The Beam Line

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High Energy Physics Horizons

by W. K. H. PANOFSKY

(Ed. Note: The following is taken from an invited talk given by SLAC's Director at the National Particle Accelerator Conference in San Francisco on March 7. Dr. Panofsky first discussed the past progress in and present status of accelerators and colliding beams and noted that historically proton accelerators have generally uncovered new particles and particle states while it has required the use of electron accelerators to explore the structure of these particles. The rest of Dr. Panofsky's talk appears below.)

In the preceding discussion based on a rough outline of past and expected progress of accelerator and colliding beam technology I have concluded that the rapid gains in that field have shown no indications of slowing down, provided of course that support of this type of work is maintained at roughly current levels. The question is whether the rate of discoveries in high energy physics will keep up with the promise set by the machines. Any such assessment is of course a subjective matter; I remember many times during the evolution of the accelerator art where "wise men" assembled in committees have said that the field is saturated and that future installations will only fill in details of previous work but nothing genuinely new will be uncovered. Subsequent experience has always contradicted such gloomy forecasts in the past.

The chart tabulates those discoveries in elementary particle physics which I consider to have profoundly shaken man's concept of nature; again such a list involves much subjective judgment and others might produce a list differing in considerable detail from the one given here. However the conclusion is sustained that there is no real indication that the rate of truly profound discoveries in elementary particle physics has been slowing down in the post-war period. We are therefore again facing the question: While this conclusion may be true in the past will it be true in the future? Will the future bring only an "extensive" filling in of spectroscopic levels rather than "intensive" experiments yielding new discoveries?

There are many indications that future technology will make both future systematic measurements and new basic discoveries possible. The remarks made above in connection with the expectations of ultra-high energy storage rings as they reach center-of-mass energies where electromagnetic and weak interactions become equal certainly indicate strongly that very profound and new revelations will accrue once such machines are built. To predict specific additional discoveries is of course speculative, but it might be useful here to list questions which should in principle be answerable by experimentation in elementary particle physics in the future and which, if answered, would lead to very profound conclusions indeed. Naturally such a list is again a subjective tabulation and only gives the sketchiest of possible outlines of known open questions in elementary particle physics.

Let me divide this list into the headings of "Strong Interactions," "Weak Interactions," "Electromagnetic Interactions," and "General Questions."

1. Strong Interactions

What is the behavior of cross sections at ultra-high energies? Will the so-called Pomeranchuk theorem be satisfied which predicts that particle and anti-particle cross sections become equal for all species? Will more detailed structure disappear from the curves which describe cross sections as a function of energy -- that is, will there be no more resonance "bumps" of any kind beyond energies of a few GeV? At higher energies can the angular distribution, and particle multiplicities be described by the Feynmann scaling variables which reduce the number of independent kinematic parameters needed to describe the phenomena? Do some of the specific models such as those describing reactions at ultra-high energies in terms of either the fragmentation of the target or the bombarding particle retain quantitative validity? Will new qualitative features emerge in ultra-high energy reactions which point toward other models? Will the present exploration of spectroscopic levels of mesons and baryons reveal any new states beyond those describable by the quark model? Specifically, are there "exotic" states which require more than two quarks for mesonic levels and three quarks for baryons? Are quarks real and observable and if so, what are their properties? If quarks are not observable, what is the dynamics which prevents their emergence into the real world?

All these questions are part of the overall problem of the strong interactions: Will the combination of phenomenology of cross sections and observation and analysis of hadron spectroscopy lead to a real understanding of the dynamics of strong interactions? Strong interaction physics is now in the situation in which optical spectroscopy found itself before the invention of quantum mechanics; many systematic regularities have been observed and much quantitative data has been gathered but no unifying dynamics is yet at hand.

2. Weak Interactions

The dominant question remains that identified above in relation to the required technical characteristics of ultra-high energy storage rings: What is going to be the modification of the theory of weak interactions at energies so high that the interaction among the four particles involved can no longer be considered pointlike? At such an energy how is the "field" of such a weak interaction carried? Will it be transmitted by a new particle given the name of the "intermediate boson W?" If so what are its properties? Is it possibly an already existing hadron? Present experiments have only established limits on the mass of the intermediate boson, should it exist; these limits are not sufficiently stringent to draw general conclusions.

