JOURNAL NOTES

Meson Structure

It is customary to assume that electrons, neutrinos, nucleons, π and μ mesons are "elementary," i.e., structureless, an assumption that is questioned in this paper where it is pointed out that the present experimental information might perhaps be explained equally well with other models for the structure of these particles. In particular, the possibility is discussed that a π meson might be a composite particle consisting of a nucleon and an antinucleon revolving around each other at a distance of the order of the Compton wavelength of the nucleon. From an extremely crude calculation it appears that such a meson would have in most respects properties similar to those of the meson of the Yukawa theory. For example, Yukawa's explanation of nuclear forces would remain valid even when the meson has a structure and is a composite particle. Appreciable deviations from the Yukawa theory would occur only at energies of the order of one billion electron volts, or higher. Another feature of the theory is that in principle the strength of nuclear forces is determined by the masses of the nucleon and the π meson. A rough estimate of the strength shows that it is not in violent disagreement with experiments. It is emphasized, however, that a rigorous mathematical treatment is very difficult and that the crude attempt made in the paper should be regarded as an illustration of a possible program, rather than a proposal of a definite model. C.N.Y.

Are Mesons Elementary Particles? By E. Fermi and C. N. Yang. *Phys. Rev. 76: 1739, December 15, 1949.*

Total Reflection Filter

Until recently prisms or gratings were customarily used for isolating a narrow band of wavelengths, but during the last few years a series of interference filters have been developed, the commonest of which is analogous to the Fabry-Perot interferometer and consists of a layer of dielectric about one wavelength thick, sandwiched between two layers of silver. The higher the reflectivity of the silver, the narrower the band width; but the reflectivity depends on the thickness of the layers, which absorb a larger amount of light as they are made thicker, so that as the filter band width is decreased the transmission is also cut down. The band width which can be achieved without reducing the transmission below a useful quantity is about one hundred and fifty Å. Unfortunately, it is not possible to achieve high reflectivity and low absorption from metal layers except in the visible spectrum.

Recently Dr. Turner at Bausch & Lomb announced the invention of his frustrated total reflection filter, which operates in the same fashion as the solid Fabry-Perot filter but replaces the silver layers by a system which gives any desired degree of reflectivity with no absorption. This is accomplished by using the total internal reflection which occurs at the hypotenuse of a right angle prism. By putting two right angle prisms together so as to make a rhomb, the reflection at the interface is cut down, depending on the thickness of the air film between the two prisms. The light which is not reflected is transmitted. By adjusting the thickness of this film it is possible to make a semitransparent mirror with any desired ratio of reflection to transmission and with no absorption.

The frustrated total reflection filter combines two such lossless reflections with high and low index layers suitably disposed. Since the behavior of this filter depends only on index differences, it can be made to operate wherever there are transparent materials. A filter was made to operate in the rock salt infrared region. The high index layer in this filter was silver chloride; the low index layers, sodium fluoride. The prisms were of rock salt. The pass bands of this filter were at 4.5 and 5 microns, and were 1/10 of a micron wide. By tilting the filter it is possible to shift the pass bands easily over a range of approximately one-half a micron.

The bands are oppositely polarized and thus the filter can be used by itself as a particularly simple gas analyzer. One band can be placed on an absorption band of the gas to be detected. The other band can be made to fall at a wavelength which is free of absorption. If a polarizer is spun in front of the filter, light passing through the filter will be modulated by a percentage which will be proportional to the quantity of gas present. B.H.B.

A Frustrated Total Reflection Filter for the Infrared. By B. H. Billings and M. A. Pittman. *J. Opt. Soc. Am. 39: 978, December, 1949.*

Accelerator Shielding

Shielding for high energy nuclear particle accelerators should contain elements of rather high atomic weight for inelastic scattering of fast neutrons, as well as an appreciable amount of hydrogen to slow down low energy neutrons. High density is desirable to conserve floor space, which in large accelerator buildings is unusually expensive because of special facilities requiring high head room. Concrete consisting of five parts by weight of dry magnetite ore concentrate to one part by weight of cement was found to have good strength and handling properties and a density of more than 200 pounds per cubic foot. Because of the small particle size of the magnetite, considerable water (up to ten percent by weight of the concrete) is retained after setting. To study loss of moisture by diffusion, spheres of various sizes were placed in a desiccator and weighed frequently over a period of several weeks. From the loss of weight data, the diffusivity could be calculated and was found to be about 10^{-2} cm^2 per hour. This information may be applied to estimate the rate of loss of moisture from a thick wall such as is used for the Carnegie Institute of Technology shield. This shield, which is 8 feet thick, will lose half its moisture in about 30 years.

Although no very high energy particles were available, some radiation attenuation measurements were made in the magnetite concrete. Spheres were provided with central cavities for gamma ray and photo neutron sources, thus making it possible to estimate the thickness of concrete required to reduce intensities to a half value. It was found that the effectiveness of this shielding material provides a saving in floor space that more than offsets the slight additional cost of the special concrete. E.C.

