

Magnetic moments of the $N(1535)$ resonance in the chiral unitary model



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Motivations

- **Experiments**

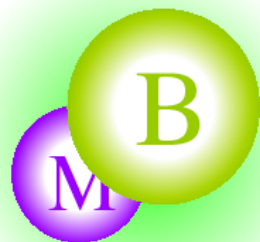
Recent developments of the experimental technique enable us to measure the **magnetic moments of the excited baryons**.

- **Application of the chiral unitary model**

Chiral unitary model

Flavor SU(3) meson-baryon scatterings (s-wave)

$J^P = 1/2^-$
Resonances



Chiral symmetry

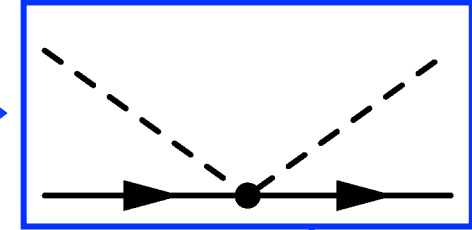
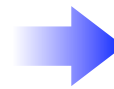
Unitarity of S-matrix

Investigation of the resonance structure

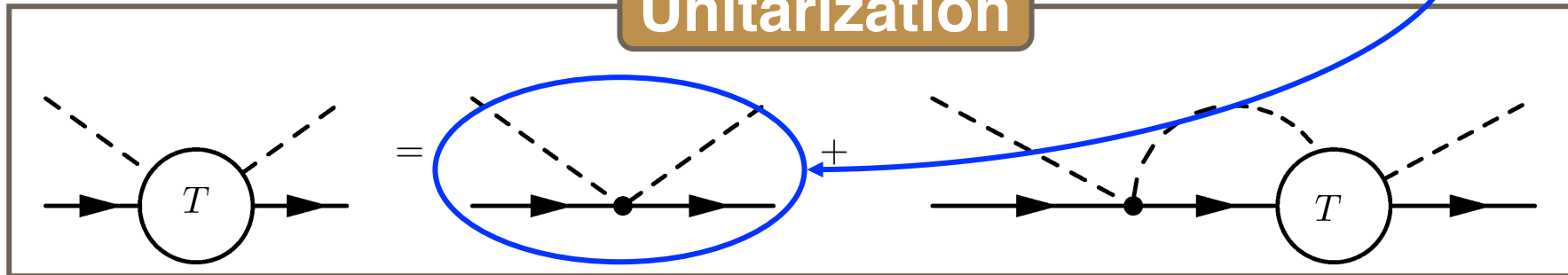
Framework of the chiral unitary model

Chiral perturbation theory

$$\mathcal{L}_{WT} = \frac{1}{4f^2} \text{Tr}(\bar{B}i\gamma^\mu[(\Phi\partial_\mu\Phi - \partial_\mu\Phi\Phi), B])$$

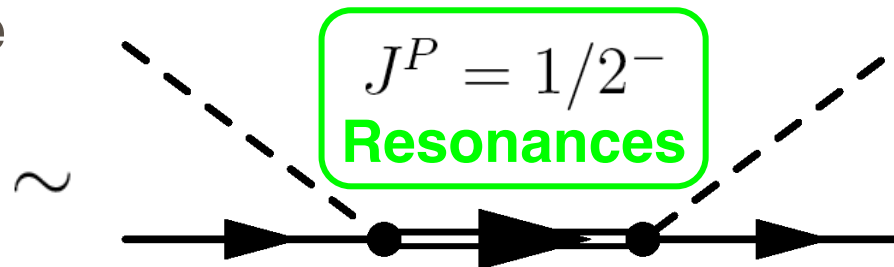


Unitarization



$$T_{ij}(\sqrt{s}) \sim \frac{g_i g_j}{\sqrt{s} - M_R + i\Gamma_R/2} + T_{ij}^{BG}$$

Generated resonances are expressed as the poles of the T-matrix.



