C_2 and C_3 emulsions were used in order to facilitate the identification of the mesons. In many cases the processed emulsions showed an apparent non-uniformity in sensitivity, and since the μ-meson track is rather tenuous in the region of the terminus of the π-track, there is a chance of missing the decay. For a more intensive study of the decay scheme, a much more sensitive emulsion is required. Ilford G_5 and Eastman NTB_3 emulsions were chosen for the present study.

The apparatus used in this study consisted of a brass chamber for holding the plates and the target. The target was 0.036-inch carbon. This assembly was mounted on a probe and inserted into the vacuum chamber of the 184-inch cyclotron. The circulating beam of 345-Mev protons irradiated the target. Mesons emitted in the backward direction entered a channel cut into the brass holder. This channel was of such dimensions that π^+ mesons from the target, with energies between 6 and 8 Mev only, will enter the emulsion after a turn of 180°. No μ-mesons from decay of the π stopping in the target can get into the plate chamber. μ-mesons from decay in flight of the π-mesons could get into the emulsion only if they were emitted in a narrow cone in the forward or backward direction. These would not be confusable with π-mesons from the target as their ranges in the emulsion would be too great or too small to have the correct energy.

The plates were studied using a high power microscope. Only those mesons which stopped in the emulsion at a distance greater than 10 microns from either surface of the undeveloped emulsion were counted.

Meson scattering from the channel walls gave a background fairly uniformly distributed, with respect to range, in the emulsion.

The analysis of the results consisted of a calculation of the number of background μ-mesons expected to fall in the main distribution. This number was subtracted from the number of mesons showing no decay found in the main distribution.

A preliminary estimate of the percentage of π-mesons from the target which do not decay into μ-mesons is, $R=0.3\pm0.4$ percent. This indicates that the branching ratio of the π^+ mesons is less than 1 percent and probably zero. A more complete account of this work will be published at a later date.

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[1] Burfening, Gardner, and Lattes, Phys. Rev. 75, 382 (1949).

Neutron Capture Cross Sections and Level Density

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It is known experimentally that neutron capture cross sections as well as nuclear binding energies exhibit fluctuations from isotope to isotope, which are related to whether the neutron and proton numbers are odd, even, or magic. It is difficult to understand the relation between the fluctuations in these two quantities if one assumes that level densities depend primarily on excitation energies measured from the ground state. The fluctuations can be correlated qualitatively, however, by the hypothesis that the significant quantity in determining level densities is the excitation energy measured not from the ground state but from a characteristic level which depends in a smooth way on the number of neutrons and protons in the nucleus.[1] This would imply that those factors which make the ground state low for even-even nuclei or nuclei with a magic number of neutrons or protons do not have an appreciable influence on the level densities at excitations corresponding to that of the compound nucleus in a capture process. In terms of the supermultiplet theory, the hypothesis is equivalent to saying that the odd, even, or magic property of N and Z has a strong influence on the supermultiplets of high symmetry but has comparatively little influence on the distribution of multiplets of low symmetry which correspond to high excitation. The same situation would be expected from the shell model since nuclei with almost completed shells and high binding energy should have fewer low lying states than nuclei with partially filled shells and relatively lower binding energy. Experiments of Kinsey, at Chalk River, on capture gamma-ray spectra indicate the correctness of this picture by showing few low lying levels for magic and near magic nuclei.[2] (These experiments give information on level densities in an excitation range lower than that at which the compound nucleus is initially formed in a capture process.)

This hypothesis implies that the neutron capture cross section is determined primarily by the binding energy of the target nucleus rather than that of the final nucleus. If the target nucleus has high binding energy, the initial system of free neutron plus target nucleus will have low energy so that the compound nucleus will be formed with low energy as compared to the smoothly varying characteristic energy. The level density will therefore be small, and hence, the capture cross section will tend to be small. One would therefore conclude that the number of neutron resonances and the average capture cross section would be large for odd-odd nuclei, intermediate for odd-even and even-odd nuclei, and small for even-even nuclei.[3] Nuclei with magic numbers of either protons or neutrons should have particularly few resonances for low energy incident neutrons and hence, small capture cross sections.

If the alternative assumption were made that the level density depends primarily on excitation measured from the ground state, it would follow that the capture cross sections should be largest where the total energy released in the capture process is largest. Thus, even Z-odd N nuclei would be expected to have higher level densities and average capture cross sections than do odd Z-even N nuclei, and odd Z-even N nuclei would be expected to have roughly the same capture cross sections as do even-even nuclei. Actually, it appears that even Z-odd N nuclei do not have larger capture cross sections than do odd Z-even N nuclei, and that even Z-even N nuclei have smaller cross sections than do odd Z-even N nuclei.

Since the neutron width, Γ_n, is roughly proportional to the level spacing, the capture cross section, when averaged over a neutron spectrum which is broad compared with the level spacing, will not depend strongly on the level spacing if the neutron width is small compared with the gamma-width.[4] Therefore, the above conclusions on average capture cross sections apply particularly to incident neutron energies in the range of a few kilovolts and above, where the ratio Γ_n/Γ_γ is not small.

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[1] The characteristic energy might be given by an expression similar to the Weizsäcker semi-empirical formula for the nuclear binding energy as a function of N and Z without the odd-even term. E. Feenberg, Revs. Modern Phys. 19, 239 (1947).
[2] B. B. Kinsey, report to the Brookhaven Conference on Neutron Physics, November 1950, unpublished.
[3] These conclusions have been reached independently on the basis of experimental evidence by Harris, Muehlhause, and Thomas, Phys. Rev. 79, 11 (1950).
[4] Feshbach, Peaslee, and Weisskopf, Phys. Rev. 71, 145 (1947), Eq. (28).

An Investigation of the Existence of a Sodium Lithium Molecule*

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The vapors of the alkali metals have been examined extensively for absorption spectra. It has been established from their band absorption that these metals form diatomic molecules in both pure metals and in combinations of two dissimilar metals.