

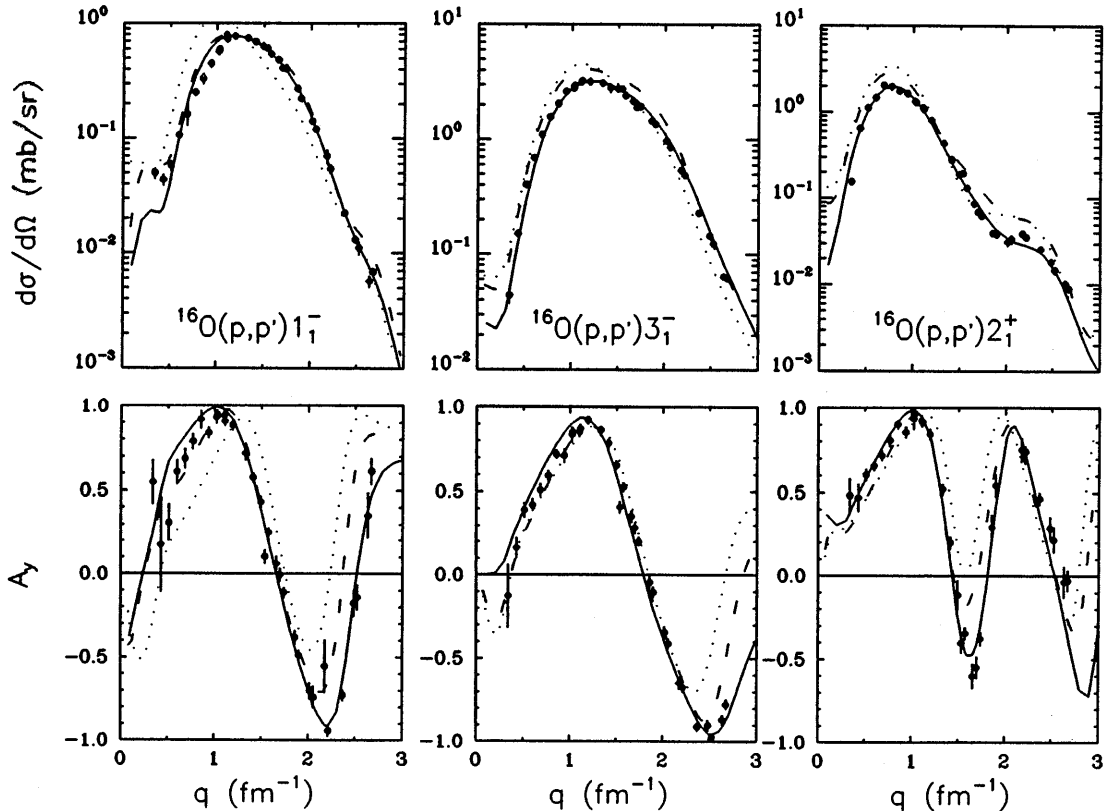
# MICROSCOPIC STRUCTURE OF THE CALCIUM ISOTOPES

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We have measured cross sections and analyzing powers for low-lying states of  $^{40,42,44,48}\text{Ca}$  excited by 100 and 200 MeV protons. In addition, data were also acquired for  $^{16}\text{O}$  at both energies. The measurements were made with the K600 spectrometer and span momentum transfers between about 0.4 and  $2.7\text{ fm}^{-1}$ . Data for the self-conjugate targets will be used to fit empirical parametrizations for medium modifications of the ef-



*Figure 1.* Preliminary  $^{16}\text{O}(p,p')$  data for  $E_p=200\text{ MeV}$ . Dotted curves show IA calculations and dashed curved show LDA calculations based upon the PH interaction. The solid curves were obtained by fitting an empirical effective interaction to inelastic scattering data for  $^{16}\text{O}$  and  $^{40}\text{Ca}$  simultaneously.

fective interaction. Data for  $^{42,44,48}\text{Ca}$  will be used to obtain neutron transition densities for comparison with structure models. Data reduction is essentially complete for  $^{16}\text{O}$  and  $^{40}\text{Ca}$  at 200 MeV and is proceeding smoothly for 100 MeV. A more complete description of the experiment may be found in Ref. 1.

