directly in a (t,p) reaction but could have admixtures of particle-quasihole states. Variation of the phases of Eq. (2) can result in a change of strength of at most a factor of 2.

It should be remarked that these values for occupancy of the various shells only approximately describe the ground-state transition. Here the spectroscopic amplitude is given by[6]

$$B(0jj) = (j+\tfrac{1}{2})^{1/2} U_j^{(122)} V_j^{(124)} (-1)^I. \quad (3)$$

V_j is the occupation of the orbital, and use of the values of U and V from Ref. 7 leaves a factor of 2 enhancement left unexplained in the cross section (although the enhancement is reduced from a factor of 14 for a pure configuration). The values from the (d,p) and (d,t) work of Ref. 2 are in better agreement, giving 1.5 enhancement. There is, in addition, a state of relative purity in ^{124}Sn, the 7^- state. The cross section for this state agrees within 20% of the calculations using the U's of Ref. 2, indicating that these are at least reasonable.

As a final note, a shell-model calculation of the separation of $f_{7/2}$ orbital from the mean radius of the Fermi surface for tin (taken here as the $d_{3/2}$ level), using the bound-state well of Takeuchi and Moldauer,[8] gives a separation of 4.9 MeV. This is excellent accordance with where the observed grouping begins. It is also possible to have further coherence in the 5^- strength at this position by considerating a mixture of the particle states as well as the quasiparticle states. Inclusion of such effects will require more detailed configuration calculations than are now available.

It thus appears that the (t,p) reaction is exciting states in the heavier tin nuclei which bridge the gap between the two major shells. The emptiness of particle orbitals in the next shell for the target nucleus will assure that the cross sections to such states will be enhanced and the additional possibility of configuration mixing which may arise from the strongly mixed initial ground state will further increase these transition amplitudes. These measurements show quite distinctly the gap which exists between the tin Fermi surface and the next shell.

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A complete description of the experimental data will shortly be forthcoming.

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CONFIGURATION MIXING IN THE CALCIUM ISOTOPES

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High-energy elastic electron scattering from Ca^{40} and Ca^{48} nuclei has been fitted by means of a nuclear charge distribution obtained from single-particle wave functions with configuration mixing generated in a nonlocal, energy-independent potential well.

For some years now it has been known that it is possible to generate nuclear charge distributions from single-particle wave functions generated in a local potential well, so as to give good fits to data from experiment on, for instance, elastic electron scattering, muonic atoms, and optical isotope shifts. However, these analyses suffered from one of two faults. Either the potential well was taken to be energy independent,[1-3] in which case the analyses failed to fit the single-particle energies as known from $(p,2p)$ scattering and also conflicted with basic fundamental theory,[4] or it was taken to be energy dependent,[5,6] in which case the resulting wave functions were

not orthogonal. When, therefore, it proved impossible to fit the very accurate experiments[7] on elastic electron scattering from $Ca^{40,48}$ at 757.5 MeV by means of single-particle wave functions in lowest configuration in either an energy-independent[7] or an energy-dependent local potential,[8] we decided to generate the single-particle wave functions in an energy-independent, nonlocal potential, in line with Hartree-Fock theory.[5]

For the potential we took the form originally used for an analysis of low-energy neutron scattering[9]

$$V(\vec{r},\vec{r}\,') = \pi^{-3/2}\beta^{-3}U(|(\vec{r}+\vec{r}\,')/2)\ \exp|-[(\vec{r}-\vec{r})/\beta]^2|,$$

where

$$U(s) = V_0 f_0(s) + V_{so}\left(\frac{\hbar}{m_\pi c}\right)^2 \frac{1}{s}\frac{df_{so}}{ds}\,\vec{l}\cdot\vec{\sigma}$$

and

$$f_{0,so}(s) = |1+\exp[(s-r_{0,so}A^{1/3})/a]|^{-1}.$$

The resulting Schrödinger equation was solved in the local energy approximation,[10] the accuracy of this approximation having been checked against an exact solution for bound states.[11] The potential was then used to fit the single-particle energies of and elastic electron scattering by individual nuclei, ranging from C^{12} to Pb^{208}, and excellent fits were obtained with parameters very close to those of Perey and Buck.[12] However, it again proved impossible to fit the data on $Ca^{40,48}$ at 757.5 MeV.

