Light Meson Dynamics

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1. Aim of workshop: bring together experimentalists and theorists, working on different aspects of light meson dynamics, in particular

   - eta' and eta decays
   - interaction of pseudoscalar mesons with vector mesons and photons
   - processes of odd intrinsic parity
   - kaon-pion dynamics from D decays
   - Goldstone-boson dynamics in the decay of heavy systems

2. Identify new research directions, impact on other physics questions, complementarities between different experiments (M. Vanderhaeghen)

Objectives

1. **Properties of light (and not so light) mesons**

   masses, widths, (transition) form factors, decay rates and distributions, etc.

   What is the nature of a resonance?

2. **Dynamics of mesons**

   scattering, (production) cross sections, generation of resonances, response to an external probe

   PP, PV, VV, + electromagnetic interaction

   also weak interactions (in particular kaon decays)

3. Connection to QCD

   mainly in terms of chiral symmetry, quark masses, Ward identities

   What are the relevant effective degrees of freedom emerging from QCD?

4. Interplay of spontaneous chiral symmetry breaking, explicit symmetry breaking and axial anomaly

   η-η' mixing

5. Processes

   (a) in the even intrinsic parity sector

$\pi\pi$ scattering, $\gamma\gamma \to \pi\pi$, $\eta \to \pi\pi\pi$, etc.

(b) driven by Wess-Zumino-Witten action

$\pi^0 \to \gamma\gamma$, $\gamma\pi \to \pi\pi$, $\eta \to \pi^+\pi^-\gamma$, etc.

6. Precision calculations

(a) of key (strong-interaction) quantities, e.g., pion scattering lengths, $\pi^0 \to \gamma\gamma$ decay rate, etc.

(b) of observables relevant for essential standard model predictions

7. Connection of space- and timelike regions for electromagnetic processes

8. Isospin-symmetry breaking including electromagnetism

9. Rare or forbidden decays

Key theoretical methods (discussed at this workshop)

1. Unitarized chiral dynamics

   Coupled-channel integral-equation approach

   with emphasis on different aspects

   (predictive power, unitarity, micro causality, etc.)

2. Various applications of dispersion relations

   Unitarity, analyticity, crossing symmetry

   (cross check of compatibility of experimental results)

3. Mesonic chiral perturbation theory

   (a) Even intrinsic parity

$$\mathcal{L}_2 + \mathcal{L}_4 + \mathcal{L}_6 \quad \text{two-loop level}$$

   (b) Odd intrinsic parity

$$S_{WZW} + \mathcal{L}_6 \quad \text{one-loop level}$$

4. Combination of above methods

5. Phenomenological Lagrangian approach including quantum corrections

   power counting, large-N_C arguments

6. **Analysis tools to extract pole parameters from experiment**

7. **(Lattice QCD)**

8. **...**

Status (progress)

1. Dispersion theory

   Explanation of σ pole position

   (Do not! treat the σ as a Breit-Wigner resonance)

   Connection between $\eta \to \pi^+\pi^-\gamma$ decay and $\eta \to \gamma^*\gamma$

   Treatment of isospin-symmetry breaking: Connection between $\langle \eta | j_\mu^{ud} | \pi \rangle$ form factors and $\eta\pi \to \pi\pi$ amplitude

   Dispersion theory and chiral dynamics: from light- to heavy-meson decays (three particles in final state)

2. Odd-intrinsic-parity sector of ChPT complete at one-loop level ($\mathcal{O}(p^6)$)

3. Chiral dynamics including vector mesons, generation of resonances, role of constraints

4. Light mesons and their interactions with photons in a Lagrangian approach

5. Role of η-η' mixing (two-mixing-angle scheme, conclusion from $V \to P\gamma$ analysis: zero gluonic content of η and η' states)

6. Connection between space- and timelike regions of transition form factors

7. A lot of activity on extracting pole parameters from experiment

Conclusion: Extremely large theoretical interest in this field

Mini proceedings

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