MESON EXCHANGE EFFECTS IN ELASTIC $e - D$ SCATTERING

R. J. Adler, S. D. Drell
Stanford University, USA
(Presented by S. BERMAN)

An effect of the 3 pion exchange current on the electromagnetic interaction of the deuteron has been calculated. Since the deuteron has isotopic spin $I = 0$, only the isotopic scalar part of the electromagnetic current contributes to elastic scattering. In the language of dispersion theory, this selection rule removes all even pion states, and in particular the simple pion exchange current illustrated by Fig. 1, *a* The least massive state is then that with 3 pions. Its contribution, via the 3 pion resonance (the ω or φ), as in Fig. 1, *b*, has been studied extensively, most recently by Jones [1] and Gourdin [2]. In addition it gives rise to an exchange current contribution which we study here in the approximation that the 3π state may be approximated by a two particle (ϱ, π) system, with the ϱ and π landing on different nucleons and thus constituting an exchange current as illustrated in Fig. 1, *c*.

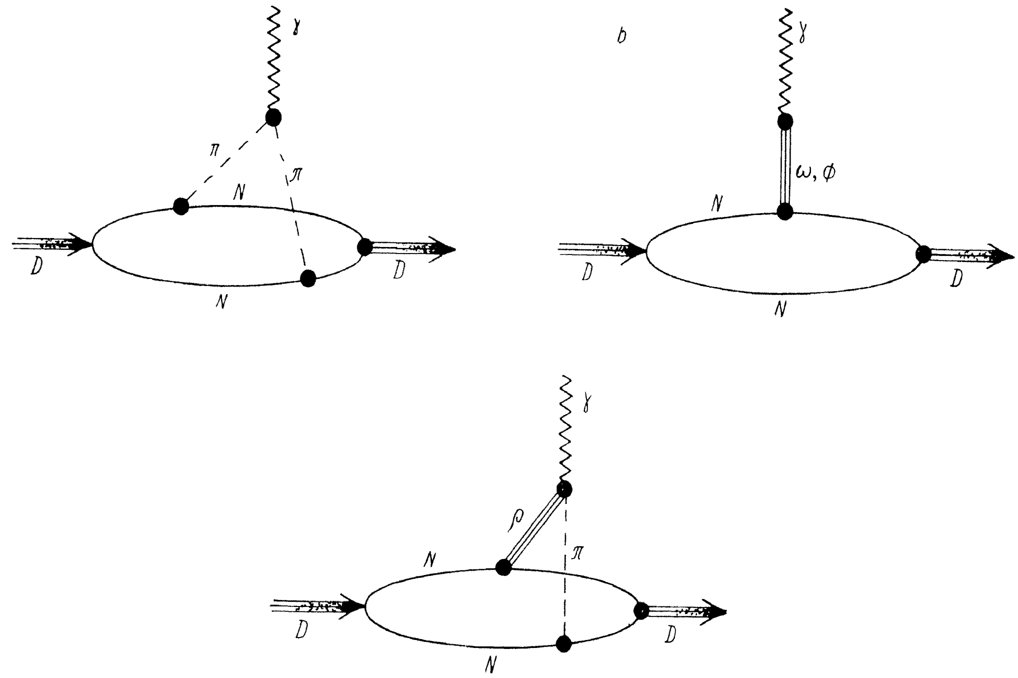

Fig. 1.

In reporting this calculation we wish especially to emphasize the importance of a measurement of the $\varrho\pi\gamma$ coupling strength. On the basis of a polology interpretation of the cross section for ϱ photoproduction in terms of one-pion exchange this coupling strength has already been estimated, although rather crudely * [3]. Using this estimate we have calculated the contribution of Fig. 1,*c* to the deuteron magnetic moment, obtaining $\sim\pm 1 \times 10^{-2}$ nuclear magnetons. This result is proportional to the $\varrho\pi\gamma$ coupling strength and is comparable in magnitude with the existing discrepancy of $+1.7 \times 10^{-2}$ nuclear magnetons between the observed moment $\mu_D = 0.857$ nm and the

