

Physics 252 – Reading Exercise #2

(due Tuesday, April 19)

Read the paper:

G. J. Feldman, *et al.*, Phys. Rev. Lett. **35**, 821 (1975)

Write a brief summary of this paper. Include answers to the questions below.

You might need to know (1) a “prong” is an observed track of a charged particle; (2) for a reaction $A \rightarrow B + C$, if the 4-momentum vector of A is known and the 4-momentum vector of B is measured, one can compute the 4-momentum and mass of C . This is the “missing momentum” and “missing mass” referred to in the paper.

1. What is the discovery claimed in this paper? How many new states are observed? The modern values of the masses of the χ states are (in MeV)

$$m(\chi_0) = 3414.75 \pm 0.31, \quad m(\chi_1) = 3510.66 \pm 0.07, \quad m(\chi_2) = 3556.20 \pm 0.09 \quad (1)$$

How do the mass values given here compare to these numbers?

2. Describe the various pieces of evidence that the decays observed have the form

$$\psi' \rightarrow \gamma + \chi \quad (2)$$

with χ decaying to hadrons. It is unstated but obvious that the detector used in this experiment was a poor detector of photons. What strategies are used to compensate for this?

3. Why do the authors worry so much about the possibility that they might be observing $\psi' \rightarrow \pi^0 + \chi$?
4. What is the role of the comparison of ψ and ψ' final states in Figure 2 (a) and (b)? What is the reason for the separation of decays with $p_x > 0.3$ GeV in Figure 2(c)?
5. An isolated charged particle might be an electron or a muon instead of a pion. How do the authors control for these possibilities?
6. What is the G parity of the observed states? Why is G -parity important in the analysis?
7. In the quark model, there is a theoretical reason why the hadronic decay of the $J = 1$ χ state might be suppressed, if the decay is modeled as going to 2 massless gluons. What is it? [Hint: Problem set 1, problem 1.]