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# THE $^{103}$Rh(d,p)$^{104}$Rh REACTION

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The $^{103}$Rh(d, p)$^{104}$Rh reaction was measured with 22 MeV deuterons up to 1.8 MeV excitation energy at laboratory angles of 20°, 30° and 50°. The best energy resolution was 3.6 keV. 91 energy levels were observed and the angular momentum transfer was determined.

## 1. *Introduction*

Amaldi et al. observed in 1935 that rhodium decays with two half–lives, 50 s and 5 min, after irradiation with slow neutrons [1]. It was later confirmed that $^{104}$Rh has an isomeric level at 128.9 keV with a half–life $T_{1/2}$ = 4.4 min and that the ground state has $T_{1/2}$ = 44 s [2-5]. Several levels of $^{104}$Rh were identified with the $(\mathrm{n}, \gamma)$ reaction in the fifties [6-9]. Improved $(\mathrm{n}, \gamma)$ techniques allowed to establish more levels [10-23]. Measurements of the $^{103}$Rh(d, p)$^{104}$Rh reaction with 7 and 15 MeV deuterons suffered due to insufficient resolution [24-25]. More recently new high resolution $(\mathrm{n}, \gamma)$ and (n, e) experiments were performed with crystal and conversion electron spectrometers [26-28]. The latest Nuclear Data Sheets on $^{104}$Rh

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were published by Blachot [30]. In order to complement these results with high resolution (d, p) data we started the present investigation which allows a better identification of the levels [29]. $^{104}$Rh is an odd-odd nucleus with a high level density.

## 2. *Measurement of the* $^{103}$Rh(d, p)$^{104}$Rh *reaction*

The measurement was performed at the Tandem Accelerator of the University of Munich and Technical University of Munich. The deuteron energy was 22 MeV. The target consisted of 50 $\mu$g/cm$^2$ Rh metal on a 3.9 $\mu$g/cm$^2$ carbon foil. The best energy resolution was 3.6 keV. The spectra were taken at laboratory angles of 20°, 30° and 50° up to 1.8 MeV excitation energy (see Figs. 1-3). The beam intensity was monitored with the elastic deuteron line and a semiconductor detector and were analyzed using standard least − squares routines. The spectra were observed at the Q3D spectrograph [31] with a new focal plane detector [32]. The energies were calibrated with new (n, $\gamma$) results [23, 28]. The experimental method and the data analysis was described in detail in Ref. 29. The results are presented in Table 1 together with the (n, $\gamma$) data. The quoted (d, p) energies are average values of all new experiments.

