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E. Etim, A.F. Grillo, G. Pancheri-Srivastava and Y. Srivastava:

COMMENTS ON THE LEPTONIC COUPLINGS OF ψ(3.1 GeV) RESONANCE. -

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ABSTRACT. -

We study in detail some bounds imposed on the leptonic coupling of the recently discovered ψ (3.1 GeV) resonance. These are based on the magnetic moment anomaly for the muon and the purely leptonic neutral current experiments. If the dip-like structure that seems to be present both in the SPEAR and in the Adone $e^+e^- \rightarrow e^+e^-$ data is taken seriously, then a possible explanation in terms of Lee-Wick type negative metric boson is also presented.

The recently discovered ψ(3.1 GeV) resonance(1) seems to exhibit some peculiarities:

i) Under the assumption that the resonance is much narrower than the experimental energy resolution ($\Delta E \gtrsim 1.9$ MeV), it has been estimated that $\Gamma(\psi \rightarrow e^+e^-) \simeq \Gamma(\psi \rightarrow \mu^+\mu^-) \simeq$ 2 to 5 keV and $\Gamma(\psi \rightarrow \text{hadrons}) \simeq$ $\simeq$ 25 to 60 keV(1, 2).

ii) SPEAR as well as Adone groups(2, 3) reports seem to show interfe-

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rence effect in the e^+e^- channel - which is destructive before the resonance. The peak in this channel seems shifted (from that seen in the hadronic channel) and the dip is ~ 1 MeV to the left of the peak. In the $\mu^+\mu^-$ decay channel a dip before the peak (again approximately ~ 1 MeV) seems also to exist.

iii) MEA group$^{(4)}$ at ADONE has also presented some evidence for a charge asymmetry in the $\mu^+\mu^-$ channel which apears to change sign in approximately 2 MeV around the resonance. If confirmed this would imply a strong parity violating component in the resonance decay.

If the interference effects in ii) and iii) (in the $\mu^+\mu^-$ channel) are taken at face value we are forced to say that the spin J of the resonance is ≥ 1. Theoretically it is appealing then to entertain the possibility that $J = 1$ and that it is indeed the intermediate vector boson for neutral weak current$^{(5)}$. But one immediately runs into severe obstacles with this nice interpretation:

a) If one accepts that Γ_e and $\Gamma_T \ll \Delta E$, it is practically impossible to see an interference effect (dips and so on) at an energy interval comparable to ΔE.

b) One obtains an <u>enhancement</u> instead of a dip before the resonance in the e^+e^- decay channel in this scheme.

c) The sign of the charge asymmetry as given by the MEA group is <u>opposite</u> to that obtained with a standard V-A coupling.

Regarding point a), one possible way out is to suppose that $\Gamma_T \gg \Gamma_{\text{hadron}}$ - the rest coming mainly from decays into neutrinos. In addition, $\Gamma_{e^+e^-}$ and $\Gamma_{\mu^+\mu^-}$ also have to be much larger than the earlier estimates of $\lesssim 5$ keV. Below, we try to bound $\Gamma_{\mu^+\mu^-}$ from the (g - 2) for the muon and $\Gamma_{\nu\bar{\nu}}$ from the available $e\nu$ data.

I. (g-2) for the muon.

Under the above hypothesis that the resonance is a pure V-A, one finds for the contribution to a_μ.

$$a_\mu^{(\psi)} \simeq -\frac{4}{\pi}\,\frac{\Gamma(\psi\to\mu\bar\mu)}{m_\psi}\left(\frac{m_\mu}{m_\psi}\right)^2 \simeq -(1.5\times 10^{-9})(\Gamma_{\mu\bar\mu}/\mathrm{keV}).$$

If one compares the experimental data with the QED plus the hadronic contribution one finds the possible anomaly$^{(6)}$

$$\Delta a_\mu \gtrsim -(50\times 10^{-9}).$$

Thus, in absence of any other cancelling contribution, $\Gamma_{\mu\bar\mu} \lesssim 100\,\mathrm{keV}$. If instead of V-A, one had pure V coupling (like in the "charm" or "color" classifications) the bound is much worse, i.e. $\Gamma^{(V)}_{\mu\bar\mu} \lesssim 175$ keV. Note that in this case $a_\mu^{(V)}$ is opposite in sign.

