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REVIEW OF N-N SCATTERING

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REVIEW OF N-N SCATTERING

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Abstract

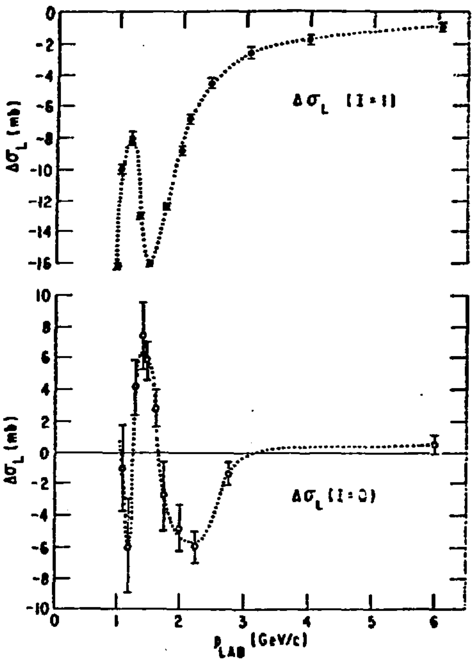
We review structures appearing in various experimental data (particularly those with polarized beams) in nucleon-nucleon systems. We present a number of candidates for dibaryon resonances which can couple to nucleon-nucleon systems.

We discuss the present status of experimental data in the nucleon-nucleon system.[1] Details of N-N scattering are written elsewhere,[2] and here we present relatively new aspects.

A striking energy dependence has been observed in the difference between the nucleon-nucleon total cross sections for pure spin states, $\Delta\sigma_L(I=1) = \sigma^{Tot}(\rightleftarrows) - \sigma^{Tot}(\rightrightarrows)$, and $\Delta\sigma_T = \sigma^{Tot}(\uparrow\downarrow) - \sigma^{Tot}(\uparrow\uparrow)$.[3,4] The observation of structures in the I = 1 system prompted us to investigate the I = 0 system.

1) $\Delta\sigma_L(I=0)$ Measurements

The Argonne PPT group has recently measured the difference between isoscalar nucleon-nucleon total cross sections for pure longitudinal initial spin states, $\Delta\sigma_L(pd)$, using a polarized proton beam and a polarized deuteron target.[5] In the simplest approximation, $\Delta\sigma_L(pd) \simeq \Delta\sigma_L(pp) + \Delta\sigma_L(pn)$. One can extract $\Delta\sigma_L(I=0)$ data using both $\Delta\sigma_L(pd)$ and $\Delta\sigma_L(pp)$ as shown in Fig. 1; a significant structure is observed around 1.5 GeV/c. This seems to suggest the existence of a new isoscalar spin-singlet dinucleon resonance. We note here that there exists a clear shoulder in the np total cross-section data[6] in the vicinity of 1.5 GeV/c.



$\Delta\sigma_L(I=0)$ together with $\Delta\sigma_L(I=1)$.

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A recent phase-shift analysis using these preliminary data by Hoshizaki et al.[7] suggests that there exists a partial wave whose behavior is consistent with the Breit-Wigner resonance formula, namely, the spin singlet $^1F_3$ wave. From the dispersion analysis of a forward I = 0 scattering amplitude using the data on $\Delta\sigma_L(I = 0)$, Grein and Kroll[8] showed that the Argand plot of the amplitude has a resonancelike behavior around 1.5 GeV/c, and that suggests the existence of a spin-singlet dibaryon resonance.

2) C_{LL}(pp) and C_{SL}(pp) Measurements

Our group has collected a very large amount of data in proton-proton scattering, using a longitudinally (L) polarized target and a longitudinally (L) or transversely (S) polarized proton beam at the following seven different incident proton momenta: p_{lab} = 1.17, 1.35, 1.48, 1.70, 2.00, 2.25, 2.50 GeV/c, and data were obtained in the channels pp → pp, π^+d covering essentially the whole kinematic range of angles in these two reactions, namely $\theta_{c.m.} \sim 10^0 - 90^0$ for pp-events. The data analysis is in progress. These data are compared with predictions from phase-shift analyses by Hoshizaki and independently Arndt which give solutions consistent with the existence of two diproton resonances, namely the $^1D_2$ (2140) and $^3F_3$ (2220).

3) A Close Investigation of $\Delta\sigma_L(I = 1)$ and $\Delta\sigma_T(I = 1)$ Data

The existence of $^1D_2$ and $^3F_3$ dinucleon resonance in the I = 1 system has been discussed by many authors.[9] Here we discuss additional structure obtained with I = 1 system. $\Delta\sigma_T$ data[4] contain only singlet structures. Then we expect to see only the triplet structure in $(\Delta\sigma_T - \Delta\sigma_L)$.[1] We observe a new triplet structure at 2.0 GeV/c in addition to the one at 1.5 GeV/c. We can deduce that the quantum number of the triplet peak at 2.0 GeV/c is as follows:

$$\Delta\sigma_T - \Delta\sigma_L \sim (2J + 1)\text{Im } R_{JJ} - (J + 2)\text{Im } R_{J+1,J} - (J - 1)\text{Im } R_{J-1,J}$$

only the R_{JJ} term has positive sign, therefore the triplet peak at 2.0 GeV/c is due to a partial wave R_{JJ}.

4) A Close Investigation of Polarization Data

We note that there is no $^3F_3$ partial-wave contribution to the polarization data at $\theta_{c.m.} = 63°$. We see an interesting structure in a plot of $k^2P\,(d\sigma/d\Omega)/\sin 2\theta_{c.m.}$ vs. p_{lab}. This quantity is proportional to $(2\,\text{Im}^3P_0 + 3\,\text{Im}^3P_1)(\text{Re}^3P_2) - (2\,\text{Re}^3P_0 + 3\,\text{Re}^3P_1)(\text{Im}^3P_2)$

by neglecting higher partial waves. Since the $^3P_2$ partial wave has very little energy dependence,[10,11] there is a good chance that either $^3P_0$ or $^3P_1$ partial wave is resonating at ~ 1.3 GeV/c.

5) Conclusion on I = 0 and I = 1 Resonances

Candidates for dibaryon resonances that can couple to nucleon-nucleon systems are summarized in the table below.

Candidates for Dinucleon Resonances

i) I = 1 Isospin State

	B_1^2 (2.14)	B_1^2 (2.18)	B_1^2 (2.22)	B_1^2 (2.43)	B_1^2 (2.43)
Mass, GeV	2.14 - 2.17	2.18 - 2.20	2.20 - 2.25	2.43 - 2.50	2.43 - 2.50
Width, MeV	50 - 100	100 - 200	100 - 200	~150	~150
Quantum State	$^1D_2$	Triplet P ?	$^3F_3$	probably $^1G_4$	Triplet R_{JJ} ?

ii) I = 0 Isospin State

	B_0^2 (2.14)	B_0^2(2.22)	B_0^2 (2.43)
Mass, GeV	2.14 - 2.17	2.20 - 2.26	2.40 - 2.50
Width, MeV	50 - 100	100 - 200	
Quantum State	Triplet ?	$^1F_3$	Triplet ?

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