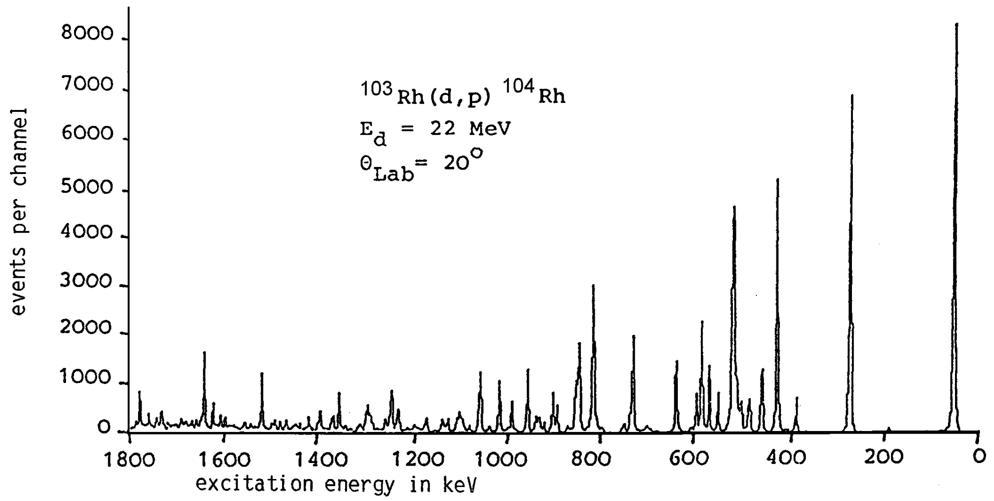


*Fig. 1. Energy spectrum of the* $^{103}$Rh(d,p)$^{104}$Rh *reaction at 20°.*

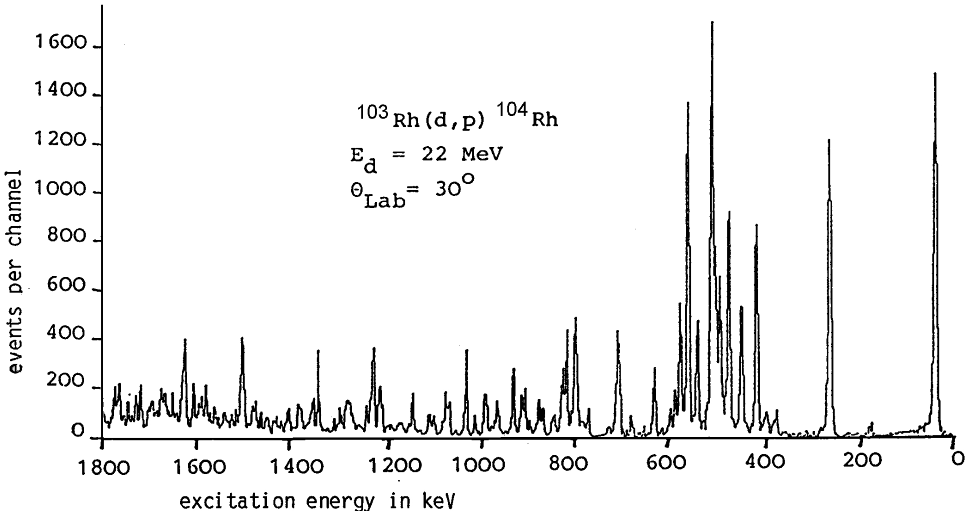


*Fig. 2. Energy spectrum of the* $^{103}$Rh(d,p)$^{104}$Rh *reaction at 30°.*

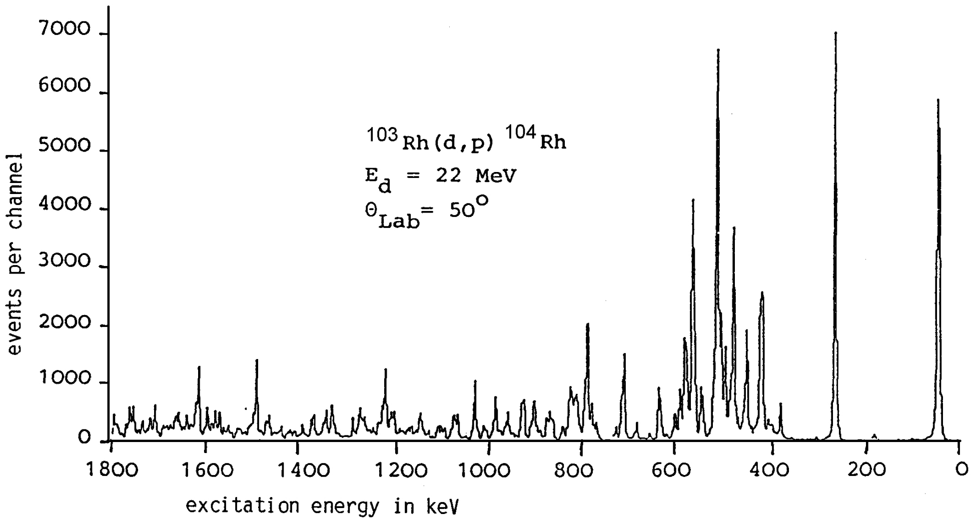


*Fig. 3. Energy spectrum of the* $^{103}$Rh(d,p)$^{104}$Rh *reaction at 50°.*

*TABLE 1.*

*Level energies and* (d, p) *intensities. Calibration lines are indicated with "→".*

