the earth on 14 and 15 June. The eccentricity of its orbit provides an opportunity to check the relativistic shift of its perihelion; its close approach to Mercury and then to the earth permits calculations of Mercury's mass relative to the earth's. Samuel Herrick of the University of California at Los Angeles has provided 1-day and 2-hour ephemerides to help locate Icarus, which will never be brighter than 13th magnitude.

Neutral Excitation Seen In Superfluid Helium

Two Berkeley experimenters report they have produced a new kind of energetic neutral excitation in superfluid helium that travels centimeters without scattering. Clifford M. Surko and Frederick Reif, writing in *Phys. Rev. Letters* **20**, 582 (1968) speculate that they are seeing an excited helium atom. If their interpretation is correct, the experiment is an interesting combination of atomic and low-temperature physics.

As Reif told PHYSICS TODAY, "For me it was intriguing to find something of this kind in a liquid. In ordinary gases people have often worried about the existence of metastable atoms, and in solids people have studied excitons, which correspond to excited atoms that can move throughout a solid. Now we may be seeing the same thing in liquids. With charged particles in liquid helium you can generate a vortex ring that moves essentially without change of size or energy for distances of many centimeters." Now Reif and Surko appear to have found a neutral particle that does the same at sufficiently low temperatures.

In the experiment they used a polonium-210 source of alpha particles in a container of liquid helium. They measured the current arriving at a collector in the vapor above the liquid and found that as they lowered the temperature below 0.7°K, the current rapidly increased with decreasing temperature. They found an anomalous current that was independent of any electric fields within the liquid, which suggested existence of a neutral excitation that traveled through the liquid and was then converted to charged particles at the surface. By time-of-flight measurements on these charged particles, Surko and Reif determined that they were He_2^+ ions and electrons. Thus the neutral must have had appreciable energy, enough to ionize a helium atom in vacuum (24.6 eV).

By introducing directional baffles in the liquid the experimenters could establish that the neutral excitation travels through the liquid in a straight line with negligible scattering. On the other hand, they believe that the neutral excitation is not a photon since they could stop it with an aluminum film that transmits photons of appropriate energy.

What is the nature of the neutral? Surko and Reif speculate that they observed one of the long-lived metastable states of the isolated helium atom. But, Reif explains, "It's very difficult to get a handle on a neutral atom." They might be able to make a pulsed source of neutral excitations to find out how fast they move, or they might get optical evidence.

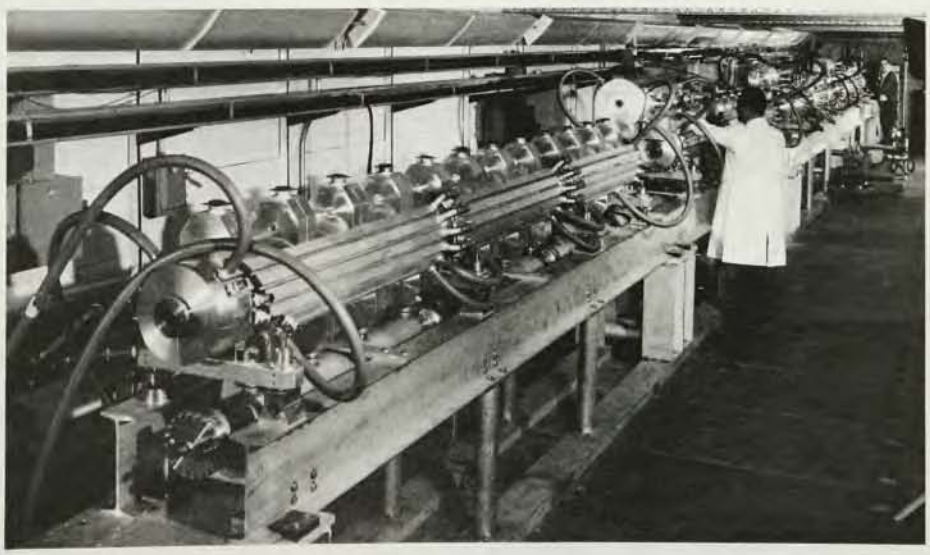
Chicago work. Stuart Rice of the University of Chicago told PHYSICS TODAY that he found evidence for a neutral excitation in liquid helium a few years ago, but he believes that the Berkeley experimenters found a different species from his. The Chicago experiments, done by Joshua Jortner, Lothar Meyer, Rice and E. G. Wilson (*Phys. Rev. Letters* **12**, 415, 1964 and *J. Chem. Phys.* **42**, 4250, 1965), also were done by irradiating liquid helium with a polonium source. By examining emission spectra from colloidally suspended oxygen and nitrogen, and from liquid and solid neon, argon, krypton and xenon, they concluded that energy was being transferred by the excited molecular-helium (He_2^*) triplet state.

