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COMMENT

Exact solution of the Dirac equation with linear scalar potential

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Abstract. We point out that the Dirac equation is exactly solvable to give *confining* bound states with the scalar-like potential $V(z) = -Az$, $A > 0$.

In a recent paper Su and Zhang (1984) give an exact solution of the Dirac equation with the scalar-like potential $V(z) = Az$, $A > 0$. They find that for $p_1 = p_2 = 0$ the bound states are confining with energy eigenvalues ($c = \hbar = 1$)

$$E_n = \pm[2(n+1)A]^{1/2} \tag{1}$$

and spatial eigenfunctions

$$\psi_1 = C_1 \begin{pmatrix} H_{n+1}(\xi) + \frac{E}{\sqrt{A}} H_n(\xi) \\ 0 \\ \mathrm{i}H_{n+1}(\xi) - \frac{\mathrm{i}E}{\sqrt{A}} H_n(\xi) \\ 0 \end{pmatrix} \exp(-\tfrac{1}{2}\xi^2) \tag{2a}$$

$$\psi_2 = C_2 \begin{pmatrix} 0 \\ H_{n+1}(\xi) + \frac{E}{\sqrt{A}} H_n(\xi) \\ 0 \\ -\mathrm{i}H_{n+1}(\xi) + \mathrm{i}\frac{E}{\sqrt{A}} H_n(\xi) \end{pmatrix} \exp(-\tfrac{1}{2}\xi^2) \tag{2b}$$

where

$$\xi = \sqrt{A}(m/A + z) \tag{3}$$

m being the mass of the Dirac particle (say, a quark). The eigenvalues (1) are independent of m.

The purpose of the present comment is to point out that the scalar-like potential $V(z) = -Az$, $A > 0$ when used in the Dirac equation gives exactly the same confining bound states given by equation (1), with exactly the same form eigenfunctions as in (2) except that now

$$\xi = \sqrt{A}(m/A - z). \tag{4}$$

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This can be readily seen by starting with the Dirac equation

$$[\gamma^{\mu}\partial/\partial x^{\mu}+(m-Az)]\psi(\boldsymbol{r},t)=0 \qquad (5)$$

and then following the steps of Su and Zhang. We forgo the steps here in order to avoid being repetitious. However we should mention that the above result cannot be obtained by simply replacing A by $-A$ in their paper; the substitution (4) is required as opposed to (3).

We thank Bruce McKeller for bringing the paper by Su and Zhang to our attention, and Wesley Williams for a fruitful discussion.

Reference

Su R K and Zhang Y 1984 *J. Phys. A: Math. Gen.* **17** 851