The earlier analysis[7] of the 757.5-MeV data had shown that a smooth density distribution, such as that given by the Fermi function, gave a too pronounced third diffraction minimum, while a distribution with considerable structure, such as that arising from single-particle wave functions, failed to give a third diffraction minimum at all. One way to meet this point was to superimpose an ad hoc modulation of adjustable size on the Fermi function, and agreement could indeed be obtained in this way.[7] We have found that equally good agreement can be obtained in terms of single-particle wave functions, provided some configuration mixing is introduced, which does in fact have a smoothing effect on the density distribution. Estimates regarding the amount of the effective $1f$-$2p$ admixture in the ground state of Ca^{40} arising from particle-hole interactions vary from about zero[13] to about one particle in occupation number,[14] and we have found it necessary to promote 1.5 particles from the $2s$-$1d$ shell to the $1f$-$2p$ shell, in order to obtain the fit shown in Fig. 1. The same distribution yields equally good fits at lower energies, and the ability to fit the data does not depend critically on the exact values of the energies. We also obtain agreement with experimental separation energies, see Table I, and in particular obtain a small value of only 46 MeV for the $1s$-shell energy in Ca^{40}, in agreement with recent results on the $(p,2p)$ reaction.[15] The agreement for the least bound levels is not perfect, but then it is not possible to interpret the experimental

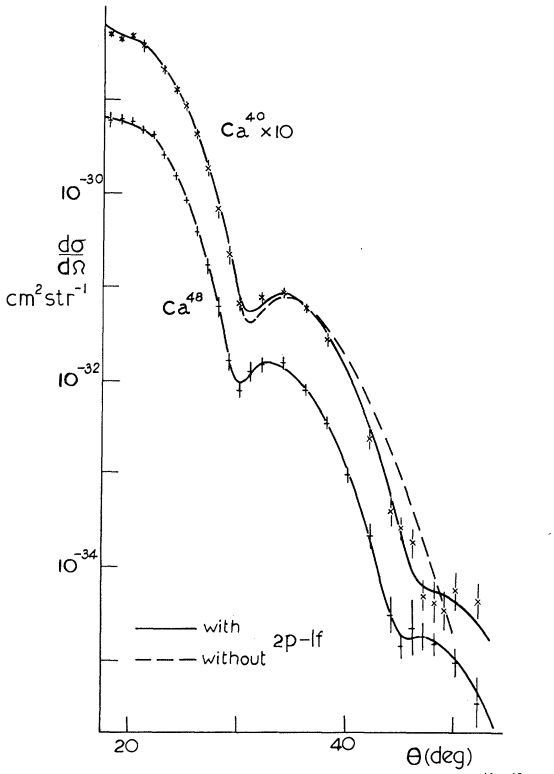

FIG. 1. Elastic electron scattering from $Ca^{40,48}$ at 757.5 MeV.

Table I. Separation energies and single-particle levels for Ca^{40} ($2p$-$1f$ admixture included).

	Experimental separation energy[a] (MeV)	Theoretical single-particle level (MeV)
$1f_{7/2}$	1.1	1.1
$1d_{3/2}$	8.3	9.5
$2s_{1/2}$	11.6	9.6
$1d_{5/2}$	15.5	17.7
$1p_{1/2}$	34	26.2
$1p_{3/2}$		33.1
$1s_{1/2}$	50	46

[a]Refs. 6 and 15.

Table II. Potential parameters and shell occupation numbers for Ca^{40} and Ca^{48} with the inclusion of $2p$-$1f$ admixture.

	Ca^{40}	Ca^{48}
V_0 (MeV)	72	78
r_0 (fm)	1.22	1.18
a (fm)	0.45	0.40
V_{so} (MeV)	10.5	10.5
r_{so} (fm)	0.8	0.8
β (fm)	0.9	0.9
Occupation numbers		
$2s$	1.7	1.7
$1d_{3/2}$	2.8	2.8
$1f_{7/2}$	0.5	0.5
$2p_{3/2}$	1.0	1.0

separation energies as exactly the single-particle energies, once particle-hole interactions are included. It should also be noted that a deeper well had to be used for the $2p$ level, which was otherwise unbound. The complete set of parameters to obtain the fit is given in Table II.

While the fit obtained in this way is unlikely to be unique, we found it impossible to obtain a better one by varying the configuration admixture within the $1f$-$2p$ shell. The resulting density distribution is labeled A in Fig. 2, and is compared with the modulated Fermi distribution, B,[7] as well as with the best lowest configuration fit at 250 MeV, C.[12] The plots of the differences of the density distribution, weighted with r^2, show that the modification required to the low-energy fit C in order to fit the high-energy data is very similar for the two distributions A and B. Although the plot of $r^2(A-B)$ shows that the two distributions are by no means identical, it gives hope that the details of the fit really give significant information on the structure of the Ca^{40} nucleus. We conclude that the 757.5-MeV data constitute evidence not only for shell structure in Ca^{40}, but also for configuration mixing. To the extent that configuration mixing has the required smoothing effect on the distribution in lowest configuration, the inclusion of even higher admixtures, perhaps from the $1g_{9/2}$ orbital, might reduce the total amount of configuration mixing needed to fit the data.

