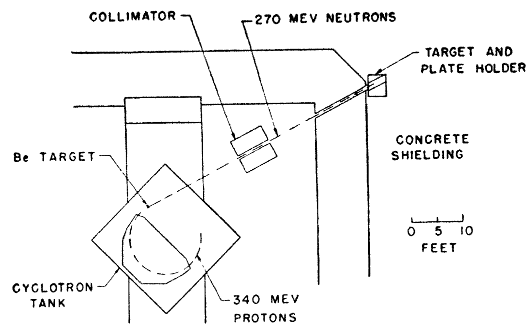

FIG. 1. General arrangement of the apparatus.

chosen to permit comparison with the results from proton beam experiments.[2] A total of 34 π-μ-decays and 307 σ- (star forming) mesons were observed to stop in the emulsions. Assuming that all π^+-mesons undergo π-μ-decay, and that 73 percent of π^--mesons produce stars, this represents a π^+/π^- ratio of $(1/12.6)\pm12$ percent. Four events classed as π-μ-decays could not be distinguished with certainty from single prong stars with a high energy prong leaving the emulsion. It is not unreasonable that this number of cases should be found in the *307* σ-events observed,[3] and therefore the true π^+/π^- ratio may be approximately 1/14. This is far different from the reciprocal of the 4.8/1 yield found when carbon was bombarded by 345-Mev protons. However, the phase space arguments which Chew[4] employed in discussing the π^+/π^- ratio from protons on carbon can be used to give qualitative agreement with the observed 1/14 ratio. His model would consider the five nucleons which are close together when a neutron enters an α-particle nucleus. If a π^- is created, the remaining particles ($3p$, $2n$) must find room in phase space and at least one proton must be energetic; if a π^+ is created, at least two neutrons of the remaining particles ($1p$, $4n$) must be energetic. The production of π^+ would therefore be inhibited. The magnitude of the effect depends on the energy available to the nucleons, and Chew's arguments would predict a ratio of the order of 1/10 to 1/20 for 50- to 60-Mev mesons.

* This work was done under the auspices of the AEC.
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[4] G. Chew and J. L. Steinberger, Phys. Rev. **78**, 497 (1950).

The Excited Nuclear State of Be^7 *

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RECENT work[1–5] has established the existence of one or more excited levels in Be^7 lying within 1 Mev of the ground state. Neutrons from the $Li^7(p, n)Be^7$ reaction should then occur in energy groups corresponding to reactions leaving Be^7 in the ground state or in an excited level.

200μ Ilford G5 emulsions and 100μ Ilford C2 emulsions were mounted 8 cm from a Li target and at 0° with the incident proton beam. The Li target had 35-kev stopping power at the threshold of the reaction. Protons of 3.49-Mev energy from the Minnesota electrostatic generator then bombarded the target for a period of several hours. Neutrons entering the emulsion produce recoil protons so the $E_p=E_n \cos^2\alpha$, where α is the angle between the direction of the incident neutron and the direction taken by the knock-on proton. In order to obtain the cleanest possible results the coordinates of the track end points were measured, and only those tracks were accepted which made an angle of 10° or less with the direction of the proton beam. Processing of the emulsion causes shrinkage by a factor of 2.5, requiring correction of the dip measurement by this amount.

The G5 plates were read at Minnesota and the C2 plates at Los Alamos. The histogram shown in Fig. 1 is a composite of the results and shows no disagreement between observers. It represents over 600 tracks, with histogram widths of 100 kev. The position of the maximum of a group was estimated by fitting a Gaussian curve to the peak and accepting the center of this curve as the corresponding energy of the neutron group. In this fashion one finds the energy of the neutrons for the reaction leaving Be^7 in the ground state to be 1.80 Mev, and those leaving Be^7 in an excited level to be 1.34 Mev. The computed energy for the neutrons leaving Be^7 in the ground state is 1.80 Mev, in coincidence

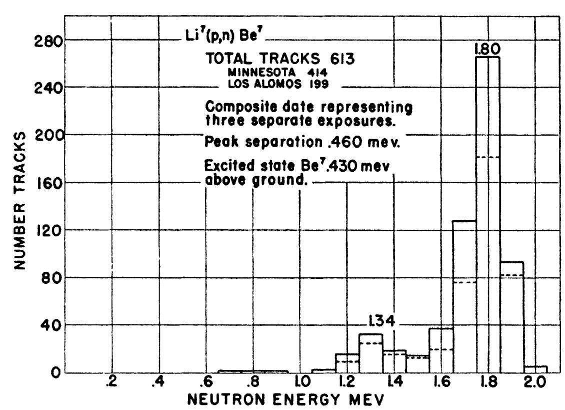

FIG. 1. Histogram showing the number of tracks as a function of the neutron energy in Mev. This histogram was made with 100-kev intervals. The height of the dotted peaks are results from measurements made at Minnesota while the remaining height of the peak shows the results from measurements made at Los Alamos.

with the observed peak, and indicates a good check with the Ilford range energy curve.[6] The best estimates of the middle of the neutron peaks were made from 50-kev width histograms of the Minnesota data

Only two neutron groups were observed with a peak separation of 460 ± 15 kev. The difference in the Q values for the reactions leading to the ground state and to the excited state of Be^7 is 428 ± 15 kev in agreement with previous experimenters.[2–5] There is no evidence for the existence of the two other states reported by Grosskreutz and Mather,[1] which would correspond to neutron energies of approximately 1.6 Mev for the Be^7 state reported 200 kev above the ground state and 1.0 Mev for an excited level 700 kev above the ground level. With the resolution obtained in this experiment one could not detect a low intensity group of neutrons corresponding to the Be^7 nucleus remaining in an excited state 200 kev above the ground state.