Another important question is the relation between structure of the hadrons and the description of weak interactions in which such hadrons are involved. With respect to electromagnetic interactions this question is illustrated by the electric and magnetic form factors which have been measured extensively with electron machines. In regard to weak interactions the corresponding form factors are more numerous and the high intensity neutrino beams, hopefully available at NAL and CERN II, appear the most promising tool for their exploration. On a different topic the question persists as to how the so-called CP violation, and presumably the violation of time reversal invariance discovered in neutral kaon decay, relates to the overall theory of weak interactions. Why has this violation exhibited itself only in the weak decays of the neutral kaon system? Why have all other decays and interactions refused to exhibit deviations in this respect?

3. Electromagnetic Interactions

A dominant question remains whether the description of electromagnetic forces by quantum electrodynamics remains quantitatively valid even in the next accessible region of energies or the region after that. Currently quantum electrodynamics represents the only known physical theory giving a quantitative description which appears to remain valid from cosmic distances down to 10^{-15} cm or so. Thus the question whether the finiteness of electromagnetic masses is or is not associated with possible breakdowns of quantum electrodynamics at small distances remains to be answered. Associated with this problem is the question whether the electron or the muon will exhibit any structure at very small distances and the even more puzzling question of electron-muon universality, that is the identity (with the exception of their masses) of electrons and muons in all respects; thus far all experiments once sufficiently refined have confirmed this identity. There are some tantalizing discrepancies remaining, for instance in electron and muon scattering on nuclei, but they are too tenuous to be taken as definite results. All this means is that the question of the muon's role in nature remains as obscure as ever, or to put it in Rabi's words when referring to the muon: "Who ordered that?" Directly associated with this problem is the question whether the electron and muon in combination with their associated neutrinos constitute the entire family of leptons or whether other probably heavier members will be discovered at higher energies.

Then there is the question of the electromagnetic structure of hadrons. The scattering of leptons, and particularly electrons, has been the dominant tool in revealing the substructure of the nucleons. In particular the inelastic scattering experiments have shown that scattering cross sections at large momentum transfer were unexpectedly large and that the cross section exhibited "scaling" properties; this means that aside from kinematic factors these cross sections could be described as a function of a single kinematic variable. These phenomena in turn have given rise to the conjecture that the electromagnetic interaction carried by the scattered lepton is transmitted to pointlike constituents within the nucleon, called "partons" by Feynman. This discovery of a substructure of the neutron and proton opens up a new slate of questions: What are these "partons?" Are they the same as quarks? What is their spin and other properties? Will "scaling" persist into the next range of interaction energies accessible to the high energy electron-positron storage rings? What is the relation of the unexpectedly large annihilation cross sections for electrons and positrons into hadrons observed at CEA and Frascati to the parton or similar models? Will the new phenomena indicate a pointlike substructure of hadrons only to be followed by evidence for yet another substructure, etc., or do these new phenomena indicate something more "ultimate?" This latter problem is equivalent to the question whether scaling will persist into the next region of higher energies or will apply only in a restricted range of kinematic variables.

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DATE	DISCOVERY	EXPLORATION
1947	Lamb shift; "g-2" of the electron	Limits of quantum electrodynamics
1947	Properties of the pion	Pion-nucleon interactions
1952	Bubble chamber for investigation of strange particles	Interactions of strange particles
1954	Composite nature of the nucleon	Electron scattering and nucleon spectroscopy
1955	Anti-proton	Matter/Anti-matter symmetry
1956	Violation of parity conservation	Weak interactions
1961	Hadron symmetries (SU^3) and discovery of omega-minus (1964)	Whole hadron spectroscopy
1962	A second neutrino	Search for new leptons
1964	Violation of CP conservation	Search for T violation
1968	Point structure within hadrons	Deep inelastic scattering and e^-e^+ storage rings

Chart showing some important post-war discoveries in particle physics.

Layoff TASK FORCE Progressing

The final statistics on our budgetary reduction-in-force show that fewer layoffs actually occurred than the originally planned 80. A total of 72 employees were given official notification of layoff on March 1 to be effective June 30. This number included 18 people who had yet to pass the six-month trial period. Shortly after March 1, a total of 13 openings at SLAC were posted. As we anticipate that all of these will be filled by people on layoff notice, it now looks like perhaps only about 60 employees will be finding employment outside SLAC because of this involuntary layoff.

