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# Magnetization Distribution of Single-Particle States and $2^+$ Rotational States from Muonic Atoms

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The lowest states in muonic atoms are rather sensitive to the spatial distribution of the nuclear magnetization density, and several results were deduced from the broadening of the muonic $2p_{1/2} - 1s_{1/2}$ and $3d_{3/2} - 2p_{1/2}$ transitions (see, for example ref. 1). By measuring low energetic transitions such as the $2s_{1/2} - 2p_{1/2}$ transition or nuclear $\gamma$-transitions, it is possible to resolve the magnetic hyperfine splittings.

The experiments have been performed at the CERN muon channel. The magnetic hf splitting of the $2s_{1/2} - 2p_{1/2}$ transition in $\mu$ $^{115}$In and of the $3/2^+ - 1/2^+$ nuclear $\gamma$-transitions in $\mu$ $^{203}$Tl at 279 keV, and in $\mu$ $^{205}$Tl at 204 keV, have been resolved. For the $2^+ - 0^+$ nuclear $\gamma$-transition in $\mu$ $^{190,192}$Os at 187 keV and 206 keV, respectively, the magnetic hf splitting of the $2^+$ rotational levels and the intensities of the hf components were determined from a nearly resolved doublet splitting. The experimental details are described elsewhere.[2-4] The results of these five isotopes are collected in Table I, together with some theoretical calculations. In the case of $^{115}$In, the shell model with configuration mixing[2] is in good agreement with the experimental data, but for $^{203,205}$Tl the same model,[5] as well as calculations with the pairing-plus-quadrupole model,[1] overestimate the very accurate experimental splittings. It should be mentioned that the optical hf anomaly of the two Tl isotopes is also in disagreement with

Table I. Experimental and theoretical magnetic hyperfine splittings of muonic atoms deduced from $\mu$ X-rays for $^{115}$In and nuclear $\gamma$-rays for the Os and Tl isotopes. The splittings of a point nucleus magnetic moment $\Delta E_{\text{point}}$, are given for comparison.

| Isotope | $I^\pi$ | $\mu$-level | $\Delta E_{\text{exp}}$ (eV) | $\Delta E_{\text{calc}}$ (eV) | $\Delta E_{\text{point}}$ (eV) | $\mu$ (nm) |
|---|---|---|---|---|---|---|
| $^{115}$In | $7/2^+$ | $1s_{1/2}$ | $3670 \pm 160$ | 3600[b] | 5580 | 5.5351 |
| | | $2p_{1/2}$ | $1050 \pm 130$[a] | 1050[b] | 1400 | |
| | | $2s_{1/2}$ | $620 \pm 130$ | 510[b] | 940 | |
| $^{203}$Tl | $1/2^+$ | $1s_{1/2}$ | $2340 \pm 80$ | 2850[b] | 4650 | 1.61169 |
| $^{205}$Tl | $1/2^+$ | $1s_{1/2}$ | $2300 \pm 20$ | 2880[b] | 4690 | 1.62754 |
| $^{190}$Os | $2^+$ | $1s_{1/2}$ | $665 \pm 80$ | 696[c] 570[d] | 1118 | $0.662 \pm 0.032$ |
| $^{192}$Os | $2^+$ | $1s_{1/2}$ | $800 \pm 80$ | 830[c] 684[d] | 1345 | $0.797 \pm 0.036$ |

a) A correction of 100 eV was applied owing to an E2 mixing of the muonic 2p levels.
b) Shell model with configuration mixing.
c) Rigid rotator.
d) Quadrupole charge at nuclear surface.

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calculations.[6] For $^{190,192}$Os, the assumption of a magnetization density produced by a charged rigid rotator agrees well with the experiment. A density produced by a quadrupole charge at the surface of the nucleus is in poor agreement.[4]

The measured hf constants of the $2^+$ states of the Os isotopes are 30–40% larger than has been assumed until now.[7] This has the consequence that muonic isomer shifts for the $2^+ - 0^+$ transitions of these nuclei have to be revised.

### References


1) J. Johnson and R. A. Sorensen: Phys. Rev. **C2** (1970) 102.
2) R. Link, H. Backe, R. Engfer, L. Fluri, R. Michaelsen, C. Petitjean, H. Schneuwly and H. K. Walter: Phys. Letters **37B** (1971) 50.
3) H. Backe, R. Engfer, U. Jahnke, E. Kankeleit, R. M. Pearce, C. Petitjean, L. Schellenberg, H. Schneuwly, W. U. Schröder, H. K. Walter and A. Zehnder: Nuclear Phys. A, to be published.
4) R. Link, L. Schellenberg, H. Backe, R. Engfer, E. Kankeleit, R. Michaelsen, H. Schneuwly, W. U. Schröder, J. L. Vuilleumier, H. K. Walter and A. Zehnder: Phys. Letters B, to be published.
5) R. Engfer and F. Scheck: Z. Phys. **216** (1968) 274.
6) H. H. Stroke, R. J. Blin-Stoyle and V. Jaccarino: Phys. Rev. **123** (1961) 1326.
7) H. Backe, R. Engfer, U. Jahnke, E. Kankeleit, K. H. Lindenberger, C. Petitjean, J. Schneuwly, W. U. Schröder, H. K. Walter and K. Wien: *Hyperfine interactions in excited nuclei,* ed. G. Goldring and R. Kalish, (Gordon and Breach, London, 1971) Vol. 2, p. 723.