The only correction found to be necessary in order to compare the relative intensities of the groups was for the variation of (n, p) scattering cross section with energy; actually, measuring the coordinates of the track end points places the same requirements on any length track and so puts no emphasis on the shorter tracks. Correction for the different probability of leaving the emulsion for different length tracks was found to be negligible. Applying the correction for (n, p) cross section one finds that the ratio of Be^7 left in the excited state to that left in the ground state is 0.10 ± 0.03.

Plates were also exposed at distances of 4 cm and 18 cm to check the inverse square law from our neutron source. Background runs with no lithium on the tantalum backing were made with photographic plates, BF_3 counters, and pulse ionization chambers. They all registered an intensity of less than ½ percent of the intensity with the lithium target in place. A survey of competing processes which might produce results such as appear here was made. Available information on the mass of Be^6 eliminates the possibility of the reaction $Li^6(p, n)Be^6$ for protons of 3.5-Mev energy. The (n, p) reaction cross sections of constituents of the emulsions are all quite low compared with the (n, p) scattering cross section. When this consideration is combined with the fact that the relative abundance of hydrogen is 3.0 times that of any other constituent, the contribution of the reaction processes can be eliminated as a source of error.

* This work was supported by the joint program of the ONR and AEC.

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Multiplication Processes for Slow Moving Dislocations

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THE slip bands observed in the plastic deformation of crystals show that on a typical active slip plane there is about 1000 times more slip than would result from the passage of a single dislocation across the plane. One of us[1] has discussed a possible explanation of this in terms of the reflection and multiplication of dislocations which have acquired velocities approaching that of sound. However, there is as yet no available experimental evidence for fast dislocations and a recent theoretical estimate[2] of the energy dissipated by a moving dislocation indicates that under typical conditions the terminal velocity of a dislocation is less than 1/10 that of sound. Though neither of these arguments is conclusive, they do attach special importance to the recognition of processes whereby a dislocation can produce a large amount of slip and can multiply without first acquiring a large kinetic energy.

We shall first show by purely topological reasoning how an unlimited amount of slip could result from the motion of a single dislocation line ABC, Fig. 1. For simplicity we assume that the horizontal planes are the only active slip planes. The segment AB is therefore fixed. A small shear stress applied on the slip plane and in the slip direction will cause the line BC to sweep around like the hand of a clock producing slip of one atomic spacing per revolution.

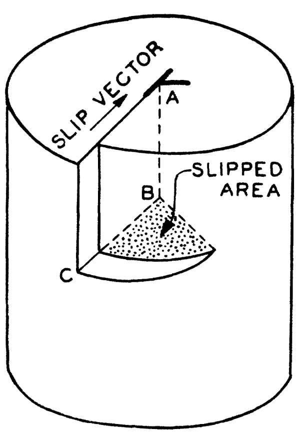

FIG. 1. Slip resulting from the motion of a single dislocation line.

Actually the line BC would not remain radial but would develop into a rotating spiral, owing to the higher angular velocity of the innermost portion. The quantitative treatment of the problem is strictly analogous to the theory of crystal growth[3] except that, when the spiral has many turns, a correction must be made for the mutual repulsion between successive turns. If slip is prevented at the boundary (as could occur in a polycrystal), the spiral would reach an equilibrium state, as is illustrated in Fig. 2 for the case of a square boundary.

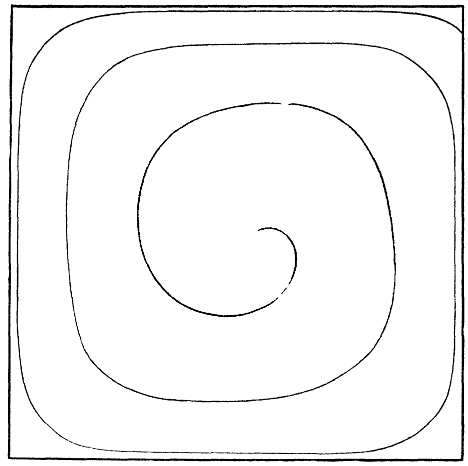

FIG. 2. Spiral form resulting from a square boundary at which slip is prevented.

Another process closely analogous to crystal growth and leading not only to continued slip but also to the generation of successive closed loops of dislocation line is illustrated in Fig. 3. The segment BC of a dislocation line lies in the active slip plane, the other parts of the line lying outside of the plane so that the points B and C are fixed. A suitable applied shear stress will cause BC to curve as shown and to generate dislocation loops at essentially the same rate as turns of the spiral were generated in the previous case. The minimum stress at which this will occur is determined by the distance BC and is approximately the rigidity modulus divided by the distance BC in lattice spacings. At a smaller stress some thermal activation will be required.

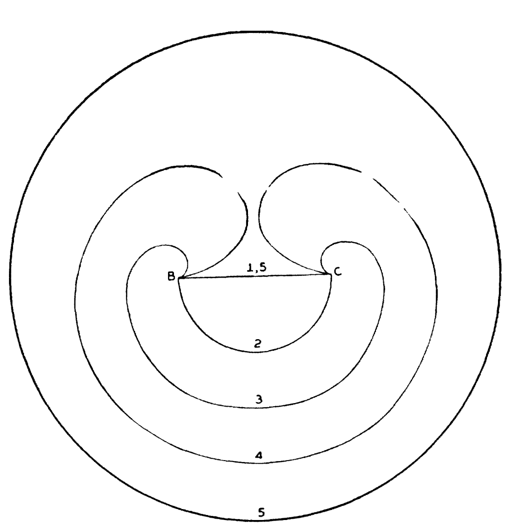

FIG. 3. Generation of successive closed loops of dislocation line.