* Recently reported measurements on π-pair photoproduction in the several GeV region are consistent with this estimate if one pion exchange is assumed. (Cambridge Electron Accelerator Collaboration Bulletin, Amer. Phys. Soc., 9, No. 4, 408 (1964).

value calculated using a 7% D-state probability for the deuteron as indicated by other experiments [4]

$$(\mu_D)_{\text{th}} = (\mu_n + \mu_p) - \frac{3}{2} P_D \left(\mu_p + \mu_n - \frac{1}{2} \right) = = 0.840 \text{ with } P_D = 0.07. \quad (1)$$

To reconcile Eq. (1) with experiment in the absence of an exchange current requires $P_D = 0.039$, i. e., the small difference between 0.857 and 0.840 nm in μ_D corresponds to a large difference, 0.039 versus 0.07, in P_D. The dominant contribution to the theoretical value for the magnetic moment comes from the cross term between the S-state and D-state amplitudes and is relatively insensitive to details of the particular deuteron model for a fixed D-wave percentage if one is reasonbaly discri minating in choosing the wave function*.

There is also a contribution to the deuteron electric quadrupole moment, Q; with the same parameters as in the exchange moment calculation the value of Q is changed by no more than 0,5% which is within experimental uncertainties and not at present very interesting**. Similarly the contribution to the electric form factor for $q^2 \neq 0$ as presently studied in elastic $e - D$ scattering is not large enough to be interesting, but for larger q^2 both the electric and quadrupole form factor corrections may become more important. We find that our correction to the magnetic form factor provides improved agreement with recent measurements of elastic $e - D$ scattering at backward angles [6, 7]. (See Fig. 2)

Lastly we remark that other resonances may contribute to an exchange current contribution in addition to the $\varrho\pi\gamma$ one considered here. If the ϱ' (or B) resonance at 1220 MeV has the same quantum numbers and couplings as the ϱ, it will contribute to $\Delta\mu$ but serves to change its magnitude by only 20% because of its larger mass. Another possibility comes from a $\omega(ABC)\gamma$ exchange term, where (ABC) stands for a scalar channel of $I = 0$. Such an interaction gives an approximate representation of a 5-pion, intermediate state but we have found it to contribute negligibly to the electromagnetic amplitudes for the small values of q^2 considered here. In particular there is no change in $\Delta\mu$.

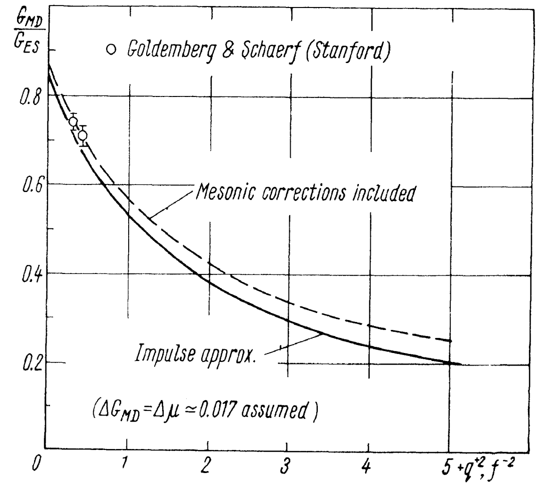

Fig. 2.

* This is in contrast to the results of D. Harrington who uses a pure S-wave deuteron model [5].

** A formally similar result for the static magnetic moment expression has been obtained by Y. Fuji and M. Kawagachi [Prog. Theor. Phys., 26, 519 (1961)]. Their methods and numerical results, as well as their expressions for corrections G_{QD} and G_{EP} are however quite different.

REFERENCES

1. Jones H. F. Nuovo cimento, **26**, 4622 (1962).
2 Gourdin W. Nuovo cimento, **28**, 2097 (1963).
3. Berman S., Drell S. Phys. Rev., **133**, B791 (1964).
4. Wilson R. The Nucleon-Nucleon Interaction, Interscience, 1963; Hadjioannou F. J. Phys. Rev., **125**, 1414 (1962).
5. Harrington D. Phys. Rev., **133**, B142 (1964).
6. Goldemberg J., Schaerf C. Phys. Rev. Lett., **12**, 298 (1964).
7. Drickey D. et al. Bull. Amer. Phys. Soc., **4**, (1964).