A preliminary analysis of the 200 MeV effective interaction is shown in Figs. 1-4. Transition densities fitted to electron scattering data<sup>2-4</sup> were used to minimize uncertainties due to nuclear structure. The calculations and notation follow those of Ref. 5. The dotted curves are impulse approximation (IA) calculations obtained by neglecting the density dependence of the Paris-Hamburg (PH) interaction<sup>6</sup> in the scattering potentials. The dashed curves are local density approximations (LDA) calculations based upon the PH theory, including the rearrangement factor.<sup>7</sup> Both of these calculations employ LDA optical potentials. Density dependent corrections are evidently most important for states whose transition densities possess substantial interior contributions, such as the  $1_1^-$  state of  $^{16}\text{O}$  and  $3_2^-$  state of  $^{40}\text{Ca}$ , and are well described by the PH interaction. However, the PH interaction does not seem to provide strong enough modifications to the IA calculations for surface modes, such as the  $2_1^+$  and  $3_1^-$  states of both targets. Apparently, the effective interaction must also be modified at low density.

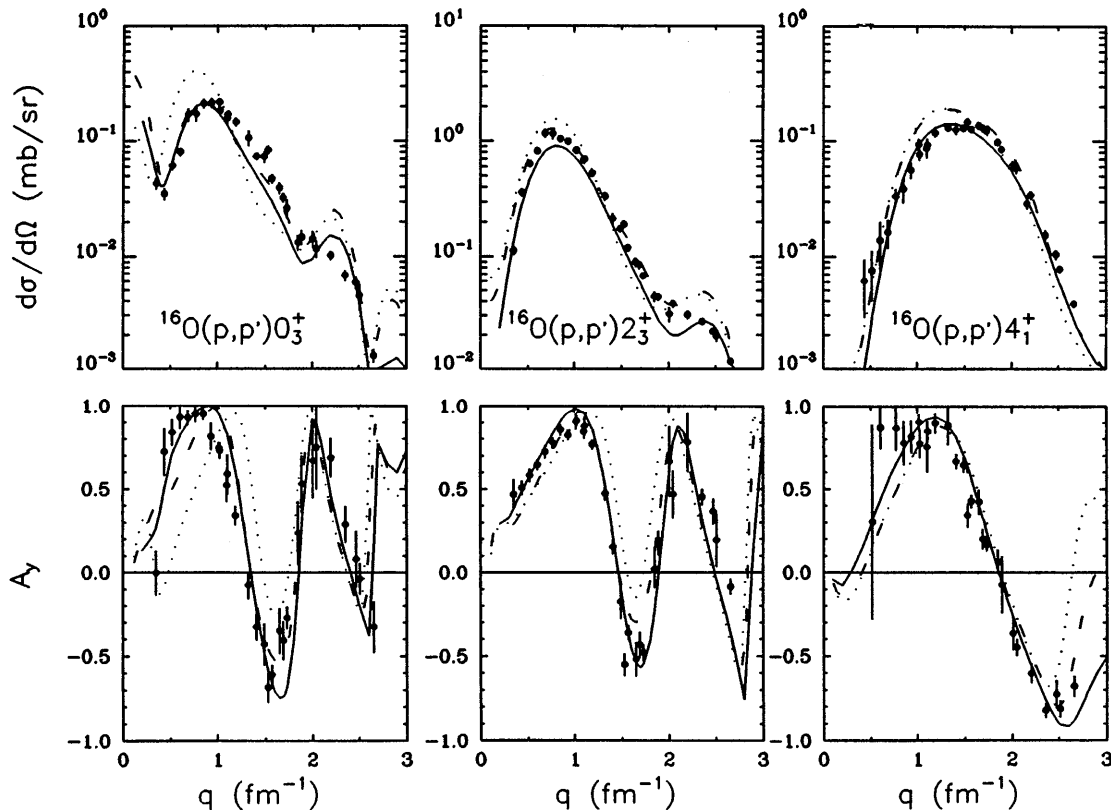


Figure 2. Preliminary  $^{16}\text{O}(p,p')$  data for  $E_p=200$  MeV. Dotted curves show IA calculations and dashed curved show LDA calculations based upon the PH interaction. The solid curves were obtained by fitting an empirical effective interaction to inelastic scattering data for  $^{16}\text{O}$  and  $^{40}\text{Ca}$  simultaneously.

