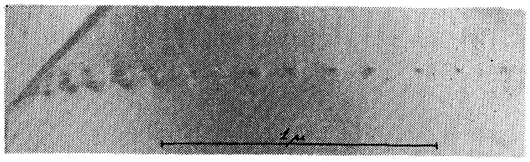

FIG. 2. Small-angle grain boundary or slip band.

60% phosphoric acid and 40% sulfuric acid; the current was 3 amp; the thickness of the specimen could be chosen from the very thin edge (thinner than 100 A) up to about 1000 A; the voltage of the electron microscope (Philips) was 100 kv.

The brightness of an electron micrograph produced by electrons which penetrated a crystal foil is determined not only by incoherent elastic and inelastic scattering and absorption but also by diffraction effects. The theory of these diffraction effects is described in detail by Heidenreich.[1] These effects are important when the Bragg condition is nearly fulfilled. Here, the intensity varies periodically with increasing thickness of the specimen and with varying angle. Through these effects an interference electron microscopy is possible showing, for example, the roughness of the surface of a transparent specimen or sliplines, etc.

Deviations of the lattice parameters inside the material, produced by internal stresses, can also be visualized as variations in brightness because these deviations locally change the diffraction situation. On the basis of this idea, it has been possible to make *dislocation lines* visible inside the material. (It has even been possible to take stereoscopic pictures of dislocation lines.) Figure 1 shows some sections of dislocation lines crossing the steel foil. Figure 2 shows either a small-angle grain boundary as discussed by Read and Shockley[3] or a slip band. It consists of a series of parallel dislocation lines which in this case are nearly perpendicular to the metal surface. (The thickness of the specimen diminishes from left to right.) The dislocation lines themselves consist—as in Fig. 1—of a row of points (visible on the left side of the picture), which seem to be related to the periodic variation of brightness with thickness.

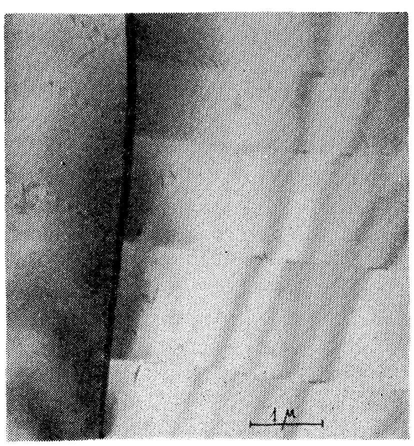

FIG. 3. Probably slip bands in a slightly rolled steel.

Around the dislocation lines a field of distortion is visible. The extension of this field, as can be seen on the picture, will depend on the diameter of the aperture diaphragm of the microscope because smaller deviations than the aperture angle contribute to brightness of the picture and are lost for contrast. Thus, by evaluation of a series of pictures taken with different diaphragm diameters, it should be possible to measure this strain field.

Figure 3 probably shows slip bands in a steel specimen which was slightly rolled before preparation. The rows of parallel dislocation lines in these bands begin at the vertical grain boundary at the left and extend into the two grains. The displacement of the interference lines at the slip bands can be due to a change of the mean lattice parameter at the band.

Applications of this kind of interference electron microscopy can be found, for example, in metallurgy for the study of plastic deformation of metals, and in semiconductors for the study of lattice distortions.

A detailed paper will follow elsewhere.

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[1] R. D. Heidenreich, J. Appl. Phys. **20**, 993 (1949).
[2] R. Castaing, Rev. mét. **52**, 669 (1955).
[3] W. T. Read, Jr., and W. Shockley, *Imperfections in Nearly Perfect Crystals* (John Wiley and Sons, Inc., New York, 1952), p. 352.

Diagrams for Processes Involving Hyperons

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THE success of the Gell-Mann model[1] in providing a scheme for a rational classification of the hyperons and their reactions has been reinforced by the experimental verification of many of its predictions.

In this theory quantum numbers are attributed to the states of the particles, which are algebraically additive and which are conserved in the "strong" and electromagnetic interactions but which may not be conserved in "weak" interaction. They are the number of particles (N), the z component of the isotopic spin (I_3), and the strangeness quantum number (S). For the antiparticle corresponding to a given particle all these quantum numbers change sign.

In a recent paper[2] d'Espagnat and Prentki, by imposing the invariance of the Lagrangian for "strong" interaction under symmetry operations in isotopic spin space, introduced a new quantum number U, the number of isoparticles, such that the charge would be given by

$$Q=I_3+\tfrac{1}{2}U. \tag{1}$$

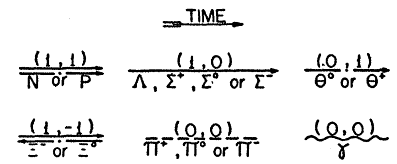

FIG. 1. Graphs for particles with the corresponding quantum numbers (N,U). For antiparticles reverse the arrows.

