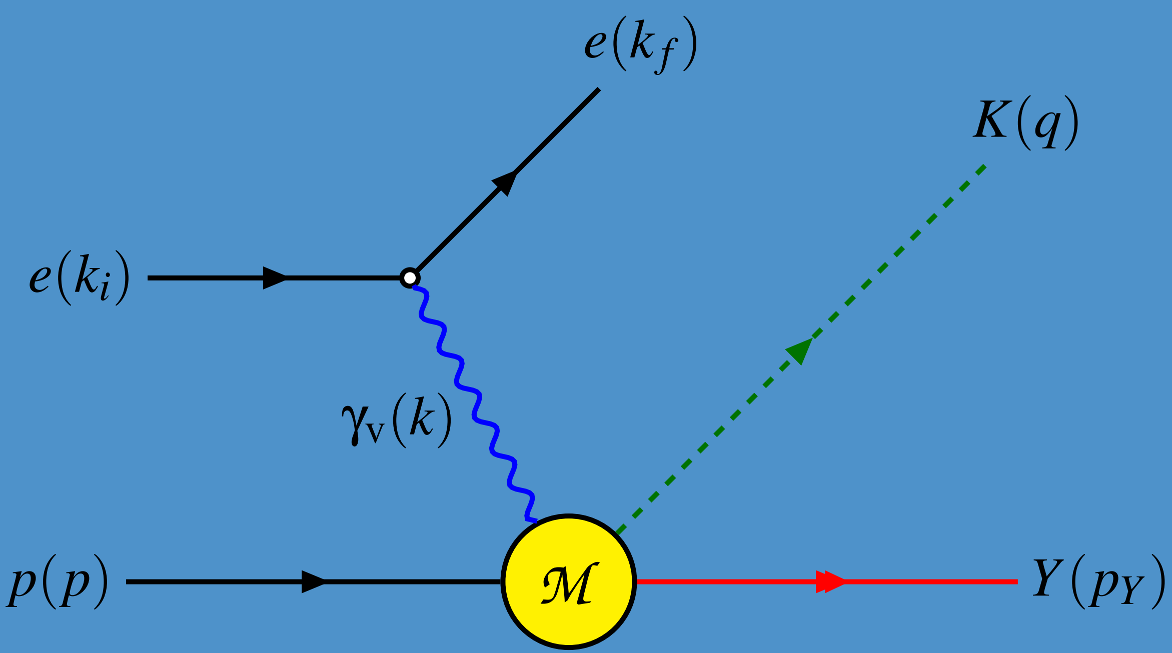
Electromagnetic Production of Kaons on Nucleons



Jovan Alfian Djaja

ELECTROMAGNETIC PRODUCTION OF KAONS ON NUCLEONS

JOVAN ALFIAN DJAJA

Preface

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla. Nulla egestas.

Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetuer.

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

JOVAN ALFIAN DJAJA

CONTENTS

1 Strangeness

In the December of 1947, George Dixon Rochester and Sir Clifford Charles Butler observed a peculiarity in the photographs of their cloud chamber detector [1]. They observed evidence of an unknown neutral particle decaying into two charged particles, which is later identified as charged pions π^+ and π^- [5]. Due to how the charged particles formed an upside-down V, the neutral particle was then referred to as 'V-particle'. The V-particle was later called the **neutral kaon** K^0.

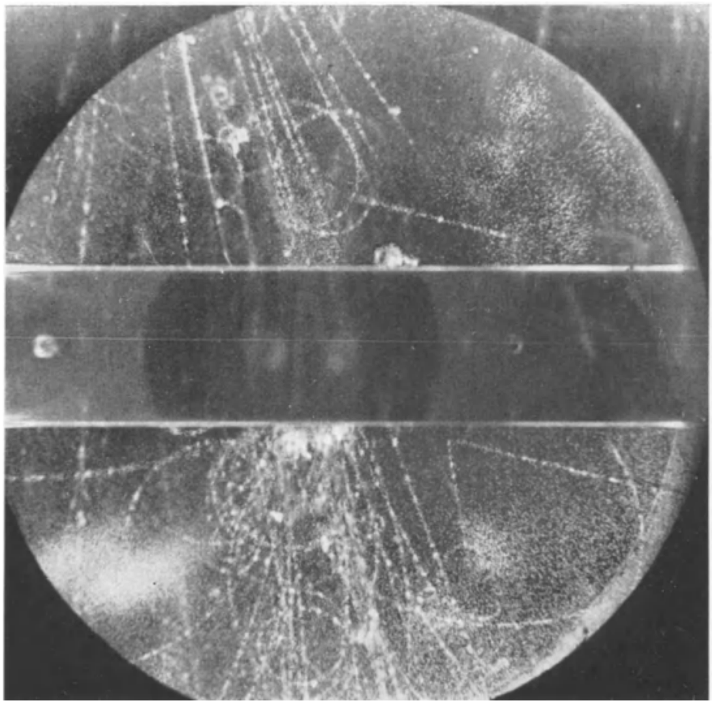


Figure 1: A photograph of V-particle decay [4]. Cosmic rays strike a lead plate, producing the V-particle. The V-particle then decays into two charged pions [1, 5].

Strangeness[1] was then introduced by Murray Gell-Mann, Abraham Pais, Tadao Nakano, and Kazuhiko Nishijima to describe this unique phenomenon. Hence, particles that exhibit those properties are referred to as *strange particles*. In modern particle physics, strange particles are said to be produced via the strong interaction, but decay due to the weak interaction [1]. Therefore, **strangeness is conserved in strong interactions, but not in weak interactions**. Mathematically, the strangeness of a particle is defined as the *difference between the number of strange antiquarks and strange quarks*:

$$s = N_{\bar{s}} - N_s. \tag{1}$$

[1]Unlike the electric charge and a majority of quantum numbers, strangeness is a *multiplicative quantum number*.

2 KAONS

According to the quark model, K mesons, also known as **kaons**, are composed of a strange quark and an up or down quark. Kaons are the *lightest strange mesons* and there are two of them [3]:

$$K^+(493.677) = u\bar{s} \quad \& \quad K^0(497.611) = d\bar{s}.$$

2.1 Kaon Production

3 ISOBAR MODEL

3.1 Pseudoscalar Coupling

3.2 Born Terms in Pseudoscalar Theory

3.2.1 Nucleon Term

3.2.2 Kaon Term

3.2.3 Λ-Hyperon Term

3.2.4 Σ-Hyperon Term

3.3 Resonance Terms in Pseudoscalar Theory

3.3.1 Kaon Resonance Term: K^*

3.3.2 Kaon Resonance Term: K_1

3.3.3 Nucleon Resonance Term: Spin-$1/2$

3.4 Pseudovector Coupling: Contact Diagram

4 ADVANCES

REFERENCES

[1] David J. Griffiths. *Introduction to Elementary Particles*. Wiley-VCH Verlag GmbH & Co., 2008.

[2] Terry Mart. *Produksi Elektromagnetik Kaon: Teori Dasar dan Formalisme*. Penerbit Duta, 2023.

[3] Brian R. Martin and Graham Shaw. *Nuclear and Particle Physics: An Introduction, 3rd edition*. John Wiley & Sons Ltd, 2019.

[4] George D. Rochester and John G. Wilson. *Cloud Chamber Photographs of The Cosmic Radiation*. Pergamon Press Ltd, 1952.

[5] Taku Yamanaka. Detection of a strange particle. *Nature*, 2019.