The N(1535) resonance in the chiral unitary model

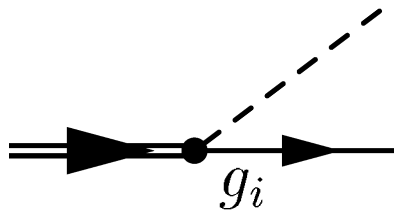
$Q = 0$	$\pi^0 n$	$\pi^- p$	ηn	$K^0 \Lambda$	$K^0 \Sigma^0$	$K^+ \Sigma^-$
$Q = 1$	$\pi^0 p$	$\pi^+ n$	ηp	$K^+ \Lambda$	$K^+ \Sigma^0$	$K^0 \Sigma^+$

Positions of the poles

$$z_{n^*} = 1536 - 37i \text{ [MeV]}$$

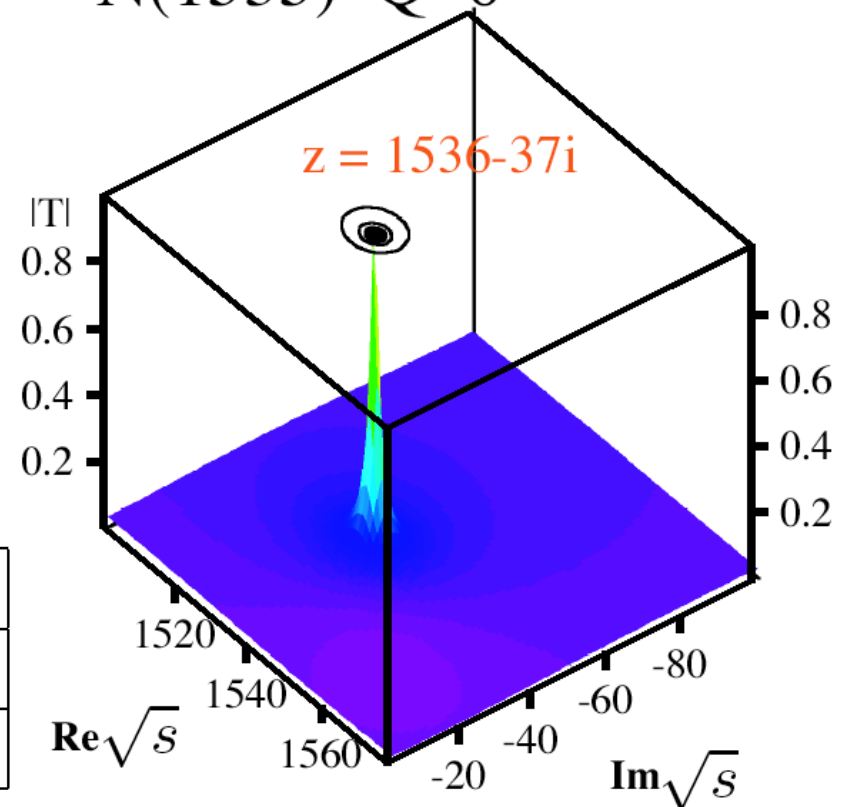
$$z_{p^*} = 1531 - 36i \text{ [MeV]}$$

Coupling strengths

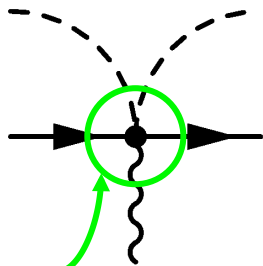
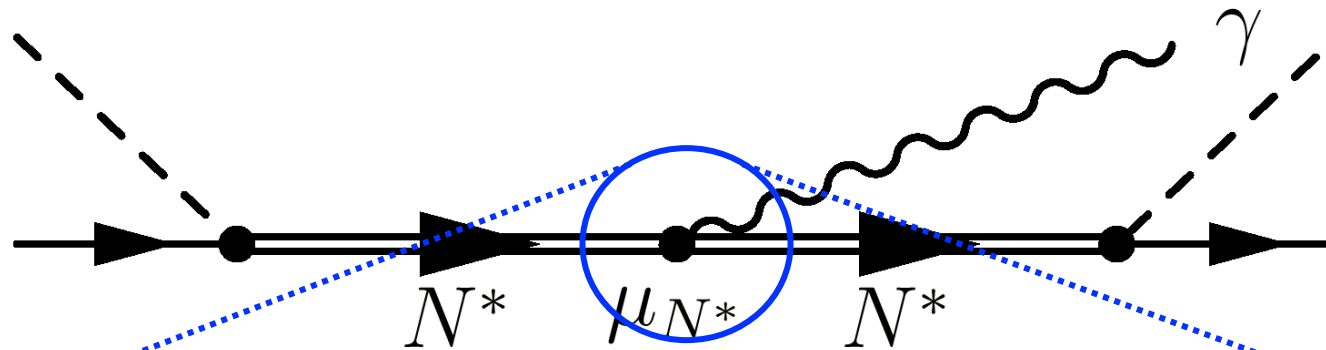


