plexity. For some time OH, CH, CH^+ and CN molecules have been known. Recent molecules in space reported include, besides H_2CO (formaldehyde) and NH_3 (ammonia), H_2O, H_2, CO, HCN (hydrogen cyanide), HC_3N (cyanoacetylene), CH_3OH (methyl alcohol) and most recently HCOOH (formic acid). In addition an unidentified molecule known as "X-ogen" has been reported.

That such complex molecules can exist as a gas in space, constantly bombarded by radiation, has surprised many observers. By contrast the materials found in the Murchison meteorite and the moon are protected inside of solids, thus preventing their dissociation by the solar wind; accordingly, amino acids, though delicate in structure, would have a chance for survival.

Some observers are hopeful of finding amino-acid clouds in space, too, though some spade work in the laboratory is probably needed—doing microwave spectroscopy on gaseous amino acids. Complex organic molecules might survive by being absorbed onto grains of silica.

Thus chemistry, biology, physics, geology and astronomy are coming together in a magnificent effort to understand evolution in its very broadest sense.

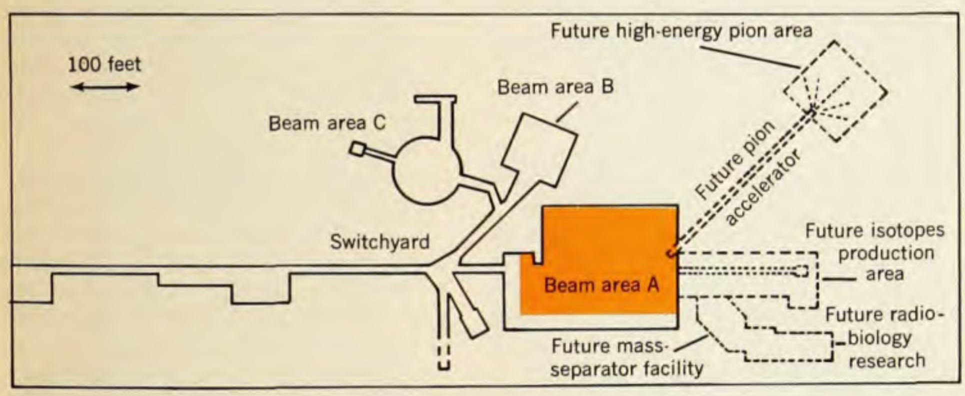
—GBL

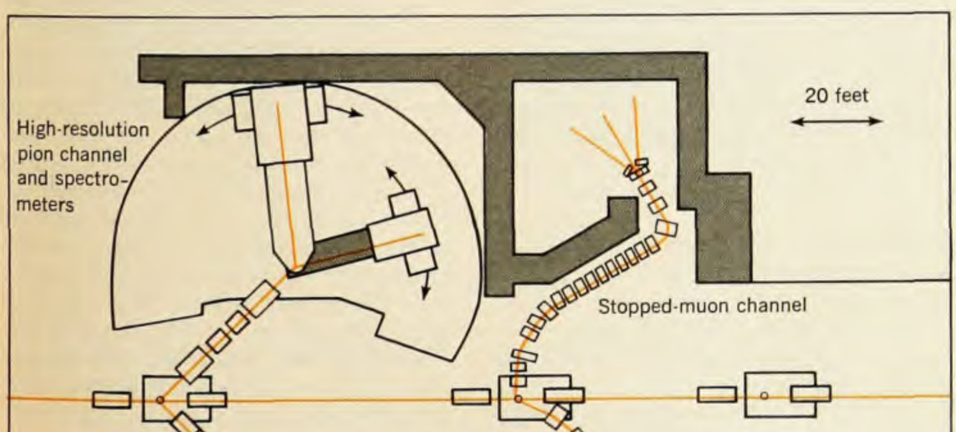
References

1. I. R. Kaplan, E. T. Degens, J. H. Reuter, Geochim. Cosmochim. Acta **27**, 805 (1963).
2. S. W. Fox, K. Harada, P. E. Hare, G. Hinsch, G. Mueller, Science **167**, 767 (1970).
3. B. Nagy, C. M. Drew, P. B. Hamilton, V. E. Modzeleski, M. E. Murphy, W. M. Scott, H. C. Urey, M. Young, Science **167**, 770 (1970).
4. S. W. Fox, P. E. Hare, K. Harada, C. R. Windsor, invited paper, International Symposium on Hydrogeochemistry and Biogeochemistry, Tokyo, 8 Sept. 1970.
5. S. W. Fox, C. Windsor, Science **170**, 984 (1970).