| Level energies from secondary $(n, \gamma)$ radiation in keV [28] | Level energies from primary $(n, \gamma)$ radiation in keV [23] | Level energies from resonance $(n, \gamma)$ radiation in keV [21] | Level energies from (d, p) reaction in keV | Rel. intensity at 20° | Rel. intensity at 30° | Rel. intensity at 50° | Angular momentum transfer |
|---|---|---|---|---|---|---|---|
| →51.4230 (2) | 51.48 (6) | 51.3 (3) | 51.49 (12) | 100.0 (51) | 19.7 (13) | 11.37 (48) | 2 |
| 97.0999 (3) | 96.92 (9) | 97.0 (6) | | | | | |
| 128.9676 (4) | | | | | | | |
| 175.2370 (5) | | | | | | | |
| 180.8406 (4) | 181.01 (7) | 179.1 (4) | | | | | |
| →186.0428 (5) | 186.04 (10) | 185.0 (3) | 185.85 (35) | 1.1 (4) | 0.7 (1) | 0.16 (5) | 4.2 |
| 197.8932 (4) | | 197.4 (10) | | | | | |
| 213.0617 (5) | 213.09 (5) | 213.7 (1) | | | | | |
| 224.4187 (4) | | | | | | | |
| | | 231.3 (8) | | | | | |
| | | 236.7 (6) | | | | | |
| | | 245.9 (8) | | | | | |
| 266.7688 (5) | 266.90 (8) | | | | | | |
| 269.2725 (7) | | 268.0 (5) | 268.67 (11) | 75.8 (41) | 15.4 (11) | 8.97 (40) | 2 |
| | | 272.7 (10) | | | | | |
| 329.7988 (6) | | | | | | | |
| 344.5923 (1) | | 341.8 (11) | | | | | |
| 358.6335 (10) | | | | | | | |
| 363.1811 (6) | | | | | | | |
| 380.5330 (12) | | | | | | | |
| →384.9717 (7) | 384.99 (6) | 384.0 (3) | 384.94 (20) | 6.6 (8) | 1.8 (2) | 0.86 (12) | 2 |
| 394.7554 (12) | | | | | | | |
| 400.7541 (10) | | | | | | | |
| 404.5088 (7) | | | | | | | |

*TABLE 1. (Continuation)*

| Level energies from secondary $(n,\gamma)$ radiation in keV [28] | Level energies from primary $(n,\gamma)$ radiation in keV [23] | Level energies from resonance $(n,\gamma)$ radiation in keV [21] | Level energies from $(d,p)$ reaction in keV | Rel. intensity at 20° | Rel. intensity at 30° | Rel. intensity at 50° | Angular momentum transfer |
|---|---|---|---|---|---|---|---|
| | | | 406.85 (26) | 1.1 (3) | 1.9 (3) | 0.71 (12) | 5 |
| 420.7708 (11) | | 422.5 (5) | | | | | |
| →426.3643 (8) | | | 426.21 (11) | 50.4 (28) | 10.2 (8) | 6.33 (36) | 2 |
| 435.0129 (20) | | | | | | | |
| →459.635 (5) | | | 459.30 (13) | 16.9 (13) | 7.3 (6) | 3.12 (24) | 2 |
| 465.8889 (13) | | | | | | | |
| 482.3169 (21) | 482.22 (8) | | | | | | |
| | | 484.8 (3) | 486.19 (10) | 9.2 (14) | 14.7 (16) | 5.77 (52) | 5 |
| 489.0537 (12) | | | | | | | |
| 505.1895 (17) | | | 504.88 (12) | 9.1 (14) | 7.5 (11) | 1.90 (31) | 4 |
| 514.5095 (8) | 514.54 (7) | 515.3 (4) | 514.36 (12) | 17.2 (22) | 8.7 (13) | 2.61 (38) | 2 |
| →521.989 (7) | 522.25 (8) | 522.7 (3) | 522.44 (8) | 60.6 (49) | 25.8 (25) | 9.89 (72) | 2 |
| 524.6992 (15) | | | | | | | |
| 533.0684 (21) | | | | | | | |
| 537.7297 (23) | 537.73 (10) | 539.7 (3) | | | | | |
| →555.4746 (27) | | | 555.51 (10) | 7.7 (11) | 6.5 (7) | 1.35 (15) | 4 |
| | | | 575.20 (8) | 13.5 (15) | 19.7 (17) | 6.90 (42) | 5 |
| 577.260 (18) | 577.29 (5) | 579.4 (3) | | | | | |
| | | 585.8 (15) | | | | | |
| 589.720 (16) | 590.10 (10) | | | | | | |
| | | 592.4 (5) | 592.40 (9) | 22.5 (22) | 5.9 (7) | 3.08 (25) | 2 |
| 595.1626 (19) | | | | | | | |
| | | 602.2 (8) | 604.26 (14) | 7.3 (12) | 1.8 (4) | 0.89 (14) | 2 |
| | | 619.6 (7) | 615.56 (20) | 1.2 (5) | 1.3 (3) | 0.51 (10) | 4,5 |
| | | | 634.87 (29) | 0.6 (3) | 0.4 (2) | 0.22 (5) | 4 |
| 644.075 (13) | 643.92 (5) | | | | | | |
| 644.7166 (17) | | 644.9 (3) | | | | | |