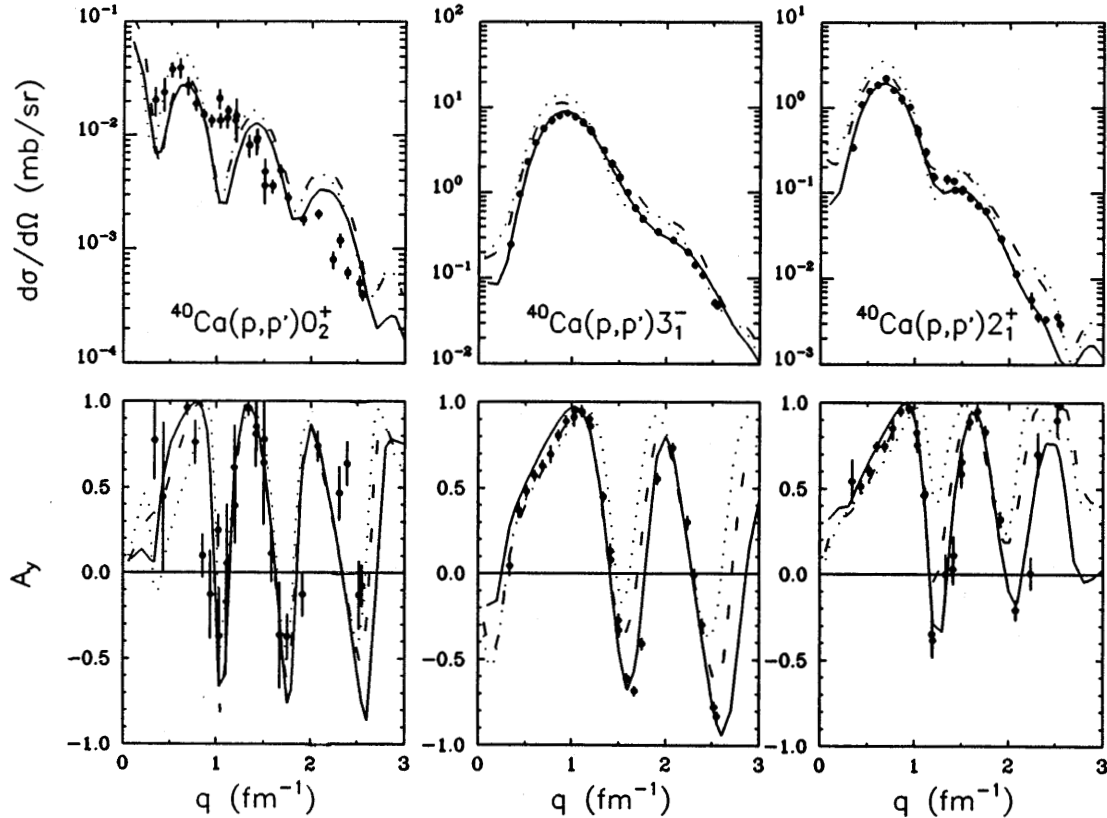
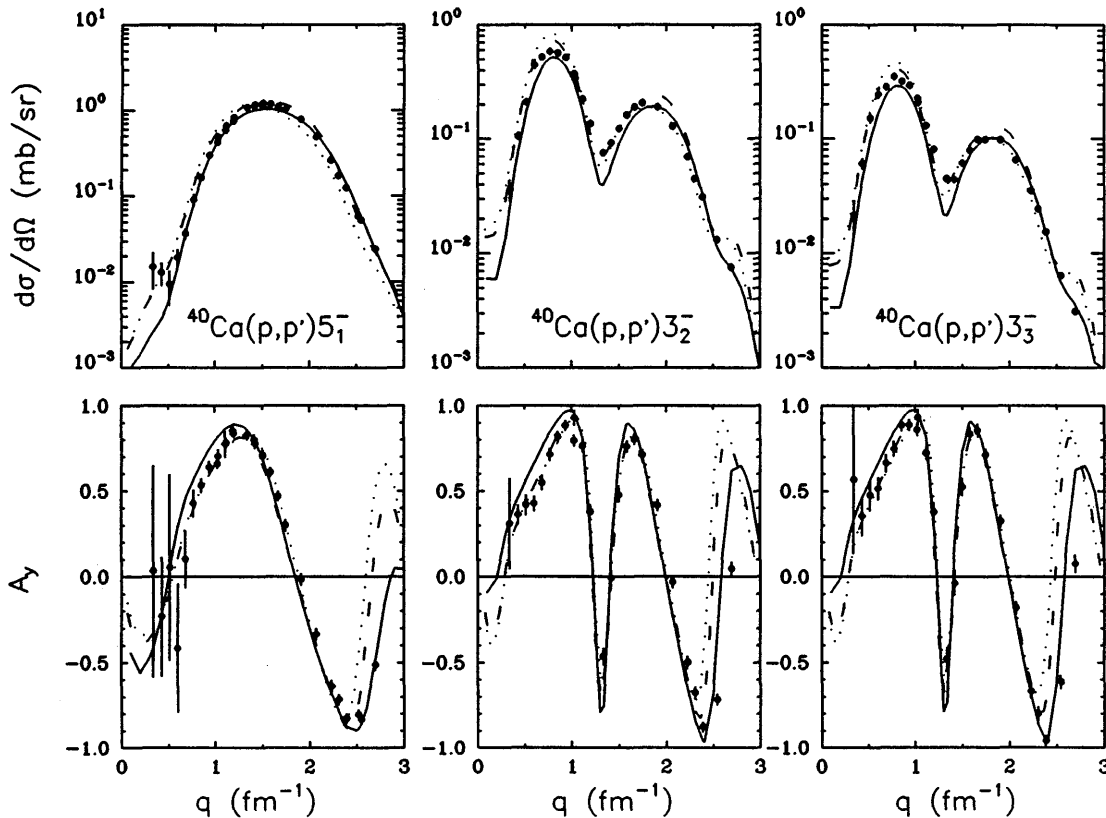