LAMPF meson factory calls for beam-time proposals

Do you have an idea for an experiment that needs an 800-MeV meson-factory beam? If so, it is time to submit it to the Los Alamos Meson Physics Facility. Louis Rosen, LAMPF director, recently summed up the current status of the accelerator and experimental areas, issued a call for proposals for beam time, and announced the formation of a program committee to consider proposals. The 11-member program committee, plus Rosen as chairman and Darragh Nagle (LAMPF deputy director) as alternate chairman, will hold its first meeting during March.





Experimental areas of the Los Alamos Meson Physics Facility. Two simultaneous 800-MeV beams (1 milliamp of protons and 0.1 milliamp of H^- ions) enter the switchyard from the left after acceleration in the half-mile-long linac. Colored region in the top illustration, "beam area A," is shown in greater detail below.

The accelerator is an 800-MeV proton linac capable of about 1 milliamp average current. A unique feature is the trick of using different parts of the rf phase to accelerate both protons and negative hydrogen ions simultaneously. Last June the first beam (5-MeV protons) was obtained; by mid-1971 a 100-MeV beam is expected, and the full energy of 800 MeV should be available by mid-1972. An experimental beam is scheduled for use about six months after the full energy is first attained.

Three experimental areas are to be ready by the time the beam is made available to experimenters. The 1-milliamp proton beam goes to area A (see figure) for meson physics. Areas B and C will take the negative hydrogen-ion beam, at about 10% of the intensity of the main proton beam, for nucleon physics and high-resolution proton spectroscopy respectively.

Meson physics. Area A will consist of four channels, for low-energy pions, pion spectroscopy, stopped muons and high-energy pions.

The low-energy pions (20–300 MeV pi-plus and pi-minus) will have good momentum resolution, achromatic and isochronous output, variable spot size and beam divergence at the output, and high intensity at moderate resolution.

The pion-spectroscopy channel includes spectrometers, a scattering chamber and a detection system. Energy resolution will be better than 50 keV, with angular resolution less than 10 milliradians. The energy range will be 50–300 MeV. Initially one spectrometer (low momentum, 680 MeV/c) will be built, with another (high momentum, 1000 MeV/c) being planned for later.

Currently the most advanced secondary beam is the stopped-muon channel; several of its magnets are already on order. The channel will consist of a pion collection system, a pion-decay portion, and an analyzer, which selects muons from either forward or backward decays. Purity of the muon beam is expected to be better than about 90%, with contamination from pions (5%), protons (1%) and electrons (1%). Muon polarization will be 0.4–0.7 for backward decays and up to 0.9 for forward decays, which are, however, harder to separate cleanly.

The pion and particle-physics channel will have positive and negative pions at high energy (100–600 MeV) and high intensity (up to 10^{10} per sec).

Nucleon physics. High-quality nucleon beams at 300–800 MeV—two neutron beams and one low-intensity proton beam (about 50 nanoamp)—are planned for area B. Neutrons will be generated in a liquid-deuterium target, scattering in the forward direction with the proton energy and intensities greater than 10^7 cm^{-2} sec^{-1}. This area will be used mainly for medium-energy nucleon–nucleon research (see the article by Michael J. Moravcsik, PHYSICS TODAY, October, page 40). A polarized proton beam (polarization approximately 0.9) is planned for later.

High-resolution proton spectroscopy. The spectrometer is already under construction in area C. It will have resolution up to 30 keV for 800-MeV protons, angular resolution of 0.8 milliradians, counting rate of 10 counts per second for a 1 microbarn/sr cross section. Users will be offered the complete set-up including a high-resolution detection system and on-line computer analysis.

Other areas to be developed at LAMPF are those for nuclear chemistry, for which several irradiation stations are planned, and for the biomedical uses of pions in radiobiology and therapy.

Users group. More than 250 prospective users of the LAMPF meson factory met at the site last October. They constitute less than half of the total number of prospective users, who represent 159 institutions between them. Chairman of the users group for 1971 is Gerald C. Phillips, of Rice University; Lewis Agnew of Los Alamos Scientific Laboratory is liaison officer.

