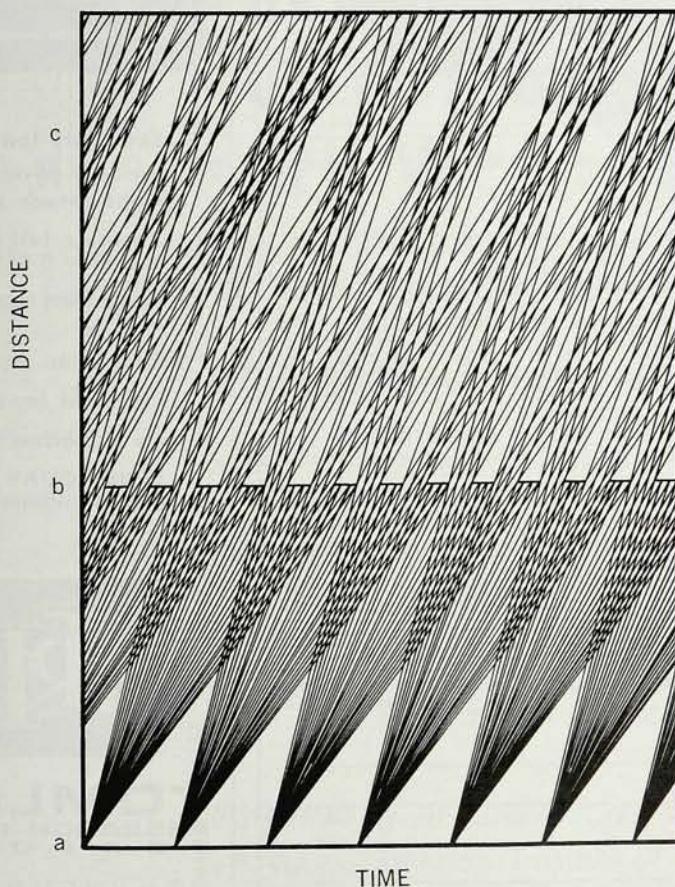
have entirely damped away. Gould, O'Neil and Malmberg published an outline of this theory in *Phys. Rev. Letters* 19, 219 (1967); they show that the second disturbance must have a higher frequency than the first and also that the echo will be very sensitive to collisions in the plasma that would destroy phase relations of individual particles. The General Atomic group verified this theory for electron waves, and identified second- and higher-order echoes (*Phys. Rev. Letters* 20, 95 1968).

Meanwhile ion-wave echoes have been seen experimentally by D. R. Baker, N. R. Ahern and Alfred Wong, who reported their observations in *Phys. Rev. Letters* 20, 318 (1968). They used a longitudinal cesium plasma with a hot plate at one end to ionize cesium atoms and a cold plate at the other to terminate the plasma;

an axial magnetic field of 4 kG ensured radial confinement. Waves were induced by two grids, spaced many mean free paths apart, at frequencies in the range 35–215 kHz. A negative-biased grid hooked up to a tuned receiver detected the echo at a point downstream from the exciting grids. The observations verified that the echo behaves according to the theoretical predictions when grid spacing and excitation frequencies are varied. Similar results were reported by H. Ikezi and N. Takahashi in *Phys. Rev.* 20, 140 (1968); they also used cesium.

Small-angle Coulomb collisions in the plasma, even at collision rates so small that their macroscopic effect on the plasma would usually be disregarded, upset the phase conditions of individual particles in the plasma wave so that the echo does not appear. This property suggests that the study of plasma waves will produce a very useful tool for plasma diagnostics. □

PRODUCTION OF PLASMA ECHO. The sloping lines on this graph represent bunches of particles with different velocities gated at two different frequencies by grids at a and b. Phase mixing apparently destroys the first wave before it reaches b and the second wave shortly after. Yet an echo appears at point c. Frequency at b must be higher than at a. This illustration is based on that of D. R. Baker, N. R. Ahern and A. Y. Wong, *Phys. Rev. Letters* 20, 318 (1968).



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