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Letters to the Editor

Nuclear charge distributions of the isotopes ^{24}Mg, ^{25}Mg and ^{26}Mg from elastic electron scattering†

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Abstract. Parameters for the ground state nuclear charge distributions of the isotopes ^{24}Mg, ^{25}Mg and ^{26}Mg have been determined from elastic electron scattering in the momentum transfer range 0·20–1·15 fm^{-1}. Calculations using a Nilsson model including configuration mixing up to 7 $\hbar\omega$ show good agreement with experiment.

The Glasgow electron scattering facility described by Hogg *et al* (1972) has been used to study the ground state charge distributions of the stable magnesium isotopes (Curran *et al* 1971, contribution to *Inst. Phys. Conf. on Nuclear and Particle Physics, Oxford*, unpublished). The magnesium targets were in the form of metal foils and a graphite target was used as a reference standard. The relative target thicknesses were determined by normalization of the elastic cross section at low momentum transfer.

Table 1. Target descriptions

	Purity (%)	Thickness (mg cm^{-2})
^{24}Mg	99·96	50·7 ± 1·0†
^{25}Mg	99·21	51·7 ± 1·0†
^{26}Mg	99·70	46·8 ± 1·0†
^{12}C	—	42·0 ± 1·0

† Determined from the ^{12}C thickness by normalization of elastic cross section at low momentum transfer.

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An independent check on the relative thickness measurements made with differential pressure transducer gauges at the Metrology Division of the National Engineering Laboratory gave agreement to within 2%. The targets are described in table 1.

The ratio of elastic cross sections for each isotope to those of ^{12}C were determined from the elastic peak areas, after applying the radiative corrections of Mo and Tsai (1969). These ratios were then compared with those calculated with a Rawitscher–Fischer phase shift code, and a best fit to the data was found with the minimization code of Powell (1964). An harmonic oscillator charge distribution including corrections for the centre of mass motion and for the finite proton size was used for ^{12}C

Table 2. Charge distributions parameters† of the ^{24}Mg, ^{25}Mg and ^{26}Mg ground states

(i) Fitting relative to ^{12}C

	c	t	RMS radius R
^{24}Mg	$2{\cdot}99\pm0{\cdot}05$	$2{\cdot}33\pm0{\cdot}03$	$3{\cdot}04\pm0{\cdot}04$
^{25}Mg	$2{\cdot}71\pm0{\cdot}05$	$2{\cdot}66\pm0{\cdot}03$	$3{\cdot}08\pm0{\cdot}05$
^{26}Mg	$3{\cdot}03\pm0{\cdot}05$	$2{\cdot}28\pm0{\cdot}03$	$3{\cdot}04\pm0{\cdot}04$

(ii) Fitting relative to ^{24}Mg

	$c-c_{24}$	$t-t_{24}$	$R-R_{24}$
^{25}Mg	$-0{\cdot}30\pm0{\cdot}02$	$0{\cdot}38\pm0{\cdot}02$	$0{\cdot}04\pm0{\cdot}02$
^{25}Mg (C2, C4 subtracted)	$-0{\cdot}12\pm0{\cdot}01$	$0{\cdot}19\pm0{\cdot}01$	$0{\cdot}04\pm0{\cdot}02$
^{26}Mg	$0{\cdot}04\pm0{\cdot}01$	$-0{\cdot}04\pm0{\cdot}01$	$0{\cdot}00\pm0{\cdot}01$

† All lengths in fm.

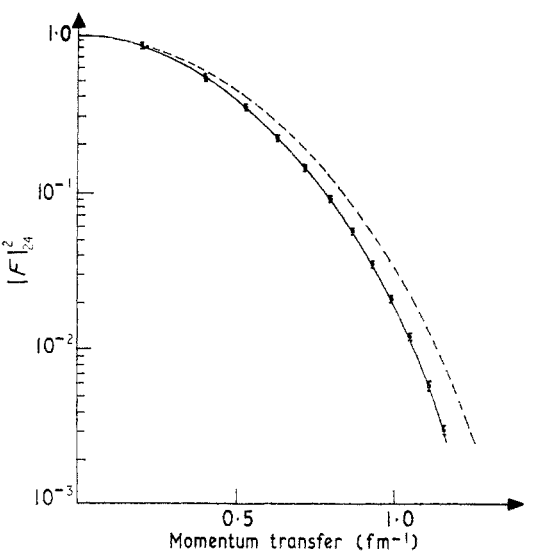

Figure 1. Elastic form factor for ^{24}Mg from best fit parameters of table 2(i). ϕ experimental points; full curve, phase shift calculation; broken curve, Born approximation.

