The production of nucleon resonances in $K^+ N$ interactions

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Outline

• Motivations
• Theoretical Model
• Results and Summary
# The status of $N^*$ resonances

<table>
<thead>
<tr>
<th>Particle</th>
<th>$L_{2I\cdot 2J}$ status</th>
<th>Overall</th>
<th>$N_\pi$</th>
<th>$N_\eta$</th>
<th>$\Delta K$</th>
<th>$\Sigma K$</th>
<th>$\Delta \pi$</th>
<th>$N_\rho$</th>
<th>$N_\gamma$</th>
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<td>$N(939)$</td>
<td>$P_{11}$ ****</td>
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<td>$N(1680)$</td>
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Current knowledge of $N^*$ resonances are mainly from:

1. $\pi N$ scattering

   Missing resonance problem

some other ways:

2. $\gamma N$ scattering

3. $J/\Psi$ decay

4. $pp$ scattering

These new data constitute a better basis to investigate the properties of nucleon resonances.

**QUESTION:** Is there any other way which is also suitable for investigating nucleon resonances?
Is there some other reaction suitable for studying $N^*$ resonance?

**Nucleon resonance production in $K^+ N$ interactions**

This topic is only very poorly studied. For example: $K^+ p \rightarrow K^+ K^+ \Lambda$

studied. The $\Lambda K^+$ invariant mass spectrum from the final state $\Lambda K^+K^+$ shows an enhancement in the region of the $N^*(1700)$ (fig. 1 and table 2). By fitting the mass spectrum, we find the contribution of the $K^+ p \rightarrow K^+N^*(1700)$ to the $K^+ (\Lambda K^+)$

NPB129,28(1977): $Plab=4.3\text{GeV}$
Isobar Model:

We ignore the s-channel contributions.

Compared to nucleon resonance production in NN scattering:
Example I: $K^+N \to KN\eta$ near threshold.

1. $K^+p \to K^+p\eta$

2. $K^+n \to K^+n\eta$

3. $K^+n \to K^0p\eta$

Results:

**Total cross sections:**

- $\Sigma$ exchange
- $\Lambda$ exchange
- $\rho$ exchange
- $\omega$ exchange
- $\phi$ exchange

**Angular distributions:**

- $\rho$ exchange
- $\Sigma$ exchange
- $\Lambda$ exchange
Interference effects:  

Destructive interference  

Constructive interference  

Some conclusions: 

1. Hyperon exchange may give important contributions in these reactions. 

2. The hyperon exchange and meson exchange induce different pattern of angular distributions. 

3. The relative roles of individual diagram change in different channels, thus a combined analysis of all these reactions may put strong constraints on the model and then help us know better about the coupling of N(1535) with hyperon or vector mesons.
Example II: \( K^+ p \rightarrow K^+ K^+ \Lambda \)  

**Feynmann diagrams:**

For \( N^* \) resonance, we consider \( N^*(1650), N^*(1710) \) and \( N^*(1720) \).

**Total cross sections:**
Results:

Total cross sections:

Angular distributions:
Some conclusions:

1. Our results show that the lambda exchange gives dominant contributions in lower energies and the rho exchange plays dominant role in higher energies.

2. Because the N*KY vertex can appear twice, this reaction is a good place to study the nucleon resonances which have large couplings to Klambda channel and is also suitable for looking for missing resonance.

3. Similarly, for the t-channel diagram if we consider the vector meson decay channel of nucleon resonance, those reactions will also be a good place to study the nucleon resonances that have large coupling to vector mesons.
Based on the model calculations, it is found that hyperon exchange may play important role in nucleon resonance production in KN interactions, which makes these reactions a good place to study the coupling of nucleon resonances with hyperons. This topic deserves further studies both in theoretical and experimental aspects.

谢谢

Thank you!