Two thirds of the people who received layoff notices have registered with the Personnel Department's Placement Assistance Task Force. More than half of these have already been interviewed for other jobs at Stanford. Some have also been attending job-search seminars. Although barely two weeks have passed, as of press time, 6 people have already secured other employment. Many more are being matched with known job openings in the area provided to the Task Force.

So, all in all, under the circumstances things seem to be progressing well. A sign of this progress perhaps is that only one official grievance against a layoff selection has been formally filed. And more than half the time for filing grievances on the layoff actions has already passed; the deadline for filing such grievances is March 30.

The Beam Line will continue to publish the statistics of progress. With more than three months to go, the Task Force is looking forward to a near-perfect success record in placement.

Benefits
Portfolios Available

The SLAC Benefits Office has a supply of new Benefit Portfolios issued recently by the University. Each portfolio contains a summary of the numerous benefits, plans, and programs which are provided for faculty and staff. The portfolios are designed to serve as a convenient "file" for the brochures and insurance certificates you may now have about Stanford's health plans, life insurance, pension and retirement plans, disability coverage, and other benefits.

This is the most comprehensive description of the staff and faculty benefit program that the Benefits Office has had available in some time. Employees are invited to drop by the Benefits Office, Room 238 A&E Building, for a copy of this portfolio.

PHONE BOOKS BIN LISTS

The new alphabetical supplementary section of the SLAC phone book, dated January 1973, is available; also the new Bin List, dated February 1973. If you would like any, please pick them up in Room 233 A&E or call 2202.

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We have been fortunate that atomic and nuclear phenomena are separated in terms of the applicable scale of distances by four orders of magnitude; this is a consequence of the small strength of electromagnetic interactions relative to nuclear forces. Nucleons are smaller than nuclei by only an order of magnitude and going from the nucleon to its substructure appears again to descend only by one further decade in dimension. How, if at all, will this progression continue?

4. General Questions

We still do not understand why all charges are exact multiples of the electronic charge or whether magnetic monopoles exist. And then: Are there some totally new phenomena at center-of-mass energies well above 100 GeV which should be accessible to the new generation of super storage rings?

Many of the questions raised under the heading of specific interactions may of course be more general and the hope, if not the expectation, is that a more unifying picture among these forces will emerge, in particular since the cross sections governed by these different forces will tend to converge in magnitude at the highest energies hopefully accessible a decade from now. Finding a unified theory for all these forces has been a quest throughout this century. To a limited extent the search has already been successful in defining some common principles between electromagnetic and weak and between weak and strong interactions.

Let me return to the topic of this talk called "High Energy Physics Horizons." A horizon represents that boundary beyond which we cannot see and I hope that in this talk I have demonstrated that there is indeed a great deal of truly profound but unknown part of nature beyond. What may of course be true is that high energy physics exhibits another property of an horizon: As we march on in high energy physics we do indeed uncover much that is new and farreaching and modifies our view of nature as we know it; however we may also discover that the horizon of complete understanding of the inanimate structure of matter is just as far away as it has always been.

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Managing Your Family's Credit

By Lucile Ketchum,
Extension Specialist in Home Management
Michigan State University

CONSUMER FACTS: Managing Your Family's Credit

Ruth Mason sighs as she looks over the bills for the month and tries to think how they'll stretch the paycheck that Jim will bring home tonight. Groceries will take $125. Then there's the house payment, light bill, payment on the new washer, payment on the car, shoes for Johnnie, and the telephone bill.

Already it adds up to almost as much as the check will be.

And there's that bill for the things she charged at Jones'. A birthday gift to buy for Susan next week. Allowances for the children. And Jim really needs his new suit before that important trip at the end of the month. They've been planning to get it from month to month but there never seems to be enough cash to go around.

Ruth decides she'll talk with Jim about getting the suit on an installment plan. They never have bought clothes "on time," but she sees no other way to get the suit by the time he needs it.

And so it goes--another "easy" payment!

More Debt: Good or Bad?

Many other families are in the same boat as the Mason's--using more and more credit to buy the things they want.

Some folks say this is a bad situation. Others say it's good--that wide use of credit is one of the things that helps to give us such a high standard of living in America.

