

EVIDENCE FOR PARTIAL OCCUPANCY OF THE  $3s_{1/2}$  PROTON ORBITAL IN  $^{208}\text{Pb}$

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Recently it has been argued that the experimentally observed quenching of nuclear multipole excitation strength in elastic and inelastic electron scattering<sup>1</sup> and the missing Gamow-Teller strength in the (p,n) reaction may be understood in terms of partial occupancy of normally occupied orbitals. For the doubly-magic nucleus  $^{208}\text{Pb}$  typical valence orbital depletions of 20-30% have been predicted.<sup>2</sup> Precise information on the occupancy of the last normally occupied proton orbital, the  $3s_{1/2}$  orbital, has not yet been obtained.

We performed a high-resolution (e,e'p) proton knockout experiment on  $^{206}\text{Pb}$  and  $^{205}\text{Tl}$  that addresses the question of the occupancy of the  $3s_{1/2}$  proton orbital in the lead region. A 410 MeV electron beam from the linear accelerator MEA of NIKHEF-K at Amsterdam was used. The coincident scattered electrons and knocked out protons were detected by two high-resolution magnetic spectrometers.<sup>3</sup> The kinematics was centered at a missing momentum  $p_m = 15$ , 80 and 160 MeV/c, respectively.

In the  $^{205}\text{Tl}(e,e'p)$  reaction three previously unknown excited states in  $^{204}\text{Hg}$  were identified at 1.64, 2.37 and 2.62 MeV (see Fig. 1). These transitions show the same  $p_m$  dependence as the ground state and are, therefore, due to a  $3s_{1/2}$  proton knockout. The ratio of the summed strengths for the  $3s_{1/2}$  proton knockout found in the individual

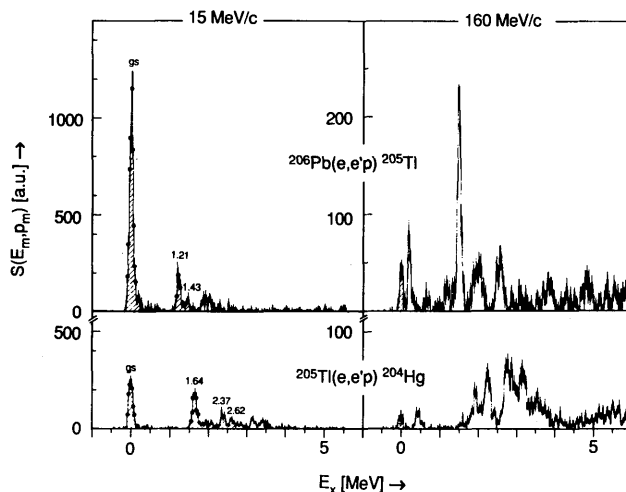


Figure 1. The experimental spectral function versus excitation energy for  $^{206}\text{Pb}$  and  $^{205}\text{Tl}$  at low and high values of the missing momentum. The states due to  $3s_{1/2}$  proton knockout are hatched.

transitions in the two isotones is  $\sum S_f(205)/\sum S_f(206) = 0.49(4)$ . Combining the precise relative spectroscopic factors for the  $3s_{1/2}$  proton removal from  $^{206}\text{Pb}$  and  $^{205}\text{Tl}$  through a sum rule with the absolute information from the charge density difference of  $^{206}\text{Pb}$  and  $^{205}\text{Tl}$  we obtain, in a largely model independent way, for the occupancy of the  $3s_{1/2}$  proton orbital in  $^{206}\text{Pb}$ :

$$z = n(206) - n(205) = n(206) - \sum S_f(205)$$

or

$$n(206) = z/[1 - \sum S_f(205)/\sum S_f(206)]$$

where  $z$  is the contribution of the  $3s_{1/2}$  proton orbital to the charge density difference between  $^{206}\text{Pb}$  and  $^{205}\text{Tl}$ . Using the value  $z = 0.7 \pm 0.1$  given in Ref. 4,

we obtain  $n(206) = 1.37(22)$  and  $n(205) = 0.67(22)$ .

With the ratio  $\sum S_f(206)/\sum S_f(208) = 0.83(7)$  for the lead isotopes  $^{206}\text{Pb}$  and  $^{208}\text{Pb}$  determined previously,<sup>5</sup> one gets  $n(208) = 1.65(30)$  for  $3s_{1/2}$  proton occupancy of  $^{208}\text{Pb}$ .

The  $3s_{1/2}$  occupation probabilities deduced from the present sum-rule analysis scale linearly with the value of  $z$ . Future changes of  $z$  will directly affect the above results. It should be mentioned that there is some ongoing criticism<sup>6,7</sup> of its value.

The results of this investigation have been submitted to Physical Review Letters for publication.

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#### PROTON KNOCKOUT FROM THE $1f_{7/2}$ ORBITAL IN $^{40}\text{Ca}$ AND $^{48}\text{Ca}$

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The extent to which proton core excitations exist in the ground states of the doubly-magic nuclei  $^{40}\text{Ca}$  and  $^{48}\text{Ca}$  has come under recent scrutiny in connection with attempts to detect signatures of non-nucleonic ( $\Delta$ -hole) degrees of freedom in the magnetic dipole<sup>1</sup> and spin-isospin<sup>2</sup> response function of complex nuclei. The most direct experimental evidence for core excitations in the ground states of  $^{40}\text{Ca}$  and  $^{48}\text{Ca}$ , in which  $1d_{3/2}$  and  $2s_{1/2}$  protons are promoted into the  $1f_{7/2} - 2p_{3/2}$  orbitals, involves an accurate determination of spectroscopic factors for picking up  $1f_{7/2} - 2p_{3/2}$  protons or stripping protons into  $1d_{3/2} - 2s_{1/2}$  holes.

In both cases, however, the transfer reactions involve "small" components of the ground-state wave functions, thus rendering the standard form factor (bound state wave function of the transferred nucleon) description in distorted-wave Born approximation (DWBA) analyses inadequate.<sup>3</sup> The use of more realistic form factors for the pickup from a nearly empty orbit reduces the extracted spectroscopic factor, whereas for stripping into nearly full orbits the opposite is true. This leads to large disagreements between the deduced number of particles and holes of the core excitation, with the hole admixtures becoming uncomfortably large.<sup>4</sup> For