

DISCUSSION ON 21st CENTURY CHIRAL PERTURBATION THEORY



Johan Bijens

Lund University



Vetenskapsrådet

`bijens@thep.lu.se`

`http://thep.lu.se/~bijens`

`http://thep.lu.se/~bijens/chpt/`

`http://thep.lu.se/~bijens/chiron/`

Who are we?



21st Century
ChPT

Johan Bijmens

Introduction

Savvas

Parameters

Questions and
applications

Conclusions

- Johan Bijmens (moderator) (Lund, Sweden)
- Christopher Sachrajda (Southampton, UK)
- Stephen Sharpe (Seattle, USA)
- Savvas Zafeiropoulos (Frankfurt, Germany)

A general Effective Field Theory:

- Relevant degrees of freedom
- A powercounting principle (predictivity)
- Has a certain range of validity

Chiral Perturbation Theory:

- **Degrees of freedom:** Goldstone Bosons from spontaneous breaking of chiral symmetry
- **Powercounting:** Dimensional counting in momenta/masses
- **Breakdown scale:** Resonances, so about M_ρ .

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We have had three talks concentrating on ChPT talks:

- Johan Bijnens: Chiral Perturbation Theory with Twisted Boundary Conditions
- Christopher Sachrajda: Lattice Kaon Physics
- Stephen Sharpe: Chiral Perturbation Theory with Physical-mass Ensembles

Many related issues appear in other talks

- Nucleon ChPT
- Nuclear EFT
- Electromagnetic corrections
- ...

Some older uses of current algebra and ChPT in Lattice QCD:

- **Extrapolation in quark masses**
 - Standard case
 - Quenched
 - Partially Quenched
- ϵ -regime (introduced by Gasser-Leutwyler 1987)

Somewhat more recent examples

- Finite volume
- Twisting
- lattice artefacts
 - Staggered
 - Wilson fermions
- Random matrix models (now a short talk by Savvas)

Parameters: Continuum

Loops	$\mathcal{L}_{\text{order}}$	LECs	effects included
$L = 0$	\mathcal{L}_{p^2}	2	strong (+ external W, γ)
	$\mathcal{L}_{e^2 p^0}$	1	internal γ
	$\mathcal{L}_{G_F p^2}^{\Delta S=1}$	2	nonleptonic weak
	$\mathcal{L}_{G_8 e^2 p^0}^{\Delta S=1}$	1	nonleptonic weak+internal γ
	$\mathcal{L}_{p^4}^{\text{odd}}$	0	WZW, anomaly
$L \leq 1$	\mathcal{L}_{p^4}	10	strong (+ external W, γ)
	$\mathcal{L}_{e^2 p^2}$	13	internal γ
	$\mathcal{L}_{G_8 F p^4}^{\Delta S=1}$	22	nonleptonic weak
	$\mathcal{L}_{G_{27} p^4}^{\Delta S=1}$	28	nonleptonic weak
	$\mathcal{L}_{G_8 e^2 p^0}^{\Delta S=1}$	14	nonleptonic weak+internal γ
	$\mathcal{L}_{p^6}^{\text{odd}}$	23	WZW, anomaly
	$\mathcal{L}_{e^2 p^2}^{\text{leptons}}$	5	leptons, internal γ
$L \leq 2$	\mathcal{L}_{p^6}	90	strong (+ external W, γ)

- No new parameters:
 - Finite temperature
 - **Finite volume** (including ϵ regime)
 - Twisted mass
 - Boundary conditions: **twisted**,...
- A few new parameters
 - Partially quenched ($2 \rightarrow 2, 10 \rightarrow 11, 90 \rightarrow 112$)
- Many new parameters
 - Wilson ChPT ($2 \rightarrow 3, 10 \rightarrow 18$)
 - **Staggered ChPT** ($2 \rightarrow 10, 10 \rightarrow 126$ (but dependencies))
 - Mixed actions
- Other operators
 - Local object with well defined chiral properties: include via spurion techniques
 - Examples: tensor current, energy momentum tensor,...

- Do we still need extrapolation in quark masses?
- Can we get observables that cannot be obtained directly from the lattice?
- Determining Low-Energy-Constants: pure ChPT game or useful for other things?
- Too many parameters?
- Can reweighting do all instead?

- Disconnected contributions
- Partially quenched
- Wilson
- Staggered
- Electromagnetism
- Finite volume
- Twisting
- From unphysical to physical observables (ϵ -regime, . . .)
- $K \rightarrow 3\pi$
- Estimating systematic errors

- ChPT still useful?
- How to make it more useful?