*TABLE 1. (Continuation)*

| Level energies from secondary $(n,\gamma)$ radiation in keV [28] | Level energies from primary $(n,\gamma)$ radiation in keV [23] | Level energies from resonance $(n,\gamma)$ radiation in keV [21] | Level energies from (d, p) reaction in keV | Rel. intensity at 20° | Rel. intensity at 30° | Rel. intensity at 50° | Angular momentum transfer |
|---|---|---|---|---|---|---|---|
| →649.245 (13) | 649.31 (5) | | 649.54 (10) | 16.1 (20) | 3.3 (4) | 1.52 (14) | 2 |
| 695.633 (6) | 695.46 (5) | 696.9 (2) | | | | | |
| | | | 701.62 (16) | 3.0 (8) | 1.2 (2) | 0.47 (8) | 2 |
| 711.049 (9) | | 712.2 (2) | | | | | |
| | 726.02 (9) | | | | | | |
| 728.36 (3) | 728.44 (6) | | | | | | |
| →730.783 (14) | 731.20 (7) | | 730.78 (9) | 22.1 (23) | 5.6 (6) | 2.46 (20) | 2 |
| | | | 748.72 (23) | 2.6 (7) | 0.6 (2) | 0.29 (7) | 2 |
| | 784.56 (7) | | | | | | |
| 787.257 (12) | 787.22 (4) | 788.6 (2) | | | | | |
| 790.346 (27) | 790.76 (5) | | | | | | |
| | | 792.9 (3) | 793.26 (19) | 2.0 (5) | 1.7 (3) | 0.48 (10) | 4 |
| | 796.13 (10) | | | | | | |
| | 800.00 (10) | | | | | | |
| | 805.04 (5) | 806.2 (3) | 804.28 (18) | 3.6 (8) | 1.7 (4) | 0.84 (13) | 2 |
| →814.677 (6) | 814.36 (6) | 816.9 (3) | 814.63 (9) | 33.7 (28) | 9.1 (10) | 3.29 (26) | 2 |
| 818.037 (30) | 817.98 (6) | | | | | | |
| 826.682 (12) | 826.47 (4) | 827.6 (1) | | | | | |
| | 832.47 (7) | | | | | | |
| 836.601 (9) | 836.51 (6) | 853.5 (5) | 836.87 (16) | 21.8 (13) | 5.5 (7) | 1.53 (11) | 2 |
| 848.251 (6) | | | 846.84 (15) | 10.0 (8) | 3.5 (6) | 1.64 (12) | 2 |
| 860.317 (5) | 860.81 (7) | | | | | | |
| | →864.05 (6) | 865.9 (2) | 864.48 (28) | 1.1 (3) | 2.4 (3) | 0.28 (5) | 0 |
| | | | 887.05 (18) | 4.9 (6) | 2.5 (2) | 0.66 (7) | 2 |
| 888.681 (20) | 888.82 (5) | 890.2 (1) | | | | | |
| | 895.39 (7) | 898.8 (3) | 896.00 (18) | 7.2 (7) | 3.0 (3) | 0.64 (7) | 2 |
| 908.20 (3) | | 907.3 (9) | | | | | |
| 914.002 (6) | 913.29 (6) | | 913.97 (25) | 1.9 (3) | 1.1 (2) | 0.29 (4) | 4 |