Figure 3. Preliminary  $^{40}\text{Ca}(p,p')$  data for  $E_p=200$  MeV. Dotted curves show IA calculations and dashed curved show LDA calculations based upon the PH interaction. The solid curves were obtained by fitting an empirical effective interaction to inelastic scattering data for  $^{16}\text{O}$  and  $^{40}\text{Ca}$  simultaneously.

We have fitted an empirical effective interaction to inelastic cross section and analyzing power data for 6 states of  $^{16}\text{O}$  and 6 states of  $^{40}\text{Ca}$  simultaneously, using the methods of Ref. 8. The fitted interaction was then used to produce new self-consistent distorting potentials and the fit was iterated until convergence was obtained. The quality of the final fits, shown as solid curves, is quite remarkable for a global analysis of 24 angular distributions using only 6 free parameters. Similar results are also obtained when the data for the two nuclei are fit separately.

In Fig. 5, we compare similar calculations with the elastic scattering data. Even though elastic data were not included in the fitting procedure, we nevertheless find that the effective interaction fitted to inelastic scattering data provides significant improvements to elastic scattering calculations. Thus, the rearrangement factor<sup>7</sup>  $(1 + \rho d/d\rho)$  appears to give a consistent description of the relationship between effective interactions for elastic and inelastic scattering.

Therefore, medium modifications to the effective interaction depend primarily upon the local density and appear to be independent of target or state. However, we find that