Magnetite Concrete for Radiation Shielding. By E. Creutz and K. Downes. *J. Appl. Phys. 20: 1236, December, 1949.*

Ferromagnetic Crystals

Much of our knowledge of the solid state of matter depends on the study of the properties of single crystals. Research on crystal structure, elasticity, piezoelectricity (fundamental and applied), and ferromagnetism, to mention only a few examples, has depended on the successful growing of crystals to a size larger than that occurring in natural or technical materials. The technique described in this article is directed toward the growing of ferromagnetic crystals, which have already been used for investigating magnetic domains, magnetic anisotropy, elastic constants, and the damping of elastic vibrations. It is believed that the methods of growing, orienting, and cutting metal crystals of rather high melting point (1400 to 1600°C), as described in this paper, will prove helpful to investigators in other laboratories. The many requests for these crystals, received at the Bell Laboratories and not fulfilled because the crystals were not available, show that they are desired in an increasing number of investigations. Work on elastic constants and neutron diffraction, as well as on various ferromagnetic phenomena, could be carried forward more rapidly if more ferromagnetic crystals were available. R.M.B.

Growing and Processing Single Crystals of Magnetic Metals. By J. G. Walker, H. J. Williams, and R. M. Bozorth. *Rev. Sci. Inst. 20: 947, December, 1949.*

Electric Breakdown

Pure single crystals subjected to an intense electric field under carefully controlled conditions break down at characteristic minimum field strengths (about 10^6 volts per centimeter). The breakdown takes the form of a thin conducting channel which suddenly and rapidly punctures the crystal. Although the breakdown paths lie along definite crystallographic directions, the breakdown field strengths are, surprisingly, found to be independent of the relative orientation of the applied field and the crystallographic axes.

It has been suggested by A. von Hippel that the breakdown process results when the applied field is capable of accelerating the few electrons in the conduction band to such energies that they are able to ionize the negative ions of the crystal by collision. The population of the conduction band then builds up locally in the form of an avalanche, which melts the crystal and produces a breakdown path.

The frictional drag on the electron, which determines the breakdown field strength, is exerted by the interaction of the electron with the vibrational modes of the crystal. This interaction is computed for ionic crystals by an adaptation of a method developed by H. Fröhlich. The drag is greatest for very slow electrons, which therefore determine the breakdown strength. These slow electrons interact only with vibrational modes of long wavelength, which are insensitive to direction. The fast electrons, however, interact with the direction sensitive modes having wavelengths comparable to the distance between atoms, thus producing the direction sensitivity of the observed breakdown paths. The computed breakdown field strengths are also in good agreement with experiment. H.C.

Electric Breakdown in Ion Crystals. By Herbert Callen. *Phys. Rev. 76: 1394, November 1, 1949.*

Ultrafast

Voltage impulses may be helpful, among their other uses, in studying the starting characteristics of physical phenomena which they themselves have initiated. The electric breakdown of solids and gases at atmospheric and higher pressures has been particularly challenging over the years, for instance, because the starting times involved can be so extremely short, being in some cases less than 5×10^{-10} seconds. It was necessary, in exploring the problem, to produce and measure twenty kilovolt impulses arising in times of less than 10^{-9} seconds. The techniques of working with such fast impulses posed many new problems, for these transients may have frequency components over the range from 10 to 3000 megacycles per second, which requires extremely broadband ultrahigh-frequency circuits. These impulses have thus been called ultrahigh-speed impulses.

The method used for producing these short impulses has been to arrange a spark gap containing 600 pounds per square inch of nitrogen along the center conductor of a coaxial transmission line. The use of the transmission line as a connection has the advantage that lead inductances and capacitances are made to look like a pure resistance. The impulses have been measured with the micro-oscillograph through a voltage divider. The knotty problem of a voltage divider was solved only by abandoning lumped circuits altogether and using instead two concentric coaxial transmission lines, the ratio of whose characteristic impedances gives the desired divider ratio. By these means voltage impulses have been produced and measured with rise times as small as 4×10^{-10} seconds. R.C.F.

Production and Measurement of Ultrahigh-speed Impulses. By R. C. Fletcher. *Rev. Sci. Inst. 20: 861, December, 1949.*

Conductivity at Microwave Frequencies

If a high frequency electric field is applied to an ionized gas, the resulting oscillatory motion of the free electrons will give rise to an alternating current. At very low gas pressures the inertia of the electrons causes this current to lag ninety degrees behind the electric field; as the pressure, and hence the density, is increased, frequent collisions of electrons with gas atoms will produce an energy loss which must be supplied by a component of current in phase with the field. This behavior may be described by assigning a complex conductivity to the ionized gas whose real and imaginary components correspond to the in-phase and out-of-phase current components. A knowledge of this conductivity is necessary in the analysis of ionosphere problems and in several phases of microwave work, such