Good or bad, certainly many families and individuals do use credit in order to enjoy today--rather than waiting until they can save the purchase price--such things as automobiles, refrigerators, automatic washers, education and even vacation trips. Others use credit in the form of a charge account simply as a convenience. Still others borrow money to meet emergencies, such as illness or being out of work. And some folks say that buying equipment and furnishings for the home on the installment plan is a way of saving--that they wouldn't be able to save the purchase price of such items without a contract to make them do it. Moreover, some will say, even though it costs more to buy "on time" it's worth the extra cost to have certain conveniences and comforts while the family is growing, rather than to wait until savings can be accumulated.

It's How You Manage Credit That Counts

Whatever your reasons, using credit in itself isn't necessarily good or bad. It's the way you use it that means either benefits or problems for you.

You have to manage credit. If you don't your debts will manage you--keep you from doing and having many things you really want.

You may not have thought of it in this way, but actually your credit -- the confidence others have in you which makes it possible for you to borrow money or to buy on time--is indeed a valuable personal asset.

The purpose of this leaflet is to bring together some ideas which may be helpful to you in using credit to your advantage.

Ask Yourself These Questions:

1. Shall I use credit for this purchase?

In order to answer this question for yourself, there are many others to think about:

How will the payments fit into your family's regular spending? If you haven't been in the habit of budgeting (planning expenses before you spend), now is the time to start--before you take on installment payments. Will you have to go without necessities or other items that are more important to your family than this purchase? No one else can give you the answer. Sometimes it's learned the hard way, by living with installment payments that are too big for your income. Sitting down together as a family and figuring all your living expenses ahead of time isn't easy--but it might save a great deal of real trouble.

How much will credit cost? What's the difference between the cash price and the price you'll pay if you buy "on time"? Is it worth the cost to you to be able to make the purchase on credit, and pay later? Or would it be better to use savings? Or to wait until you can save enough to pay cash?

Will whatever you are planning to buy outlast the time you'll be making payments? Give long service? (It's no fun to pay for "dead horses"!)

Is this something that you will want as much when you are making the payments as you do now?

Will it mean better family living? (Save time? Save energy? Give satisfaction to the family? Protect health? Make it possible to increase income?)

Is your income certain for the length of time that payments will run? And do you have enough life insurance protection to cover the debt?

2. How do I shop for the best credit "buy"?

Main sources of consumer credit are:

Credit Unions
Personal Loan Department of Banks
Small Loan Companies
Sales Finance Companies
Retail Sales Establishments

The charges from these different sources vary a great deal. Take time to investigate. Find out what kind of service you can expect, what the cost and repayment terms will be. Do this before you decide where to use your credit.

Find out the cost

You probably compare prices on shoes, dresse coats, housewares. Why not on the cost of credit?

Credit costs vary widely among different lenders and among stores that sell "on the installment plan." In fact, costs may differ considerably among the various "plans" available from a single store.

The Truth-in-Lending Law (Consumer Credit Protection Act) requires that ALL costs, terms, and conditions of credit transactions shall be stated--and expressed in the same terms by everybody. In comparing costs you'll want to look for the FINANCE CHARGE and the ANNUAL PERCENTAGE RATE?

Find out about service

As you shop for credit consider other factors beside cost. What service will you get? Are payment arrangements convenient? Are the payments spread over a long enough time so that you can handle them along with your other expenses? At the same time, are you paying off the loan as quickly as possible to save financing costs?

What does the fine print say? Be sure you know before you sign the contract, because when you sign, you agree to all the terms stated.

3. How is my "credit rating"?

You often hear it said that it is an advantage to establish credit, but perhaps not as much is said about keeping your credit good. Once you establish credit, you are watched--not only your record of payments, but any reports about your activities from newspapers and other sources. Your credit rating follows you all over the country through the National Credit Exchange.

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This article is one of a series on various consumer topics distributed by the credit union for your benefit.

Notes on Health

America's eating habits are so terrible that they cost the nation $30 billion a year in health care, a University of California researcher says. Furthermore, the problems of bad nutrition are a component of many illnesses that kill, like heart attacks, alcoholism and diseases of diabetes and digestive disturbances.

Persons suffering from colds, allergies and other infections causing head congestion are particularly vulnerable to a jet-age ear disease and shouldn't fly if they can possibly avoid it, says a physician who has studied the problem. Aerotitis, a traumatic inflammation of the middle ear resulting from rapid changes in cabin air pressure, often causes intense pain in the ears, temporary deafness and, occasionally, broken ear drums.

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