Rice and Morrel Cohen, also at Chicago, are working on a theoretical interpretation of the Surko and Reif experiment. They believe that the neutral consists of a He_2^+ ion and an electron, which are bound together above the normal ionization energy of the He_2 molecule by the repulsion of the electron from the surrounding liquid helium atoms. They believe that the trapped "bubble" migrates, and when it hits the repulsive barrier that exists at the surface, the electron flies out. —GBL

Los Alamos Prototype Tests Meson-Factory Linac Design

Something new in accelerator design is the electron linear accelerator that recently came into operation at Los Alamos. Although it produces a useful beam of its own, it is mainly a prototype for the 800-MeV, 1-milliampere proton linac that will one day be the Los Alamos meson factory LAMPF (PHYSICS TODAY, December 1966, page 21, November 1967, page 75 and April 1968, page 81). Louis Rosen, director of the medium-energy-physics division, is in overall charge of meson-factory development. This month a users' meeting is being held at Los Alamos.

Heart of the new design is a row of 100 resonant cavities arranged in four groups of 25 each along an 18-meter length. (LAMPF will have 4400



LOS ALAMOS ELECTRON LINAC is prototype for proton accelerator that will some day power a meson factory. 100 in-line cavities produce a 24-MeV, 1-milliampere beam. Cavities above and below main axis couple accelerating cavities.

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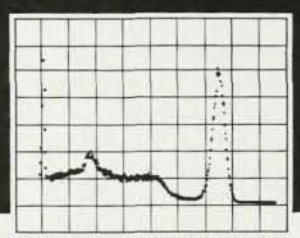
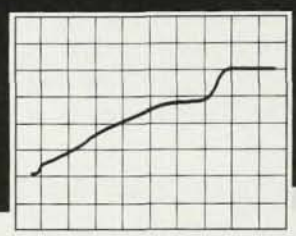


Acquisition: pulse height spectrum stored in analyzer memory



Reduction: integral curve obtained by pushbutton command

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cavities in a 73-meter length.) Edward A. Knapp and Darragh E. Nagle are the principal designers.[1,2] As indicated by the drawing, the beam goes along the center line of the cavities, which have drift spaces and accelerating lengths adjusted so that the electrons stay in phase with the 805-MHz oscillations. Each cavity is out of phase by 90 deg with its nearest neighbors, and the operation is referred to as a "$\pi/2$ mode."

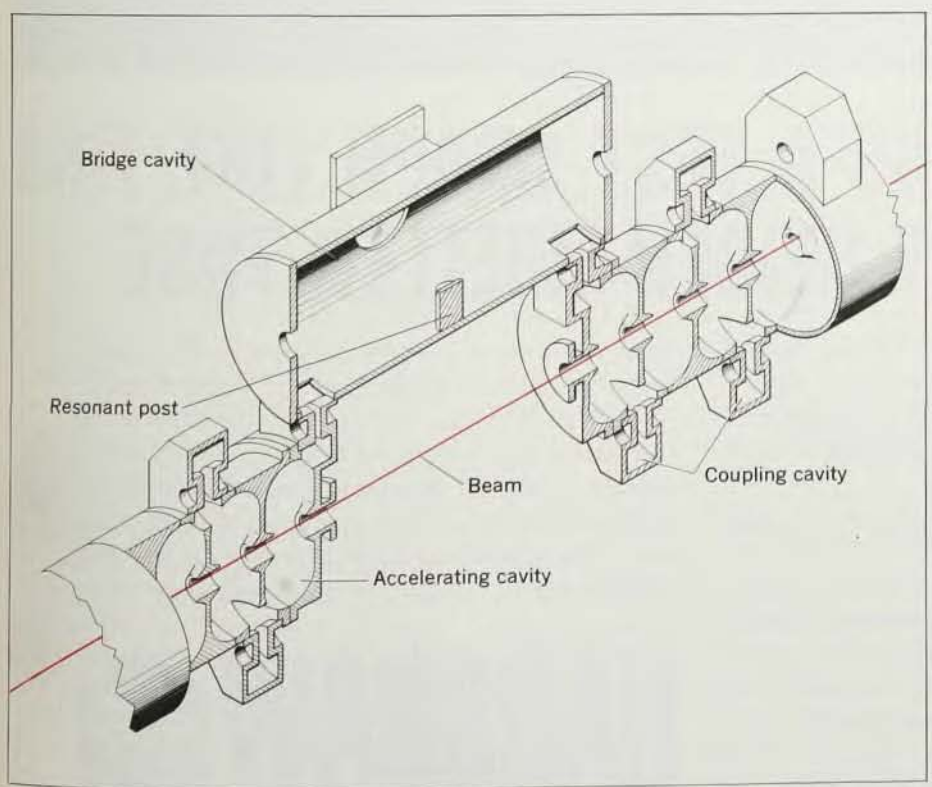
Coupling between the accelerating cavities in a 25-cavity section is provided by side cavities that are visible in both drawing and photograph as they protrude above and below the main axis. Similarly bridge cavities couple successive 25-cavity sections together and serve also as rf power inputs. The coupling cavities take essentially no energy from the system, behaving somewhat like a short-circuited quarter-wave line that has a high potential but low current at its open end. A Los Alamos computer supplied precise dimensions for all the cavities after the builders had told it about their basic design.

