HFS-Measurements in the $4d^9 5p\ ^1P_1^0$- and $^3D_1^0$-States of ^{105}Pd ($I = 5/2$)

M. Baumann, M. Lauenstein, and H. Liening
Physikalisches Institut der Universität Tübingen

Z. Naturforsch. **36a**, 780–781 (1981);
received May 19, 1981

The hfs of the $4d^9 5p\ ^1P_1^0$ - and $^3D_1^0$ - states of ^{105}Pd ($I = 5/2$) has been investigated by level-crossing spectroscopy. From the measurements we get the following hfs coupling constants: $A(^3D_1^0) = -302$ (6) MHz and $A(^1P_1^0) = -220$ (6) MHz.

Naturally occuring Palladium has one odd isotope ^{105}Pd ($I = 5/2$) with an abundance of 22%. From the $J = 1$ states in the $4d^9 5p$ configuration (Fig. 1) only the hfs of the $^3P_1^0$-state has been investigated so far using level-crossing (lc) spectroscopy [1, 2]. As may be concluded from the g_J sum-rule [2], the influence of configuration interaction in the states of the $4d^9 5p$ configuration should be very small. Therefore it should be possible to treat the hfs of these states theoretically with good accuracy. In order to test such calculations, the hfs-data of the $J = 1$ states are of special interest.

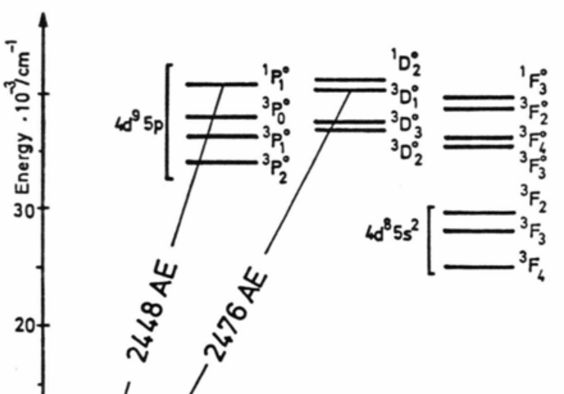

Fig. 1. Part of the level scheme of the Pd I spectrum.

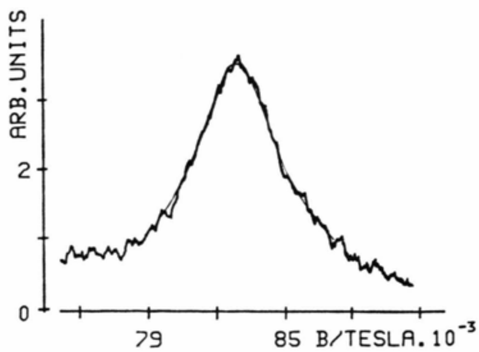

Fig. 2. $\Delta m = 2$ lc-signal of the $4d^9 5p\ ^1P_1^0$-state of ^{105}Pd. The drawn line is a calculated signal curve for $A = -302$ MHz and $B = -250$ MHz.

In addition to the zero-field level crossings a $J = 1$ state with $I > 1/2$ will yield one $\Delta m = 2$ lc-signal with $\Delta F = 1$ and $(2I - 2)$ "foldover" crossing-signals with $\Delta F = 0$ which are in most cases too wide and weak to be useful [3]. The single occuring $\Delta m = 2$ lc-signal in the $^3D_1^0$- or $^1P_1^0$-state of ^{105}Pd has been detected with an experimental arrangement similar to that described elsewhere [2]. An atomic beam of natural Pd, produced in an oven of coaxial construction, was irradiated perpendicularly to the magnetic field B with the unpolarized light of a hollow cathode lamp. The fluorescence radiation in the direction of B has been observed by means of a photomultiplier through a linear analyser and a monochromator tuned to the resonance line under investigation (Figure 1). By rotating the analyser the lc-signals have been modulated [4] for lock-in detection in combination with an averaging computer. The magnetic field was generated by a pair of Helmholtz coils. As an example the $\Delta m = 2$ lc-signal of the $4d^9 5p\ ^1P_1^0$-state is shown in Figure 2. In order to get this signal-to-noise ratio signal processing up to twelve hours had to be employed.

According to the Breit formula [5] the line shape has been calculated and fitted to the experimental curves making use of the experimental values for the mean lifetimes [6] and the g_J-factors [7, 8] by choosing a fixed value for the quadrupole coupling constant B and varying the A-factor. In principle, the position of the $\Delta m = 2$ lc-signal ($\Delta F = 1$) is mainly determined by the magnetic coupling constant A whereas the B-factor only slightly influences the line shape of the lc-signal. With regard to

Reprints requests to Dr. H. Liening, Physikalisches Institut der Universität, Morgenstelle 14, D-7400 Tübingen.

0340-4811 / 81 / 0700-0780 $ 01.00/0. — Please order a reprint rather than making your own copy.

the experimental uncertainties in both states here under study this influence is too small to give accurate values for the B-factors. Therefore their order of magnitude has been estimated using the tensor formalism first reported by Schwartz [9, 2]. One obtains nearly the same values for the B-factors in the $^3D_1{}^0$- and $^1P_1{}^0$-state to be $-(250 \pm 150)$ MHz. This value has been chosen in the fit procedure. The uncertainty due to this method is expressed in the relative large errors of the magnetic coupling constants. The results are:

$$A(^3D_1{}^0) = -220(6)\ \text{MHz},$$
$$A(^1P_1{}^0) = -302(6)\ \text{MHz}.$$

The negative signs are in accordance with a theoretical estimation [10] and with an optical measurement of the A-factors due to Steudel in the early fifties [11] who derived the following results: $A(^3D_1{}^0) = -246$ MHz and $A(^1P_1{}^0) = -331$ MHz.

We like to thank Prof. H. Krüger for his continuous support of this work.

[1] B. Budick, Phys. Rev. **168**, 89 (1968).
[2] H. Liening, Z. Physik **266**, 287 (1974).
[3] P. Thaddeus and M. N. McDermott, Phys. Rev. **132**, 1186 (1963).
[4] M. Baumann, Z. Naturforsch. **249** 1049, (1969).
[5] P. A. Franken, Phys. Rev. **121**, 508 (1961).
[6] M. Baumann and H. Liening, Phys. Lett. **36A**, 329 (1971).
[7] A. G. Shenstone, Phys. Rev. **36**, 669 (1930).
[8] C. H. Lindsley and N. Rosen, J. Opt. Soc. Amer. **31**, 531 (1941).
[9] C. Schwartz, Phys. Rev. **97**, 380 (1955).
[10] M. Lauenstein, Diplomarbeit Tübingen 1976 (unpublished).
[11] A. Steudel, Z. Physik **132**, 429 (1952).