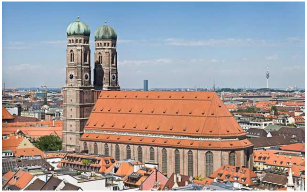
DISCUSSION ON 21st CENTURY CHIRAL PERTURBATION THEORY



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Who are we?

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

Chiral Perturbation Theory

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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Talks

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
- ...

The 20th century

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

Parameters: Extensions for the lattice

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

Questions

- 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?

Possible applications

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

Conclusions

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