*TABLE 1. (Continuation)*

| Level energies from secondary $(n,\gamma)$ radiation in keV [28] | Level energies from primary $(n,\gamma)$ radiation in keV [23] | Level energies from resonance $(n,\gamma)$ radiation in keV [21] | Level energies from (d, p) reaction in keV | Rel. intensity at 20° | Rel. intensity at 30° | Rel. intensity at 50° | Angular momentum transfer |
|---|---|---|---|---|---|---|---|
| | 915.89 (4) | 916.6 (1) | | | | | |
| 924.178 (7) | →923.74 (6) | | 924.44 (20) | 4.0 (5) | 2.9 (3) | 0.98 (10) | 4 |
| | 929.89 (7) | 932.0 (5) | 931.61 (24) | 3.1 (5) | 3.1 (3) | 0.26 (8) | 0,4 |
| | | 943.1 (8) | | | | | |
| | | | 948.94 (13) | 11.4 (8) | 5.1 (3) | 1.21 (9) | 2 |
| 952.29 (6) | 952.07 (4) | 953.4 (1) | | | | | |
| | | 973.4 (3) | | | | | |
| | | 982.4 (4) | 982.47 (12) | 7.9 (10) | 3.8 (6) | 0.82 (11) | 2 |
| | | 988.1 (6) | | | | | |
| | | | 995.27 (26) | 0.9 (2) | 0.9 (2) | 0.37 (6) | 4,5 |
| | → 1008.02 (5) | 1009.6 (2) | 1007.62 (11) | 10.7 (12) | 5.1 (7) | 1.15 (13) | 2 |
| | →1031.12 (7) | | 1030.94 (19) | 1.4 (4) | 1.8 (4) | 0.41 (9) | 4 |
| | 1032.76 (6) | 1032.8 (4) | | | | | |
| | 1047.04 (8) | | | | | | |
| | →1049.50 (5) | 1050.8 (2) | 1050.29 (10) | 15.2 (15) | 6.1 (8) | 1.45 (14) | 2 |
| | 1069.52 (6) | 1064.5 (?) | | | | | |
| | | 1072.3 (4) | 1072.82 (19) | 1.3 (3) | 0.8 (2) | 0.13 (5) | 2.4 |
| | 1081.85 (4) | | | | | | |
| | →1087.78 (7) | 1082.9 (0) | 1087.54 (12) | 3.9 (6) | 2.9 (4) | 0.63 (9) | 4 |
| | 1093.18 (6) | 1092.9 (4) | | | | | |
| | 1094.19 (6) | | 1095.18 (13) | 5.5 (7) | 2.8 (4) | 0.63 (9) | 2 |
| | 1098.33 (8) | | | | | | |
| | | | 1100.75 (25) | 2.4 (4) | 1.1 (3) | 0.27 (6) | 2 |
| | 1108.98 (10) | | | | | | |
| | 1114.89 (6) | | | | | | |
| | 1118.12 (5) | 1118.5 (2) | 1119.52 (14) | 2.8 (5) | 1.8 (3) | 0.34 (7) | 4,2 |
| | 1122.74 (10) | | | | | | |

*TABLE 1. (Continuation)*

| Level energies from secondary $(n,\gamma)$ radiation in keV [28] | Level energies from primary $(n,\gamma)$ radiation in keV [23] | Level energies from resonance $(n,\gamma)$ radiation in keV [21] | Level energies from (d, p) reaction in keV | Rel. intensity at 20° | Rel. intensity at 30° | Rel. intensity at 50° | Angular momentum transfer |
|---|---|---|---|---|---|---|---|
| | →1130.52 (6) | | 1130.05 (13) | 3.1 (5) | 2.2 (3) | 0.41 (7) | 4 |
| | 1150.33 (7) | 1151.7 (4) | 1151.67 (29) | 0.6 (3) | 0.5 (2) | 0.21 (6) | 4,5 |
| | 1161.89 (5) | 1162.9 (8) | | | | | |
| | →1167.99 (7) | | 1167.25 (12) | 4.1 (6) | 3.0 (4) | 0.78 (10) | 4 |
| | | 1179.0 (7) | | | | | |
| | 1185.81 (5) | 1187.2 (3) | | | | | |
| | | | 1191.00 (19) | 2.0 (5) | 1.4 (3) | 0.34 (8) | 4 |
| | 1193.75 (7) | 1196.0 (7) | | | | | |
| | 1200.39 (5) | 1201.6 (2) | | | | | |
| | 1202.69 (5) | | | | | | |
| | 1208.28 (7) | | | | | | |
| | | 1212.6 (10) | 1210.67 (26) | 1.2 (4) | 0.8 (3) | 0.20 (10) | 4 |
| | 1217.27 (7) | | | | | | |
| | 1231.81 (6) | 1232.8 (4) | 1230.45 (11) | 6.8 (9) | 4.8 (6) | 0.90 (13) | 4 |
| | 1239.71 (5) | 1241.7 (4) | | | | | |
| | →1244.96 (11) | | 1244.87 (10) | 14.6 (15) | 6.7 (7) | 1.52 (19) | 2 |
| | 1254.74 (7) | 1256.4 (3) | | | | | |
| | →1257.64 (6) | | 1256.99 (19) | 3.4 (7) | 1.4 (3) | 0.52 (17) | 2 |
| | | 1265.4 (3) | | | | | |
| | | | 1272.39 (26) | 1.0 (4) | 0.9 (2) | 0.16 (7) | 4 |
| | 1282.79 (6) | | | | | | |
| | | 1285.9 (5) | | | | | |
| | →1287.81 (5) | | 1287.24 (16) | 6.0 (10) | 2.4 (3) | 0.55 (6) | 2 |
| | | 1291.0 (8) | | | | | |
| | 1294.13 (6) | | 1294.77 (15) | 8.6 (7) | 3.3 (3) | 0.79 (7) | 2 |
| | 1295.83 (7) | | | | | | |
| | 1303.08 (5) | 1304.3 (4) | | | | | |
| | 1307.50 (8) | | | | | | |