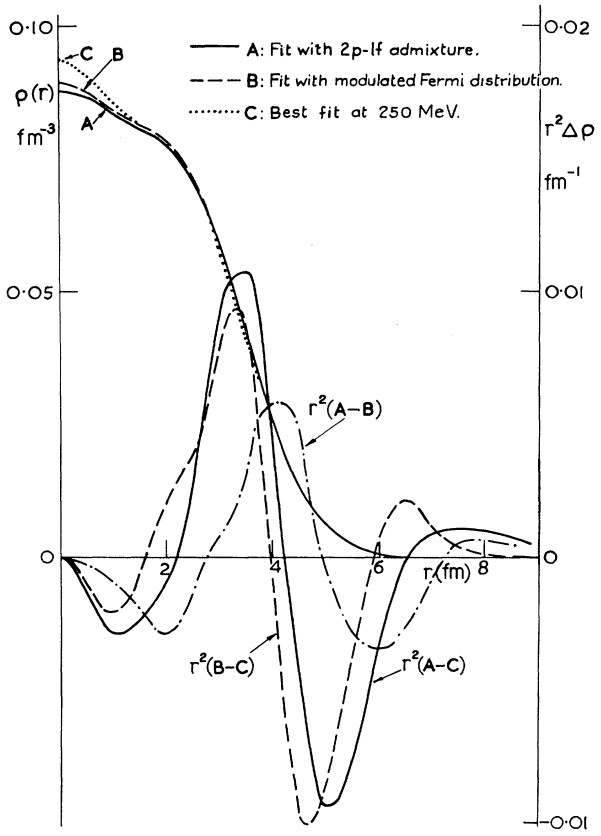

FIG. 2. Charge density distributions for Ca^{40}.

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ACCELERATION OF FISSION FRAGMENTS*

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Fission fragments produced by the isotope ^{252}Cf were accelerated to energies of ~200 MeV using a model MP Van de Graaff accelerator. The fragment-energy spectra were measured as a function of accelerator voltage. Some information was obtained on the average charges of the fragments. Estimates are given of the energies which could be attained by fragments if much higher acceleration voltages are used.

The purpose of this Letter is to present the results of experiments in which fission fragments were accelerated from an average energy of ~80 MeV up to an average energy of ~200 MeV. These experiments were undertaken to investigate a possible means of circumventing the present difficulties associated with the acceleration of heavy ions. The difficulty is that present accelerators are not able to accelerate ions of mass much greater than argon to energies sufficient to penetrate the Coulomb barrier of uranium (the value of B_C for the reaction $^{238}U + ^{140}Xe$ is about 725 MeV).

If such energetic heavy ions were available, an exciting new region of nuclear reactions would become accessible. It should then be possible, for example, to find out whether compound-nucleus products are formed, to determine the conditions for such reactions, and investigate reaction dynamics. One might even test certain predictions of the liquid-drop theories as applied to heavy-ion reactions. It should be noted that large negative Q values in the new region which is made accessible by heavier projectiles may make it possible to study new kinds of reaction products which could be formed at relatively low excitation energies.

The availability of energetic ions much heavier than argon would also present new possibilities in the search for superheavy elements. Some of these possibilities are discussed by several authors[1-4] in connection with their calculations concerning special stability associated with $Z = 114$ and $N = 184$. These calculations indicate that a major difficulty in producing observable superheavy nuclei by nuclear reactions involving presently available projectiles is that the products tend to be extremely neutron deficient. The half-lives are expected to increase by factors of 10^2 to 10^3 as the result of the addition of each neutron.

The use of fission fragments as projectiles may have certain advantages over conventional ions in attempting to solve some of the problems mentioned above. The fragments have high initial charges ($\bar{q} \sim 20$) and energies of the order of 80 MeV to begin with and they have a greater neutron richness than is available from any other projectile. Further, since the probable reactions leading to a stable superheavy-element nucleus have not been specifically isolated, the extensive range of projectile masses and energies arriving at the target might even be an advantage.

A preliminary experiment was performed at the model MP accelerator at High Voltage Engineering Corporation in Burlington, Massachusetts. A source of 6 μg of ^{252}Cf was placed at the high-voltage terminal. A schematic drawing of the setup is shown in Fig. 1. The fragments were emitted from a source of ~3 mm diam prepared by R. Latimer of the Lawrence Radiation Laboratory in Berkeley. In order to prevent contamination of the accelerator the source was covered by several protective layers: first by a coating of 200 μg/cm^2 of aluminum, then a 100-μg/cm^2 nickel foil, and finally ~3 cm downstream there was a 10-μg/cm^2 carbon foil. Both thin foils were held on a 92% transparent electromesh and lasted without breaking throughout repeated