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PHYSICS III COMMITTEE

REQUEST FOR ADDITIONAL SC TIME TO CONTINUE EXPERIMENT SC 2a:

Nuclear Excitation in Muonic Atoms and Study of Nuclear Volume Effects

H. Backe, R. Engfer, E. Kankeleit, H.K. Walter and K. Wien

Institut für Technische Kernphysik der Technischen Hochschule Darmstadt

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In the past year this group has persued its aim of studying nuclear volume effects by the nuclear excitation process in muonic atoms. This excitation has been observed in the isotopes of all targets of natural isotopic composition tested so far. These are Sm, Tm, Ta, W, Re, Os, Ir, Pt, Au, Tl, Bi (1,2,3). Very fortunately for this new technique the excitation probability in muonic atoms is not only large in deformed nuclei (with large B(E2)) but turned out to be substantial also in spherical nuclei more probably due to a resonance mechanism (4). Therefore it is expected that this method can be applied to a much larger number of isotopes than anticipated.

The most important success so far was the precise determination of the magnetic hyperfine interaction between a $1s_{1/2}$-muon and ^{203}Tl and ^{205}Tl nuclei (3). From a well resolved doublet appearing in the prompt γ ray spectrum an analysis with respect to the nuclear magnetization distribution can be made (4) (Bohr-Weisskopf effect). A comparison of the data with a first evaluation of a nuclear model turns out to be most promising for future studies of the magnetization distribution of other nuclei.

From these measurements it can be concluded that very fast transitions due to electron conversion occur between the hyperfine doublets (2,3). Because these transitions in excited nuclear states are faster than the nuclear γ transitions, negative energy shifts of the γ rays, particularly in 2^+-0^+ transitions, are observed. They contribute a severe correction to the isomer shift data. For a number of deformed even-even nuclei the change in charge distribution between nuclear ground and excited states could be determined (2). There seems to be some evidence now (by comparison with not sufficiently reliable Mössbauer data) that in the beginning of the region of deformed rare earth nuclei the excited state has, with respect to the ground state, an increased radius $\langle r^2 \rangle$

and a reduced skin thickness. The opposite seems to hold at the upper end of the deformed region. The analysis has been performed with a Fermi charge distribution. Nuclear polarization effects have been neglected.

Because of the correlation between isomer shift data, magnetic hyperfine splitting and excitation mechanism more precise information on these can only be obtained by a broad survey on many isotopes. This research program is directed to answer the following questions.

1) What are the excitation mechanisms in different nuclei and what is the population probability of the magnetic substates.

2) How large is the magnetic hyperfine splitting in ground and excited states.

3) How fast is the M1 interdublett transition.

4) How large is the isomer shift.

2. The experimental situation

The results obtained so far were possible only with high resolution Ge detectors and amplifiers developed at this institute. With a new calibration technique it was possible to detect isomer shifts with an accuracy of as 3.0 eV in some cases.

In the coming months we will install an on-line computer which has been granted by the German Bundesministerium für wissenschaftliche Forschung. With this installation we are able to use more than one Ge detector and larger parts of the spectra can be stored. In addition a NaJ detector will be used in coincidence with Ge detector pulses. Background should be reduced this way and information on the excitation mechanism be obtained. A good part of more refined data reduction will be done on the computer off-line.

3. Request for SC time in 1969

100 shifts are asked for the whole year 1969 which should be distributed in approximately 10 shifts/month. For the first period up to easter 30 shifts will be needed.

References

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