*TABLE 1. (Continuation)*

| Level energies from secondary (n, $\gamma$) radiation in keV [28] | Level energies from primary (n, $\gamma$) radiation in keV [23] | Level energies from resonance (n, $\gamma$) radiation in keV [21] | Level energies from (d, p) reaction in keV | Rel. intensity at 20° | Rel. intensity at 30° | Rel. intensity at 50° | Angular momentum transfer |
|---|---|---|---|---|---|---|---|
| | →1310.20 (10) | 1310.6 (9) | 1309.27 (20) | 2.8 (4) | 2.0 (2) | 0.31 (4) | 4 |
| | 1324.16 (5) | 1325.3 (2) | 1324.77 (29) | 1.6 (3) | 1.0 (2) | 0.06 (3) | 4 |
| | 1329.86 (10) | | | | | | |
| | 1339.00 (6) | | 1337.89 (26) | 2.5 (4) | 0.7 (1) | 0.19 (4) | 2 |
| | | 1343.4 (10) | | | | | |
| | →1350.30 (9) | 1351.1 (10) | 1350.94 (14) | 9.7 (7) | 4.2 (5) | 0.99 (8) | 2 |
| | 1359.90 (6) | | | | | | |
| | →1362.95 (7) | 1365.0 (4) | 1363.44 (18) | 5.2 (5) | 2.8 (4) | 0.76 (8) | 2 |
| | 1377.65 (6) | | | | | | |
| | 1382.03 (5) | 1382.9 (2) | | | | | |
| | 1388.50 (8) | | 1389.67 (16) | 6.3 (6) | 3.0 (4) | 0.78 (7) | 2 |
| | 1393.07 (5) | | | | | | |
| | 1396.09 (5) | 1395.0 (3) | | | | | |
| | 1409.90 (5) | 1411.5 (3) | 1412.89 (17) | 3.4 (3) | 2.1 (2) | 0.41 (5) | 4,2 |
| | 1422.31 (7) | 1424.6 (6) | | | | | |
| | | | 1429.87 (28) | 1.7 (3) | 0.7 (2) | 0.22 (4) | 2 |
| | 1432.23 (8) | 1433.3 (6) | | | | | |
| | 1441.70 (6) | | 1440.30 (22) | 2.6 (3) | 1.2 (2) | 0.28 (4) | 2 |
| | 1450.99 (5) | 1452.8 (2) | | | | | |
| | | | 1458.58 (20) | 2.9 (3) | 1.3 (2) | 0.35 (5) | 2 |
| | →1471.10 (5) | 1472.4 (3) | 1471.18 (25) | 2.2 (3) | 1.1 (2) | 0.20 (4) | 2 |
| | 1476.57 (4) | 1478.4 (2) | | | | | |
| | →1482.72 (8) | | 1482.30 (23) | 2.7 (3) | 2.0 (3) | 0.55 (8) | 4 |
| | 1487.28 (6) | | 1488.63 (28) | 2.2 (3) | 1.5 (3) | 0.39 (7) | 4 |
| | 1490.37 (5) | 1491.8 (2) | | | | | |
| | 1499.71 (5) | | 1499.21 (48) | 1.1 (3) | 0.6 (1) | 0.19 (8) | 4,2 |
| | 1505.09 (6) | 1505.8 (5) | | | | | |
| | 1510.25 (9) | | 1508.86 (13) | 13.2 (9) | 8.8 (6) | 2.02 (18) | 4 |

