IS $\chi(3505)$ A VECTOR BOSON?

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Although direct experimental information on the J^P values for the $\chi(3415)$, $\chi(3505)$, $\chi(3550)$ is still not available, their values have been recently suggested by the SLAC-LBL group to be 0^+, 1^+, 2^+ respectively for $\chi(3415)$, $\chi(3505)$, $\chi(3550)$. It is suggested in this note that the $\chi(3505)$ is not a vector boson.

Recently, the SLAT-LBL group has suggested [1] the J^P values for the $\chi(3415)$, $\chi(3505)$, $\chi(3550)$ to be 0^+, 1^+, 2^+ respectively. It may be mentioned here that the direct experimental spin-parity assignments are not yet available for the particles concerned. The purpose of this note is to show that $J^P = 1^+$ suggested for the $\chi(3505)$ is not justified. For our purpose we proceed as follows. We note that the G-parity, C-parity and the actual spin J of a boson invariably satisfy the following relation (*not* valid for diffractive mesons like A_1 and bumps)

$$G(-1)^J = \pm C; \ +\text{sign for even } G \text{ and } -\text{sign for odd } G. \tag{1}$$

Since the actual parity $P = (-1)^J$ for a normal boson and $P = -(-1)^J$ for an abnormal boson, Eq. (1) takes the following forms for normal and abnormal bosons, respectively:

$$GP = \pm C; \ +\text{sign for even } G \text{ and} - \text{sign for odd } G \text{ (normal boson)}, \tag{2a}$$

$$GP = \pm C; \ -\text{sign for even } G \text{ and } +\text{sign for odd } G \text{ (abnormal boson)}. \tag{2b}$$

With the help of a particle data table [2] the validity of Eqs. (1), (2a) and (2b) can be checked. In fact, the relation $G(-1)^J = C$ is found to be true for the G-even bosons $\eta(540, G = +, C = +, J = 0)$, $\varrho(770, G = +, C = -, J = 1)$, $\eta'(958, G = +, C = +, J = 0)$, $S^*(993, G = +, C = +, J = 0)$, $\varepsilon(1200, G = +, C = +, J = 0)$, $B(1235, G = +, C = -, J = 1)$, $f(1270, G = +, C = +, J = 2)$, $\varrho'(1600, G = +, C = -, J = 1)$, $g(1680, G = +, C = -, J = 3)$, $h(2040, G = +, C = +, J = 4)$. Also, the relation $G(-1)^J = -C$ is found to hold true for the G-odd bosons $\pi(140, G = -, C = +, J = 0)$, $\omega(784, G = -, C = -, J = 1)$, $\phi(1020, G = -, C = -, J = 1)$, $A_2(1310, G = -, C = +, J = 2)$, $\psi(3095, G = -, C = -, J = 1)$, $\psi'(3684, G = -, C = -,$

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$J = 1$). Obviously, then Eq. (1) is found to be perfectly valid for the particles for which the values of G, C and J are well established. Needless to mention that the validity of Eq. (1) guarantees the same for Eqs (2a) and (2b). However, the validity of Eqs. (2a) and (2b) can be directly checked for the particles for which the values of G, P and C are well established. In fact, Eqs. (2a) and (2b) are found to be true without a single exception for the nonstrange bosons which are not diffractive mesons or bumps.

It is well known [1, 3] that the χ states are observed in the radiative transitions $\psi'(3684) \to \chi\gamma$. This fact clearly suggests that the χ states must have even C. Further, the χ states are found to decay into even number of pions [1, 3] and they must have even G. This is further supported by the decays $\psi'(3684) \to \chi\gamma$ since $\psi'(3684)$ and γ have odd G. We have already noted that for even-G bosons Eq. (1) takes the form $G(-1)^J = C$ which is satisfied for the $\chi(3415, G = +, C = +, J = 0)$ and also the $\chi(3550, G = +, C = +, J = 2)$, $J = 0$ and $J = 2$ being the suggested values of the spins of the $\chi(3415)$ and $\chi(3550)$ respectively. Obviously, the relation $G(-1)^J = C$, valid for an even-G boson, is not satisfied for the $\chi(3505, G = +, C = +, J = 1)$, $J = 1$ being the suggested [1] value for the spin of the particle concerned. The value $J = 1$ is clearly inadmissible for the $\chi(3505)$. This is so because the $\chi(3505)$ is neither a diffractive meson nor a bump. As the relation $G(-1)^J = C$ is satisfied for all the even-G bosons so far observed, there is no reason why it should not be valid for the $\chi(3505)$ which is also an even-G boson. The relation concerned, we have noted above, is satisfied by both the $\chi(3415)$ and $\chi(3550)$. We emphasize that for pure resonances Eq. (1) is found to be true without a single exception. We can conclude, therefore, that the $\chi(3505)$ cannot be a spin-one boson.

It may be recalled that the $\pi^+\pi^-$ and K^+K^- modes have been seen [1, 3] in the decays of both the $\chi(3415)$ and $\chi(3550)$. Obviously, then, both these particles are normal bosons. We may note that Eq. (2a), valid for normal bosons, takes the form $GP = C$ for even-G bosons. The relation concerned is satisfied both for the $\chi(3415, G = +, C = +, P = +)$ and $\chi(3550, G = +, C = +, P = +)$, $P = +$ being the suggested values for the particles concerned. It may be noted that $\pi^+\pi^-$ and K^+K^- modes have not been observed [1, 3] in the decays of the $\chi(3505)$ which is, therefore, an abnormal boson. It is evident that Eq. (2b), valid for abnormal bosons, takes the form $GP = -C$ for even-G bosons. Obviously, the relation $GP = -C$ is not satisfied for the $\chi(3505)$ which is an even-G abnormal boson. Needless to mention that for even G abnormal bosons $\eta(540)$, $\eta'(958)$ and $B(1235)$ the relation $GP = -C$ is satisfied. From what has been said so far we can conclude that the suggested value $J^P = 1^+$ for the $\chi(3505)$ is not justified. In a future communication we shall suggest the J^P values for the χ states making use of Eqs. (1) and (2) along with the selection rule discussed in previous papers [4, 5].

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