	$ g_{\pi N} ^2$	$ g_{\eta N} ^2$	$ g_{K\Lambda} ^2$	$ g_{K\Sigma} ^2$
n^*	0.623	2.30	1.93	7.29
p^*	0.619	2.35	1.88	7.37

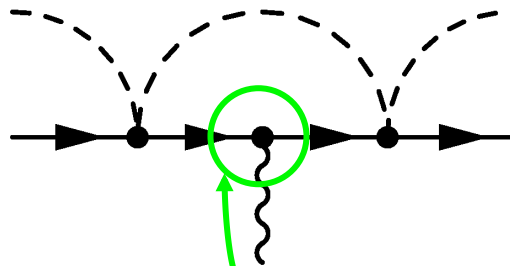
N(1535) Q=0



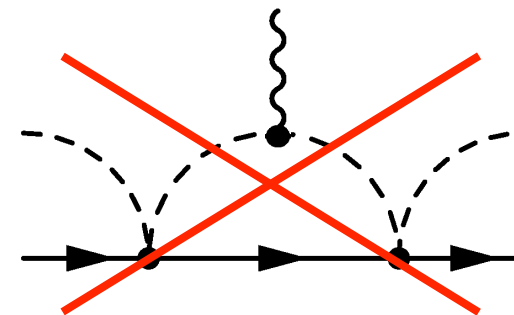
Photon coupling diagrams



ChPT



μ $o\phi$ ground state baryons



do not contribute

Extract μ_{N^*}  **T. Hyodo *et al.*, nucl-th/0305023**

Flavor SU(3) symmetry

Numerical results :

$$\mu_{n^*} \sim -0.25 \mu_N , \quad \mu_{p^*} \sim 1.1 \mu_N .$$

magnetic moments of $\Lambda(1670)$

$$\mu_{\Lambda^*} \sim -0.29 \mu_N$$

→ D. Jido *et al.*, Phys. Rev. C 66, 025203 (2002)

SU(3) octet → Coleman-Glashow relation

$$\mu_{n^*} = 2 \mu_{\Lambda^*}$$

Qualitatively : ○

Quantitatively : ×

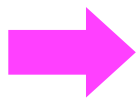
Flavor SU(3) symmetry

SU(3) decomposition of the coupling constant

representation	1	8	8	10	$\bar{10}$	27
$n^*(1535)$	—	5.2	6.2	0.17	—	0.58
$\Lambda^*(1670)$	4.0	2.3	7.3	—	—	0.16

- **Octet components** are dominant and 10, 27 are small.
- $\Lambda(1670)$ contains a **singlet component**.


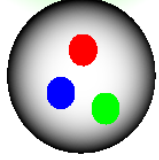
The deviation from the SU(3) relation:



- mixture of the singlet component
- SU(3) breaking effects

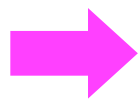
Comparison with quark model

Compare the results with the **quark model**.

	$n^* [\mu_N]$	$p^* [\mu_N]$	picture
ChU model	-0.25	1.13	
Quark model	-1.28	1.89	

 W.-T. Chiang *et al.*, nucl-th/0211061

The **absolute values** of the present results differ from those of the quark model, especially in n^* .



difference of pictures
of the excited states

Conclusions

We calculate the **magnetic moments of the N(1535) resonance** using the chiral unitary model.

$$\mu_{n^*} \sim -0.25\mu_N, \quad \mu_{p^*} \sim 1.1\mu_N.$$

- Signs of the results are consistent with the **SU(3) (Coleman-Glashow) relation**.
- The results qualitatively agree with those of the quark model, but the quantitative disagreement would reflect the **difference of the pictures** of the excited baryons.

D. Jido *et al.*, Phys. Rev. C 66, 025203 (2002)

T. Hyodo, S.I. Nam, D. Jido and A. Hosaka nucl-th/0305023