The following expression for S then resulted:

$$S=U-N. \tag{2}$$

It turned out that for all well-established cases[3] U has the value 0 for integral I and ± 1 for $I=\frac{1}{2}$. U also changes sign for the antiparticle corresponding to a given particle.

Here we wish to emphasize the advantage of the use of the quantum number system (N,Q,U) instead of the other systems previously used. From the relations (2) and (3) it is clear that the systems which have been used up to here: (I_3,N,S), (I_3,N,Q), (I_3,Q,S), (N,Q,S) as well as the systems (N,U,Q), (I_3,N,U), (I_3,U,S), (I_3,U,Q), (N,U,S), (Q,S,U), are all equivalent. (We do not include the total isotopic spin I because we are considering only the additive quantum numbers.) However, the simplest set is (N,U,Q) because the quantum numbers N,U,Q for one particle assume only three values 0, $+1$, or -1, in contrast to I_3 and S which have five possible values.[3] Another advantage is that Q and N are always conserved and only U may not be conserved in weak interactions.

Finally we wish to propose a generalization of Feynman diagrams which we think is very suggestive for the representation of reactions involving hyperons. This is based on the fact that the quantum numbers N,Q, and U are additive and may assume only the values $+1$, -1, or 0. Indeed it is this property which allows us to use in Feynman diagrams an arrow in the direction of time propagation for particles $(N=1)$ or in the opposite direction for antiparticles $(N=-1)$ and no arrow for bosons $(N=0)$. The conservation law for the number of particles assures us that a particle line

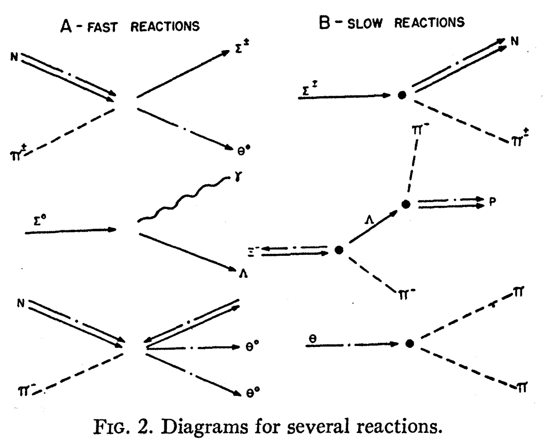

FIG. 2. Diagrams for several reactions.

can be followed from one end to the other without being interrupted or without reversal of orientation of the arrows. In the same way we can follow the charge or an isoparticle line if we use arrows in the direction of propagation for values $+1$, in the opposite direction for values -1, and no arrow for the value 0 of these constants of motion.

If we take the direction of increasing time from left to right and represent the particles $(N=1)$ by $\longrightarrow$ and the isoparticles $(U=1)$ by $-\cdot\longrightarrow$ the lines of propagation of the particles will be those indicated in Fig. 1. For the corresponding antiparticles all arrows should be reversed. An oriented line for the propagation of the charge could be added but is unnecessary.

In Fig. 2, column A, are given the diagrams for a number of well-established fast reactions for which there is no interruption of particle or isoparticle lines. In column B some "slow" reactions are represented for which there is a creation or annihilation of an isoparticle line.

We should mention, finally, that if the existence of Y^- particles[4] with $U=-2$ $(S=-3,\ N=1,\ I=0)$ should be proved,[3] the present scheme could still be used if they are represented by a particle line $(N=1)$ and *two* isoparticle lines. In this case the simplicity of the original scheme would be lost. It is possible that the values $U=\pm 2$ should be excluded for elementary particles and allowed only for compound ones.

[1] M. Gell-Mann and A. Pais, *Proceedings of the 1954 Glasgow Conference on Nuclear and Meson Physics* (Pergamon Press, London, 1955), p. 324.

[2] B. d'Espagnat and I. Prentki, Nuclear Phys. **1**, 33 (1956).

[3] Actually there is a possibility for charged particles with $U=\pm 2$, but for all well-established cases only the values 0, ± 1, appear. The authors of reference 2 give, however, an argument against the possibility $U=\pm 2$.

[4] Y. Eisenberg, Phys. Rev. **96**, 541 (1956); M. Goldhaber, Phys. Rev. **101**, 433 (1956).

First Excited States of Heavy Even-Even Nuclei

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THE systematic behavior of first excited states of even-even nuclei is well known, and indeed the pronounced maxima of the first excited state energies at the "magic numbers" are among the most striking manifestations of nuclear shell structure.[1,2] Between the closed shells, in the regions $155<A<185$ and $A>225$, rather flat minima are developed whose constancy and low energy point to the collective nature of the excitations.[3] In their review paper on alpha decay, Perlman and Asaro[4] point out that the first excited states of even-even nuclei in the transuranium region are always between 40 and 50 kev above the ground state and that