# Reply to 'Comment on 'Approximate analytical solutions of the Dirac equation with the Pöschl–Teller potential including spin–orbit coupling''



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**REPLY**

# Reply to 'Comment on 'Approximate analytical solutions of the Dirac equation with the Pöschl–Teller potential including spin–orbit coupling''

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**Abstract**
We reply to the comment on our recent paper made by H Ackay (2009 *J. Phys. A: Math. Theor.* **42** 198002). We agree that the definitions of some parameters are wrong, and give some corrections to our recent paper (2008 *J. Phys. A: Math. Theor.* **41** 255302).

There are some notation errors in this recent paper (2008 *J. Phys. A: Math. Theor.* **41** 255302).

(1) In equation (2) on page 3, the matrix $\beta$ should read

$$\beta = \begin{pmatrix} I & 0 \\ 0 & -I \end{pmatrix}.$$

(2) In definitions of parameters $\beta$ and $\gamma$ given in equations (13*b*) and (13*c*) on page 4, replace (13*b*) and (13*c*) with

$$\beta = -\frac{(M - E_{n\kappa} + C)B(B-\alpha)}{4\alpha^2} + \frac{1}{4}\kappa(\kappa - 1),$$
$$\gamma = -\frac{(M - E_{n\kappa} + C)A(A+\alpha)}{4\alpha^2}.$$

(3) In definitions of parameters $\eta$ and $\delta$ given in equations (14) and (17) on page 5, replace (14) and (17) with

$$\eta = \frac{1}{4}\left(1 + \sqrt{1 - \frac{4(M - E_{n\kappa} + C)B(B-\alpha)}{\alpha^2} + 4\kappa(\kappa - 1)}\right),$$
$$\delta = \frac{1}{4}\left(1 - \sqrt{1 - \frac{4(M - E_{n\kappa} + C)A(A+\alpha)}{\alpha^2}}\right).$$

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(4) At the bottom of page 5, equation (22) should read

$$M^2 - E_{n\kappa}^2 + C(M + E_{n\kappa}) = 4\alpha^2\Bigg(-n - \frac{1}{2} + \frac{1}{4}\sqrt{1 - \frac{4(M - E_{n\kappa} + C)A(A+\alpha)}{\alpha^2}} - \frac{1}{4}\sqrt{1 + 4\kappa(\kappa-1) - \frac{4(M - E_{n\kappa} + C)B(B-\alpha)}{\alpha^2}}\Bigg)^2.$$

(5) At the top of page 6, equation (23) should read

$$M^2 - E_{n\kappa}^2 + C(M + E_{n\kappa}) = 4\alpha^2\Bigg(-n - \frac{1}{2} + \frac{1}{4}\sqrt{1 - \frac{4(M - E_{n\kappa} + C)A(A+\alpha)}{\alpha^2}} - \frac{1}{4}\sqrt{1 - \frac{4(M - E_{n\kappa} + C)B(B-\alpha)}{\alpha^2}}\Bigg)^2.$$

(6) The condition $\delta + \eta < 0$ given below equation (25) on page 6 should be replaced with $\delta + \eta + n < 0$.

(7) In the last paragraph on page 6, replace the sentences

'In order to show the procedure of determining the bound state energy eigenvalues from equation (22), we take a set of physical parameter values, $\alpha = 0.35, A = 1.50, B = 1.00, M = 5.00$, and $C = -0.35$, to give a numerical example. When $n = 1$ and $k = -1$, equation (22) yields the following values of $E_{1,-1}$: $-4.749874$, $4.534463$. We choose $E_{1,-1} = -4.749\,874$ as the solution of equation (22), and find that the values of $\eta$ and $\delta$ are $\eta = 3.859\,947$ and $\delta = -7.050\,444$, respectively. If we take $E_{1,-1} = 4.534\,463$ as the solution of equation (22), the values of $\eta$ and $\delta$ are $\eta = 1.096\,028$ and $\delta = -0.596\,650$, which do not satisfy the regularity condition, $\eta < -\delta$. Thus, we can only take the negative energy value $E_{1,-1} = -4.749\,874$ as the solution of equation (22).'with

'In order to show the procedure of determining the bound state energy eigenvalues from equation (22), we take a set of physical parameter values, $\alpha = 0.35, A = 3.00, B = 1.60, M = 1.00$, and $C = -5.00$, to give a numerical example. When $n = 1$ and $k = -1$, equation (22) yields the following values of $E_{1,-1}$: $-1.954940$, $-3.867166$. We choose $E_{1,-1} = -1.954\,940$ as the solution of equation (22), and find that the values of $\eta$ and $\delta$ are $\eta = 3.234\,909$ and $\delta = -6.231\,288$, respectively. If we take $E_{1,-1} = -3.867\,166$ as the solution of equation (22), the values of $\eta$ and $\delta$ are $\eta = 1.301\,037$ and $\delta = -1.419\,417$, which do not satisfy the regularity condition, $\delta + \eta + n < 0$. Thus, we can only take the negative energy value $E_{1,-1} = -1.954\,940$ as the solution of equation (22).'

(8) At the top of page 7, table 1 must be replaced with

**Table 1.** The bound state energy eigenvalues $E_{n\kappa}$ of the pseudospin symmetry Pöschl–Teller potential for several values of $n$ and $k$.

| $\tilde{l}$ | $n, \kappa < 0$ | $(l, j)$ | $E_{n,\kappa<0}$ | $n-1, \kappa > 0$ | $(l+2, j+1)$ | $E_{n-1,\kappa>0}$ |
|---|---|---|---|---|---|---|
| 1 | 1,−1 | $1s_{1/2}$ | −1.954940 | 0,2 | $0d_{3/2}$ | −1.954940 |
| 2 | 1,−2 | $1p_{3/2}$ | −1.849226 | 0,3 | $0f_{5/2}$ | −1.849226 |
| 3 | 1,−3 | $1d_{5/2}$ | −1.717583 | 0,4 | $0g_{7/2}$ | −1.717583 |
| 4 | 1,−4 | $1f_{7/2}$ | −1.576032 | 0,5 | $0h_{9/2}$ | −1.576032 |
| 1 | 2,−1 | $2s_{1/2}$ | −1.403027 | 1,2 | $1d_{3/2}$ | −1.403027 |
| 2 | 2,−2 | $2p_{3/2}$ | −1.343060 | 1,3 | $1f_{5/2}$ | −1.343060 |
| 3 | 2,−3 | $2d_{5/2}$ | −1.267058 | 1,4 | $1g_{7/2}$ | −1.267058 |
| 4 | 2,−4 | $2f_{7/2}$ | −1.185920 | 1,5 | $1h_{9/2}$ | −1.185920 |

(9) In equation (27) on page 7, equation (27) should read

$$\lim_{\alpha \to 0} E_{n\kappa} = -(A - B)^2 - M$$

## Acknowledgment

Dr Akcay has correctly pointed out that some notations are wrong. We would like to thank Dr Akcay for his helpful comments.