*TABLE 1. (Continuation)*

| Level energies from secondary $(n,\gamma)$ radiation in keV [28] | Level energies from primary $(n,\gamma)$ radiation in keV [23] | Level energies from resonance $(n,\gamma)$ radiation in keV [21] | Level energies from (d, p) reaction in keV | Rel. intensity at 20° | Rel. intensity at 30° | Rel. intensity at 50° | Angular momentum transfer |
|---|---|---|---|---|---|---|---|
| | 1522.44(5) | 1523.2 (6) | 1521.74 (28) | 1.2 (2) | 1.1 92) | 0.61 (11) | 4,5 |
| | 1525.71 (5) | 1526.9 (4) | | | | | |
| | 1533.95 (5) | | 1532.05 (30) | 1.5 (3) | 1.2 (2) | 0.13 (3) | 4 |
| | 1536.45 (5) | 1536.1 (3) | | | | | |
| | 1540.42 (6) | 1542.6 (6) | | | | | |
| | 1546.35 (6) | 1546.1 (7) | 1545.63 (24) | 2.3 (4) | 2.3 (4) | 0.66 (10) | 4 |
| | | 1558.0 (7) | | | | | |
| | 1563.91 (5) | 1564.9 (3) | | | | | |
| | 1567.52 (10) | | 1568.44 (30) | 2.0 (5) | 2.3 (4) | 0.30 (6) | 0,4 |
| | 1570.42 (9) | | | | | | |
| | 1575.11 (5) | | | | | | |
| | 1577.41 (9) | 1576.5 (2) | | | | | |
| | 1581.89 (10) | | | | | | |
| | 1584.38 (5) | 1585.9 (3) | 1586.13 (21) | 3.8 (6) | 3.8 (5) | 0.65 (8) | 4 |
| | 1588.59 (6) | | | | | | |
| | 1598.30 (6) | | 1596.93 (22) | 4.2 (6) | 3.2 (4) | 0.66 (8) | 4 |
| | 1601.06 (6) | 1600.2 (6) | | | | | |
| | 1607.65 (5) | 1607.9 (7) | | | | | |
| | →1612.15 (9) | | 1612.67 (19) | 6.9 (8) | 3.6 (5) | 0.77 (8) | 2 |
| | 1615.39 (7) | | | | | | |
| | 1634.42 (6) | 1634.9 (4) | 1632.44 (14) | 18.0 (12) | 9.4 (8) | 2.09 (16) | 2 |
| | 1635.35 (6) | | | | | | |
| | 1643.43 (7) | 1644.5 (5) | | | | | |
| | 1646.15 (5) | | | | | | |
| | 1649.42 (5) | | 1649.14 (43) | 1.9 (5) | 1.0 (3) | 0.27 (8) | 2 |
| | 1652.23 (4) | 1652.9 (2) | | | | | |
| | | | 1658.39 (31) | 2.2 (4) | 2.1 (4) | 0.48 (9) | 4 |

*TABLE 1. (Continuation)*

| Level energies from secondary $(n,\gamma)$ radiation in keV [28] | Level energies from primary $(n,\gamma)$ radiation in keV [23] | Level energies from resonance $(n,\gamma)$ radiation in keV [21] | Level energies from (d, p) reaction in keV | Rel. intensity at 20° | Rel. intensity at 30° | Rel. intensity at 50° | Angular momentum transfer |
|---|---|---|---|---|---|---|---|
| | 1661.92 (6) | | | | | | |
| | 1666.08 (5) | 1665.7 (9) | | | | | |
| | 1673.58 (5) | | 1673.36 (20) | 3.1 (3) | 2.8 (4) | 0.56 (7) | 4 |
| | 1676.08 (5) | 1676.4 (4) | | | | | |
| | 1680.55 (7) | | 1682.25 (20) | 3.6 (4) | 3.1 (4) | 0.54 (6) | 4 |
| | 1687.16 (5) | 1687.9 (4) | | | | | |
| | 1692.51 (6) | | 1693.46 (28) | 1.8 (3) | 1.4 (3) | 0.33 (5) | 4 |
| | 1696.38 (7) | | | | | | |
| | 1699.88 (6) | 1701.4 (7) | 1701.83 (30) | 1.4 (3) | 2.2 (3) | 0.31 (5) | 0,4 |
| | 1704.37 (6) | | | | | | |
| | 1707.33 (9) | | | | | | |
| | 1710.84 (8) | | 1710.24 (27) | 1.8 (3) | 1.6 (3) | 0.35 (5) | 4 |
| | 1723.56 (8) | | | | | | |
| | 1728.93 (6) | | 1726.99 (17) | 6.5 (6) | 2.9 (3) | 0.88 (9) | 2 |
| | 1732.48 (4) | 1733.0 (1) | | | | | |
| | 1738.97 (7) | | 1738.11 (21) | 3.5 (4) | 2.4 (3) | 0.59 (8) | 4 |
| | 1741.24 (5) | 1742.1 (6) | | | | | |
| | 1747.50 (5) | 1748.4 (4) | 1747.08 (41) | 1.3 (3) | 1.2 (2) | 0.16 (4) | 4 |
| | 1754.98 (7) | | 1755.47 (22) | 4.3 (5) | 1.8 (3) | 0.49 (7) | 2 |
| | 1756.56 (7) | | | | | | |
| | 1760.59 (5) | 1761.7 (2) | | | | | |
| | 1766.40 (6) | | 1765.39 (34) | 1.9 (3) | 0.9 (2) | 0.19 (3) | 2 |
| | 1772.55 (6) | | | | | | |
| | 1776.43 (5) | 1776.3 (5) | 1775.38 (18) | 10.2 (8) | 3.4 (4) | 0.79 (9) | 2 |
| | 1780.55 (5) | 1781.8 (4) | | | | | |
| | 1786.36 (8) | | 1784.29 (24) | 1.8 (4) | 3.0 (3) | 0.84 (10) | 5 |