II. Elastic $e\nu$ and $e\bar\nu$ scattering.

Regarding some speculations which admit of the possibility that the neutrino decay modes may be anomalously large (for example, as large as ~ 700 keV !), we present some bounds which rule out this way of escape. Our observations stem from considering $\nu_\mu e^-$ and $\bar\nu_\mu e^-$ elastic scattering, for which experimental bounds exist. Adler and Tuan$^{(7)}$ have given expressions for these cross-sections taking into account the experimental cuts. In terms of the e^+e^- and $\nu_\mu\bar\nu_\mu$ decay widths, these cross-sections become (in the pure V-A form):

$$\sigma(\bar\nu_\mu e^- \to e^-\bar\nu_\mu) \simeq (0.053)\left(\frac{\Gamma_e\,\Gamma_{\nu_\mu}}{\mathrm{keV}^2}\right)\left(0.035\times 10^{-41}\,\mathrm{cm}^2\,\frac{E_{\bar\nu}}{\mathrm{GeV}}\right),$$

$$\sigma(\nu_\mu e^- \to e^-\nu_\mu) \simeq (0.16)\left(\frac{\Gamma_e\,\Gamma_{\nu_\mu}}{\mathrm{keV}^2}\right)\left(0.054\times 10^{-41}\,\mathrm{cm}^2\,\frac{E_{\bar\nu}}{\mathrm{GeV}}\right),$$

to be compared with CERN Gargamelle results

$$(0.03)\times 10^{-41}\,\mathrm{cm}^2\,\frac{E_{\bar\nu}}{\mathrm{GeV}} < \sigma(\bar\nu_\mu e^- \to e^-\bar\nu_\mu) < (0.3)\times 10^{-41}\,\mathrm{cm}^2\,E_{\bar\nu}/\mathrm{GeV}$$

and

$$\sigma(\nu_\mu e^- \rightarrow e^- \nu_\mu) < 0.26 \times 10^{-41}\ \mathrm{cm}^2\ E_{\bar{\nu}}/\mathrm{GeV}.$$

Thus, one obtains

$$18 \lesssim \Gamma_e \Gamma_{\nu_\mu} \lesssim 30\ \mathrm{keV}^2 .$$

Experimentally, from $\gamma\gamma$ group at Adone, $\Gamma_e > 2.4$ keV, which limits

$$\Gamma_{\nu_\mu} < 12.5\ \mathrm{keV}.$$

Similar bounds can also be obtained for Γ_{ν_e}. Saturating the experimental upper bound

$$\sigma(\bar{\nu}_e e^- \rightarrow e^- \bar{\nu}_e) < (1.3 \times 10^{-41}\ \mathrm{cm}^2)\ (E_{\bar{\nu}}/\mathrm{GeV}),$$

we obtain

$$\Gamma_{\nu_e} \lesssim 20\ \mathrm{keV}.$$

These bounds are not much different for Weinberg-Salam type models. Thus, the total decay width cannot be substantially increased by appealing to the neutrino channels.

Conclusion

As discussed previously, taking the dip which is seen in the e^+e^- data about 1 MeV below the peak at its face value, one is led to demand a large total width which however cannot now be attributed to known leptonic channels. The problem of the destructive interference before the resonance can be partially understood provided one employs a negative metric boson of the Lee-Wick type. Also, the charge asymmetry in $\mu^+\mu^-$ channel as observed requires one to relax the pure V-A structure and thus give up chirality. Lastly the possibility of spin other than 1 is still open. We hope to return to these problems elsewhere.

Acknowledgments. -

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