When we saw the prototype at Thanksgiving time, the first section had been successfully operated, and the builders were about to put succeeding sections into operation. More recently the builders have operated the entire accelerator with complete success. It has provided a 1-mA average current at 24 MeV, 500 microsecond pulse length and 6% duty factor. To the builders' delight they have seen no indications of transverse-mode instabilities, which might have been expected.

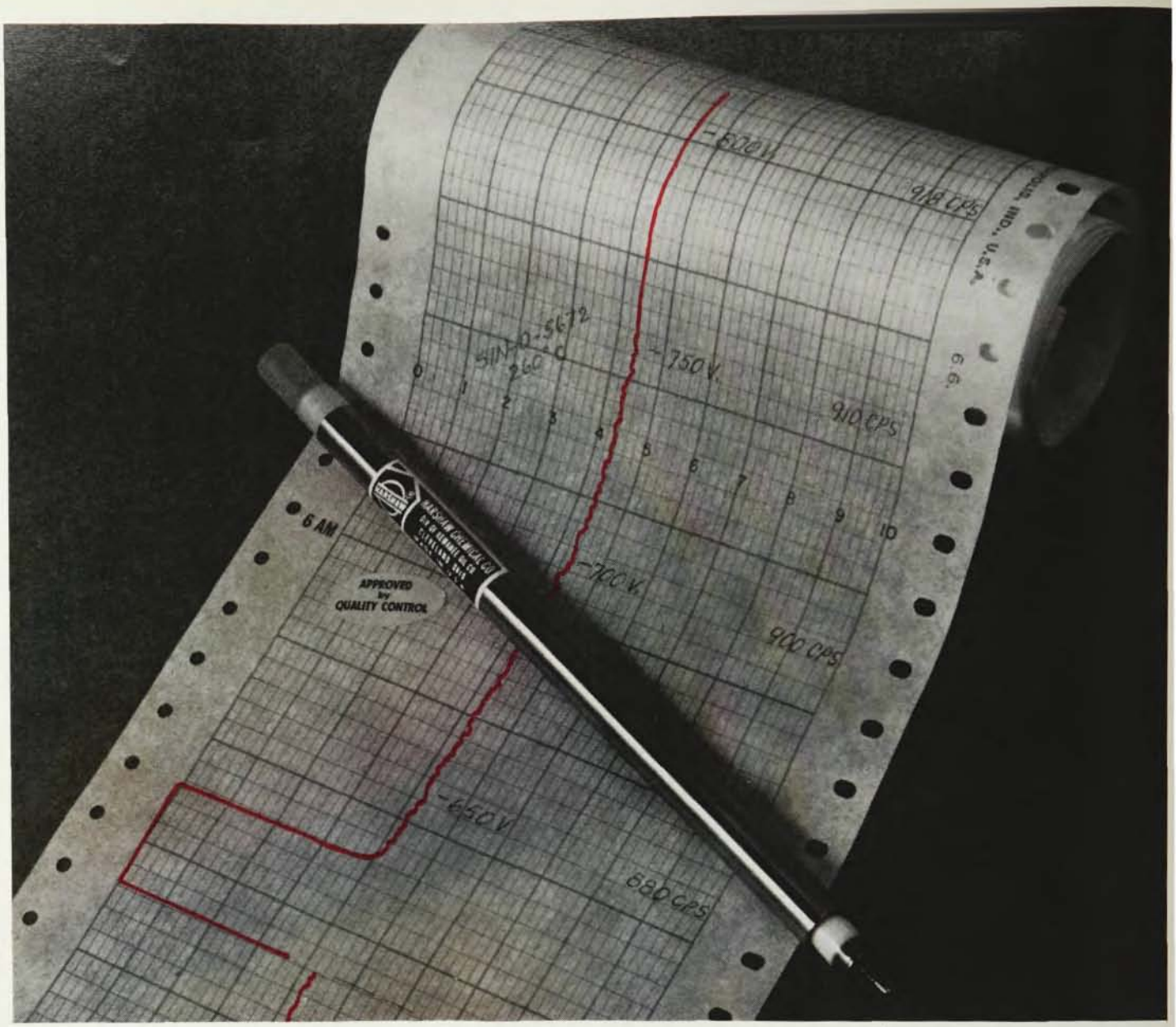
Shunt impedance, which is a measure of the cavity-system efficiency in converting rf power into beam energy, is very high, greater than 42 megohms/meter. This value is higher by a factor of four than an equivalent π-mode iris-loaded waveguide operated in a resonant mode for the same purpose.