## 3. Discussion

The ratios of the (d, p) intensities at the different angles depend only on the transfered angular momentum. These ratios have been calculated with the program DWUCK4 by J. R. Comfort. The relevant ratios are given in Table 2. Since there are no $p$, $f$ or $i$ neutron orbits near the ground state of $^{104}$Rh, angular momentum transfer of 1, 3 or 6 are not expected. Using the calculated ratios of Table 2 and the measured ratios we determined the transfered angular momentum for all measured transitions using a $\chi^2$ method (last column in Table 1).

Energies of 91 levels were measured and 63 are in agreement with the values of Kennett et al. [23]. In Fig. 4 the correlation of the (d, p) intensities at 20° and primary (n, $\gamma$) intensities is plotted. No correlation of these intensities is observed indicating that direct neutron capture does not play a role in our case.

*TABLE 2.*
*Calculated intensity ratios of relevant angular momentum transfers.*

| Angular momentum transfer | $I(20°)/I(30°)$ | $I(20°)/I(50°)$ |
|---|---|---|
| 0 | 0.644 | 8.473 |
| 2 | 3.131 | 9.104 |
| 4 | 1.032 | 4.610 |
| 5 | 0.668 | 1.898 |

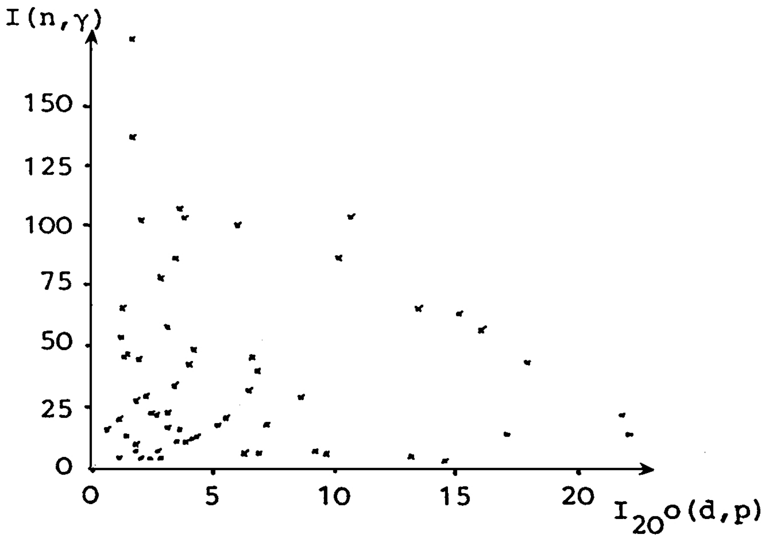


*Fig. 4. Correlation diagram of primary* (n, $\gamma$) *intensities [23] and* (d, p) *intensities at 20°.*

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## NUKLEARNA REAKCIJA $^{103}$Rh(d,p)$^{104}$Rh

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Nuklearna reakcija $^{103}$Rh(d,p)$^{104}$Rh istraživana je pomoću deuterona energije 22 MeV do energije pobuđenja od 1.8 MeV pod kutovima od 20°, 30° i 50°. Najbolje energijsko razlučivanje iznosilo je 3.6 keV. Opažena je 91 energijska razina i određen je pripadni prijenos momenta impulsa.