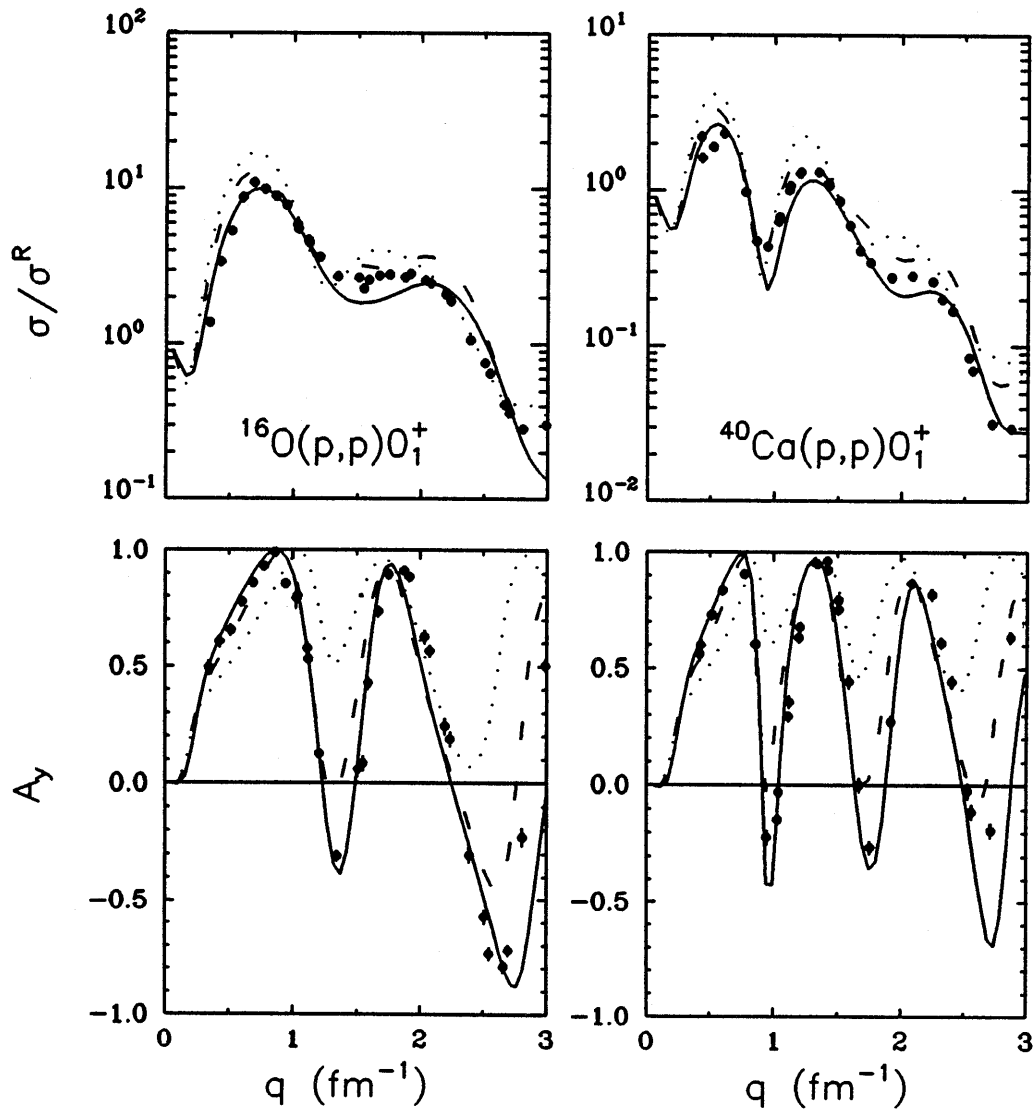


*Figure 4.* Preliminary  $^{40}\text{Ca}(p,p')$  data for  $E_p=200$  MeV. Dotted curves show IA calculations and dashed curved show LDA calculations based upon the PH interaction. The solid curves were obtained by fitting an empirical effective interaction to inelastic scattering data for  $^{16}\text{O}$  and  $^{40}\text{Ca}$  simultaneously.

the empirical effective interaction for finite nuclei differs from theoretical interactions for infinite nuclear matter in two important respects. First, the interaction is suppressed at low densities more strongly than would be expected for Pauli blocking based upon the local density. Second, the subsequent density dependence is somewhat less than predicted by the PH calculation. Evidently, nonlocal effects for finite nuclei make Pauli blocking more effective in the surface and less effective in the interior than it would be for infinite nuclear matter of corresponding density. These effects can be understood as arising from the delocalization of nucleon orbitals.

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*Figure 5.* Elastic scattering of 200 MeV protons by  $^{16}\text{O}$  and  $^{40}\text{Ca}$ . Dotted curves show IA calculations and dashed curves show LDA calculations. The solid curves use the effective interaction that was fitted to inelastic scattering data.