The prototype will investigate many features of the proton linac besides the novel accelerator cavities. Rf power sources are a 100-kW-peak and a 1-MW-peak klystron, each with 6% duty factor. The latter is a prototype tube for LAMPF. A group under Donald C. Hagerman and Robert A. Jameson designed the rf system for the prototype, which investigates the final amplifier and also tests fast closed-loop control systems that regulate field amplitude and phase in the 25-cavity sections. A group headed by Thomas M. Putnam Jr and Harold Butler built the controls for the accelerator.

A digital-computer control system



DESIGN has field-free and accelerating spaces adjusted to keep electrons in phase with accelerating voltage. Computer put finishing touches on cavity cross sections.



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will operate LAMPF. Many of the ideas and circuits for the proton linac are built into the electron prototype, and computer-controlled operation of the prototype was accomplished in March. The prototype will also investigate targeting for LAMPF because thin-target damage is almost identical for the two.

Prospective users of LAMPF will meet at Los Alamos on 20 June, right after the American Physical Society meeting there. Open to all interested scientists, the meeting will include talks by Louis Rosen, R. Ronald Rau (Brookhaven), G. Victor Beard (executive director of Associated Western Universities, Inc), George Igo (Los Alamos), Ken Crowe (Berkeley), Vernon Hughes (Yale).

An organizing committee will be elected to draft a charter for the users' organization and to submit a list of nominees for office. Election of officers and adoption of a charter will be considered at a future meeting.

Invitations are available from Fred Tesche at Los Alamos. Those who are not US citizens should inform Tesche. —RHE

References

1. D. E. Nagle, E. A. Knapp, Rev. Sci. Instr. 38, 1583 (1967).
2. E. A. Knapp, B. C. Knapp, J. M. Potter, Rev. Sci. Instr. 39, 979 (1968).

The Tale of the Eta (Or More on C Invariance)

The asymmetry that wouldn't go away could almost be the title of a detective novel. This time, however, it describes the latest chapter in the CP-violation story. At the Washington APS meeting, Wonyong Lee and his Columbia collaborators (Mike Gormley, Emile Hyman, Tom Nash, John Peoples, Claude Schultz and Steve Stein) said that they had found a very small asymmetry in the decay of the η meson. If the asymmetry exists, it is evidence for violation of charge-conjugation (C) invariance in the electromagnetic interaction or some other intermediate interaction. Although the effect is small, three-standard-deviations worth, Lee feels their data is very suggestive of C violation. But to really be sure, they will have to do a new experiment.

In the spark-chamber experiment done at the Brookhaven AGS, the Columbia group observed some 40 000 events in which η decayed into π^+, π^- and π^0 and 8000 decays into π^+, π^- and γ. They calculated N^+, the number of events for which the positive pion had more energy than the negative pion, and N^-, the number of events for which the negative pion had more energy than the positive pion. The asymmetry $A = (N^+ - N^-)/(N^+ + N^-)$ turned out to be $+ 1.5\% \pm 0.5\%$. In earlier experiments with 1351 events, Paolo Franzini and his collaborators (PHYSICS TODAY, August 1966, page 71) found $A = +7.2\% \pm 2.8\%$, and a CERN spark-chamber experiment with 10 665 events (PHYSICS TODAY, October 1966, page 85) found $A = +0.3\% \pm 1.0\%$.

Six months after the end of the experiment, Lee still hesitated to announce finding an asymmetry since the effect may disappear with further data. He feels that a more useful approach than quoting a value for A is to look at the experimental points far from the center of their Dalitz plot. These values, where the energy difference between positive and negative pions is large, are more likely to show an asymmetry than those in the middle of the plot.

Hybrid Magnets Will Need Less Power for Same Field

More intense magnetic fields for the same power input can be had by piggy-backing standard water-cooled solenoids with superconducting ones. Plans at Francis Bitter National Magnet Laboratory, MIT, foresee superconducting boosters that could add 100 kilogauss to any of the 25 conventional solenoids now available at the Bitter laboratory. Then, since the laboratory 10-megawatt power supply can be divided into four independently controlled blocks, one can have four simultaneous experiments in 200-kG fields or one experiment at more than 300 kG. With its present equipment the laboratory is limited to one experiment at more than 200 kG and a maximal field of 225 kG.

Superconducting magnets by themselves are useful and economical up to 125 kG even at large bores. At more intense fields, though, cost rises rapidly because one reaches the limiting current for the conductor to remain superconducting. Meanwhile conventional water-cooled coils are cheap at all fields but are limited by the power they require. Thus one operates the