Rosen told the assembled users that LAMPF policy will be to make the facility available to all qualified research teams. He praised the prospective users for the help they have already given in the design of equipment, and hoped they would continue to supply guidance in setting specifications. —JTS

Partons

continued from page 17

the constituents a very sharp, swift jab and do the kinematics in the right way, we can think of the neutrons and protons as being instantaneously free during the moment that they are being hit. We think of finding an insolated proton inside the nucleus and kicking it out.

Applying the same impulse-approximation arguments to electron–proton scattering, we think of doing elastic scattering from one of the constituents of the proton. Deep inelastic scattering when viewed from the trolley car satisfies this condition of the impulse approximation. That is, of taking an instantaneous snapshot of its constituents. Then scaling is observed.

The ratio of the momentum and energy transfer is fixed by the elastic condition, and the structure functions are measuring the momentum distribution within the proton of the constituents of the proton. Viewed from the trolley car the protons have large momentum, and we measure how the momentum along one direction is shared by the constituents; the structure functions measure the probability of finding the constituents with different fractions of the momentum.

What are the constituents like? It is generally agreed that they have spin 1/2 because the cross section for scattering transverse photons is much bigger than the longitudinal cross section for deep inelastic scattering. It is observed that the scattering is proportional to the squares of the charges, and it looks as if the charges come out with a value considerably less than the electronic charge.

Weisskopf thinks of fast-moving protons as consisting of a probability distribution of n partons, where n is greater than or equal to three. We can learn the relative momentum of those partons, whether they have 1/2 the momentum, or 1/3, or 1/4, and so on. Then, for example, if the object doing the scattering has 1/3 the momentum of the proton, then the proton would consist of four such partons. "This all sounds like quarks," Weisskopf remarks. "The proton may consist of three quarks, and with a certain probability distribution it consists of five quarks or seven quarks. It may be three quarks and then in addition a quark–antiquark pair or two quark–antiquark pairs." One could imagine something like a sea of quark–antiquark pairs floating around in an undefined quantity.

The original SLAC measurements reported by Richard Taylor and his collaborators were for protons. At the "Rochester" conference held in Kiev in September the group reported measurements on neutrons, which showed that the scattering is lower for neutrons. On the basis of a simple quark picture the structure functions for both neutrons and protons are too low. On the other hand, the ratio of neutron scattering to proton scattering predicted by the simple picture is 3/2, agreeing roughly with experiment. (The neutron would have one quark of charge 2/3 and two with charge-1/3. The proton would consist of two quarks with charge 2/3 and one with 1/3. The ratio of the sum of the squares is 3/2.) As the number of partons increases beyond three the ratio of neutrons to protons approaches one. Thus the neutron and proton difference would become less significant as the number of quark–antiquark pairs is increased.

In a more complicated quark model, one can assume configuration mixing of higher quark states (5, 7, 9, 11) and a neutral "gluon" sea (particles that use up excess proton momentum and don't contribute to electrical properties) to make the value of the structure functions as small as the SLAC experimenters observe.

Drell and his collaborators (T. M. Yan, now of Cornell, and Donald Levy, now at Berkeley) have shown how to apply the conditions for the impulse limit in a canonical, relativistic field-theory formulation and derived scaling behavior. They were then able to predict for colliding-beam experiments that the annihilation cross section has the same energy dependence as if the annihilation was to pointlike particles, in agreement with a scaling prediction. He explained that you think of the proton as a series of point partons.

When you annihilate, you make them in pairs, which then decay into physical pions and nucleons. Similarly, when you scatter, you scatter from the partons, which are simply the bare or free pointlike constituents that appear in the perturbation expansion of a physical proton.

It's all a question of scale, Drell went on. When we do elastic scattering from an atom, we see a charge distribution, but when we do hard scattering from the atom, we see scattering from point constituents—the electrons or the nucleus. Similarly when we do hard scattering from a nucleus, the proton and the neutron look like points. When we look at the proton and do elastic scattering we see an extended charge-current distribution and observe that the proton behaves like a bowl of jelly. But when we do deep inelastic scattering, we see point constituents inside the jelly. So the proton looks less like jelly and more like raspberry jam—with seeds.

Weisskopf, who has always been skeptical about quarks, still is dubious. However, he tells the story of Niels Bohr, who visited a friend's house, noticed a horseshoe over the door and asked what it meant. His friend told him, "That brings luck."

Bohr said, "Do you really believe in this?" His friend said, "Oh, I don't believe in it. But I am told it works even if you don't believe in it." —GBL□