Ruhr-University Bochum   Modern Techniques in Hadron Physics

MTHS24 – Exercise sheet 5

Morning: Eric Swanson / Mikhail Mikhasenko

Afternoon: Nadine Hammoud, Dhruvanshu Parmar

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Lecture material

Discussed topics:

- Three body decay kinematics
- Cascade parametrization of decays
- Helicity and covariant formalism

References:

- A.D. Martin, T.D. Spearman, Elementary Particle Theory, inSpire
- Eero Byckling, K. Kajantie, Particle Kinematics, inSpire

Exercices

5.1 Plastisin and Wires

In a laboratory setup, particle vectors for a three-body decay are represented using metal wire sticking out from a plasticine ball. The particles involved in the decay have masses of $1\,$GeV, $2\,$GeV, and $3\,$GeV respectively.

(a) Compute the center of mass energy.

(b) Compute the boost to the rest frame.

(c) Locate the kinematic point on the Dalitz plot.

(d) Use the plasticine and wire to show how the decay kinematics looks like in the system rest frame.

5.2 Spin of a New Λ_b^{**0} State

A new Λ_b^{**0} state has been discovered decaying into $\Lambda_b^0\pi^+\pi^-$ with a prominent Σ_b^* resonance line on the Dalitz plot. The decay intensity distribution along the Σ_b^* band is provided in the supplementary material, which includes the helicity angle distribution. Your task is to determine the spin J of the Λ_b^{**0} state.

(a) Write down the decay matrix element for $\Lambda_b^{**0} \to \Lambda_b^0\pi^+\pi^-$ using helicity formalism.

(b) Identify the partial waves in the decay $\Sigma_b^* \to \Lambda_b^0\pi$.

(c) Determine the partial waves in the decay $\Lambda_b^{**0} \to \Sigma_b^*\pi$ for $J^P = \frac{1}{2}^\pm, \frac{3}{2}^\pm, \frac{5}{2}^\pm$.

(d) Compute the unpolarized differential distribution given by:

$$\frac{\mathrm{d}I}{\mathrm{d}\cos\theta} = \sum_{\lambda_0,\lambda_1}^{\{-1/2,1/2\}} \left|\langle L,0;3/2,\lambda_0|J,\lambda_0\rangle d^{3/2}_{\lambda_0,\lambda_1}(\theta)\langle 1,0;1/2,\lambda_1|3/2,\lambda_1\rangle\right|^2$$