

LETTERS TO THE EDITOR

RECENT RESULTS ON ORBITAL CAPTURE

In 1958 Brysk and Rose<sup>1</sup> computed the theoretical L capture to K capture ratios. Most of the experimental measurements on L/K ratios have been in substantial agreement with theory. The large errors associated with these determinations did not provide a critical comparison with theory. In recent years the development of multiwire proportional counters<sup>2</sup> operated in conjunction with anti-coincidence grating circuitry together with the use of gaseous radioactive sources has made possible such a critical comparison. Precision results obtained with this technique are assembled in Table I and display a systematic deviation from the calculations of Brysk and Rose,<sup>1</sup> the experimental results being 5 to 10% larger than theoretical values. These deviations imply that some important factor is missing in the original calculation. This missing factor recently discovered by Bahcall<sup>3</sup> is the exchange term. The effect of exchange among the bound electrons that take part in the electron capture process leads to a correction of the form

$$\left( \frac{P_L}{P_K} \right) \left( \frac{\lambda_{1L}}{\lambda_K} \right) \left[ \frac{|1 - 2R_{1K}(O)/R_{2K}(O)| \langle 1S' | 2S \rangle}{|1 - 2R_{2K}(O)/R_{1K}(O)| \langle 2S' | 1S \rangle} \right]$$

where  $\lambda_{1L}/\lambda_K$  is the usual ratio as given by Brysk and Rose's theory.  $\langle 1S' | 2S \rangle$  is the overlap integral between the 1s electron in the daughter atom and a 2s electron in the parent atom and

$$\frac{R_{1L}(O)}{R_{2K}(O)}$$

the ratio of radial wave functions taken at the nuclear surface. Bahcall<sup>3</sup> has calculated the overlap integrals and the radial wave functions are given by Brysk and Rose.<sup>1</sup> In Table I are given the exchange correction. It is seen that agreement between theory (with exchange included) and experiment is excellent.

From Table I it is seen that as Z increases the discrepancy with Brysk and Rose's results is decreasing. It is not unlikely that negative deviations may occur for higher Z nuclei. It will be of great interest, therefore, to measure L/K ratio for a nucleus such as Cs<sup>131</sup> which decays by pure electron capture. Further, one may note that all reliable precision results have

TABLE I  
Comparison of L/K ratio with theory

Nuclide	Decay Energy (Kev)	Theoretical ratio due to Brysk and Rose	Exchange correction factor	Corrected theoretical ratio	Observed ratios	References
Ar <sup>37</sup>	815 ± 5	0.0820	1.22	0.100	0.102 ± 0.008	1
					0.103 ± 0.003	2
					0.102 ± 0.004	3
					0.097 ± 0.001	4
Cr <sup>51</sup>	752 ± 5	0.0885	1.17	0.1034	0.102 ± 0.0004	5
Mn <sup>54</sup>	545 ± 5	0.0899	1.16	0.1043	0.098 ± 0.006	6
Fe <sup>55</sup>	231 ± 2	0.0937	1.15	0.1078	0.106 ± 0.005	6
					0.106 ± 0.003	7
Co <sup>57</sup>	730 ± 5	0.0916	1.14	0.1044	0.099 ± 0.011	6
Co <sup>58</sup>	1500 ± 20	0.0908	1.14	0.1035	0.107 ± 0.004	6
Zn <sup>65</sup>	234,1347	0.0965	1.13	0.1090	0.119 ± 0.007	8
					(av.)	
Ge <sup>71</sup>	231 ± 3	0.1032	1.12	0.1156	0.116 ± 0.005	9
Kr <sup>79</sup>	1620, 1372	0.102	1.09	0.111	0.1191 ± 0.001	7
					(av.)	0.108 ± 0.005

Reference to Table I

1. Kiser, R. W. and Johnson, W. H., *J. Am. Chem. Soc.*, 1959, **81**, 1810.
2. Santos-Ocuampo, A. G. and Conway, D. C., *Phys. Rev.*, 1960, **130**, 2196.
3. Dougan, P. W., Ledingham, K. W. D. and Drever, R. W. P., *Phil. Mag.*, 1962, **7**, 475.
4. Manduchi, C. and Zannoni, G., *Nuovo Cimento*, 1961, **22**, 462.
5. Fasoli, V., Manduchi, C. and Zannoni, G., *Ibid.*, 1962, **23**, 1126.
6. Moler, R. B. and Fink, R. W., *Phys. Rev.*, 1963, **131**, 821.
7. Manduchi, C. and Zannoni, G., *Nucl. Phys.*, 1962, **36**, 497.
8. Santos-Ocuampo, A. G. and Conway, D. C., *Phys. Rev.*, 1962, **128**, 258.
9. Drever, R. W. P. and Moljk, A., Private Communication, see Reference 6.

come from one technique only, namely the multiwire proportional counter. It will be very helpful if alternative techniques are developed which can yield results of comparable precision. Then one can eliminate a possible systematic error in the multiwire counter technique.

On the theoretical side it may be worthwhile to re-examine Brysk and Rose's theory to see if any refinements can be made without the inclusion of the Bahcall exchange effect. It seems, however, unlikely that any refinement will yield a correction as large as the exchange term. Further one would expect that the exchange effect will be more important for M/L ratio. Unfortunately, precision measurements of

this quantity are beset with considerable experimental difficulties.

There is no doubt that further data will put the exchange effect on a sound basis.

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Karnatak University,  
Dharwar-3, October, 1, 1963.

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1. Brysk, H. and Rose, M. E., *Revs. Modern Phys.*, 1958, **30**, 1169.
  2. See the Review Article by Robinson, B. L. and Fink, R. W., *Ibid.*, 1960, **32**, 117.
  3. Bechall, J. N., *Phys. Rev. Letters*, 1962, **9**, 500.
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