(Bentz *et al* 1967). For the magnesium isotopes, a two-parameter Fermi distribution characterized by the half-density radius c and the skin thickness t was used (Elton 1961). The parameters giving a best fit to the data for ^{24}Mg relative to ^{12}C are shown in table 2(i) and figure 1 shows the corresponding best fit elastic form factor. The ratios of the ^{25}Mg and ^{26}Mg cross sections to those of ^{24}Mg were fitted with the phase shift code to obtain the differences between the ground state charge distributions. Figure 2

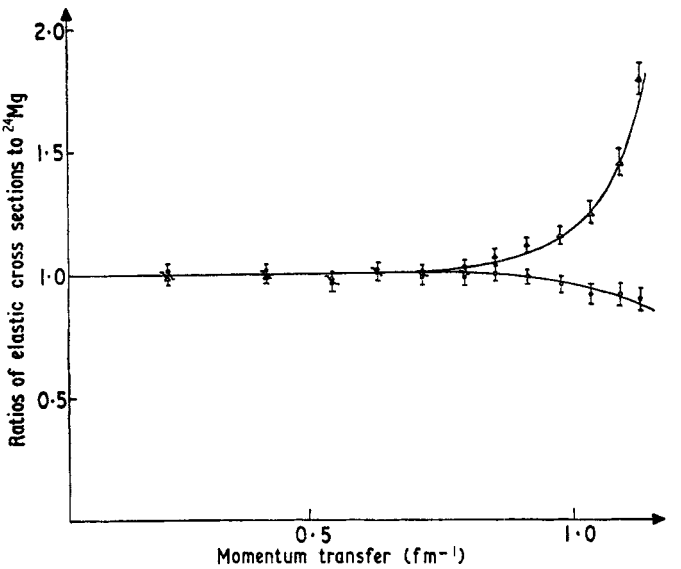

Figure 2. Ratios of the ^{25}Mg ($\frac{5}{2}^+$) and ^{26}Mg (0^+) cross sections to ^{24}Mg; full curves are best fits.

shows the ratios of experimental best fit cross sections of ^{25}Mg and ^{26}Mg relative to ^{24}Mg. The differences in charge distribution can be determined more accurately in this fashion than by a direct comparison of the best fits relative to ^{12}C. The results are shown in table 2(ii).

Since ^{25}Mg has a ground state J^π value of $\frac{5}{2}^+$ and CO, C2 and C4 multipoles will contribute to its elastic form factor, a better comparison of charge distributions can be made after the higher multipoles of ^{25}Mg have been subtracted. The M1, M3 and M5 magnetic contribution was estimated and proved to be negligible. The Born approximation form factor for ^{25}Mg was generated from the c and t parameters of table 2(i) and this was compared to the Born approximation calculations of the extended Nilsson model (Drake and Singhal 1972). The calculated C2 and C4 contributions of figure 3 were then subtracted from the experimental data. The remaining CO contribution was fitted relative to ^{24}Mg with a phase shift code to obtain the differences in c and t as listed in table 2(ii). The C2 contribution corresponds to an intrinsic ground state quadrupole moment of $61{\cdot}5e$ fm^2 for ^{25}Mg.

The ground state rotational bands of ^{25}Mg and ^{26}Mg have also been studied by inelastic electron scattering, and will be discussed in a future publication (Curran *et al* 1972).

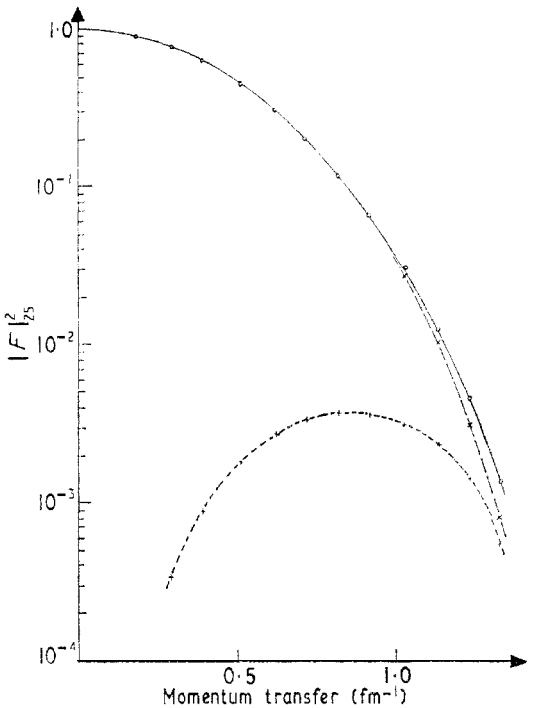

Figure 3. The full curve is the ^{25}Mg elastic form factor in the Born approximation given by the best fit parameters of table 2(i). The open circles, the broken and dashed curves show respectively, the total longitudinal elastic form factor, the CO and C2 contributions of the Nilsson model calculation for ^{25}Mg using $\eta = 4{\cdot}0$, and an oscillator parameter $b = 1{\cdot}753$ fm. Configurations up to 7 $\hbar\omega$ are included. The C4 contribution is too small to be shown here.

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