Summary Talk

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Supported by the US DOE and Sloan Foundation

Background by S. Hossenfelder

Summary-Execution Talk

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Final Talk

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Outline

- Program
- Is nuclear EFT dead?
- Are conventional (crack)pots any less dead?
- What is the point of V_{lowk}?
- Few- and many-body developments?
- Conclusions?

Program

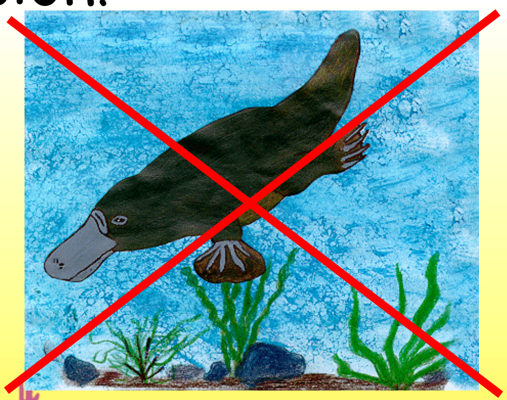
Week 1	Monday 20-6	Tuesday 21-6	Wednesday 22-6	Thursday 23-6	Friday 24-6
Morning	Timmermans	Carlson	Coraggio	Kievsky	Quaglioni
	Friar	de Swart	Gross	Machleidt	Ruiz Arriola
Afternoon	Vigdor	Nogga	Pederiva	Gardestig	Thomas
	Navratil	Schwenk	Dean	Horowitz	Zuker
Week 2	**Monday 27-6**	**Tuesday 28-6**	**Wednesday 29-6**	**Thursday 30-6**	**Friday 1-7**
Morning	Lazauskas	Deltuva	Marcucci	Oka	Cohen
	Rentmeester	Epelbaum	Higa	Pavon Valderrama	van Kolck
Afternoon	Griesshammer	Birse	Hemmert	Phillips	
	Truhlik	Kaiser	Stetcu	Weise	

Lots of good discussion!

Now, everybody already cited!

Here emphasis on youngsters

not Johan! alas, not me either…



Serway, Physics

In 1600 William Gilbert extended these experiments to a variety of materials. Using the fact that a compass needle orients in preferred directions, he suggested that the Earth itself is a large permanent magnet. In 1750 John Michell used a torsion balance to show that magnetic poles exert attractive or repulsive forces on each other and that these forces vary as the inverse square of their separation. Although the force between two magnetic poles is similar to the force between two electric charges, there is an important difference. Electric charges can be isolated (witness the electron or proton), whereas *magnetic poles cannot be isolated*. That is, *magnetic poles are always found in pairs*. All attempts thus far to detect an isolated magnetic monopole have been unsuccessful. No matter how many times a permanent magnet is cut, each piece will always have a north and a south pole. (There is some theoretical basis for speculating that magnetic monopoles—isolated north or south poles—may exist in nature, and attempts to detect them currently make up an active experimental field of investigation. However, none of these attempts has proven successful.)

An electromagnet is used to move tons of scrap metal. *(Ray Pfortner/Peter Arnold, Inc.)*

The relationship between magnetism and electricity was discovered in 1819 when, during a lecture demonstration, the Danish scientist Hans Christian Oersted (1777–1851) found that an electric current in a wire deflected a nearby compass needle.[1] Shortly thereafter, André Ampère (1775–1836) formulated quantitative laws for calculating the magnetic force between current-carrying conductors. He also suggested that electric current loops of molecular size are responsible for *all* magnetic phenomena.

Hans Christian Oersted (1777–1851), Danish physicist. *(The Bettmann Archive)*

In the 1820s, further connections between electricity and magnetism were demonstrated by Faraday and independently by Joseph Henry (1797–1878). They showed that an electric current can be produced in a circuit either by moving a magnet near the circuit or by changing the current in another nearby circuit. These observations demonstrate that a changing magnetic field produces an electric field. Years later, theoretical work by Maxwell showed that the reverse is also true: A changing electric field gives rise to a magnetic field.

There is a similarity between electric and magnetic effects that has provided methods of making permanent magnets. In Chapter 23 we learned that when rubber and wool are rubbed together, both become charged, one positively and the other negatively. In an analogous fashion, an unmagnetized piece of iron can be magnetized by stroking it with a magnet. Magnetism can also be induced in iron (and other materials) by other means. For example, if a piece of unmagnetized iron is placed near a strong magnet, the piece of iron eventually becomes magnetized. The process of magnetizing the piece of iron in the presence of a strong external field can be accelerated either by heating and cooling the iron or by hammering.

This chapter examines forces on moving charges and on current-carrying wires in the presence of a magnetic field. The source of the magnetic field itself is described in Chapter 30.

29.1 THE MAGNETIC FIELD

In earlier chapters we found it convenient to describe the interaction between charged objects in terms of electric fields. Recall that an electric field surrounds any electric charge. The region of space surrounding a *moving* charge includes a

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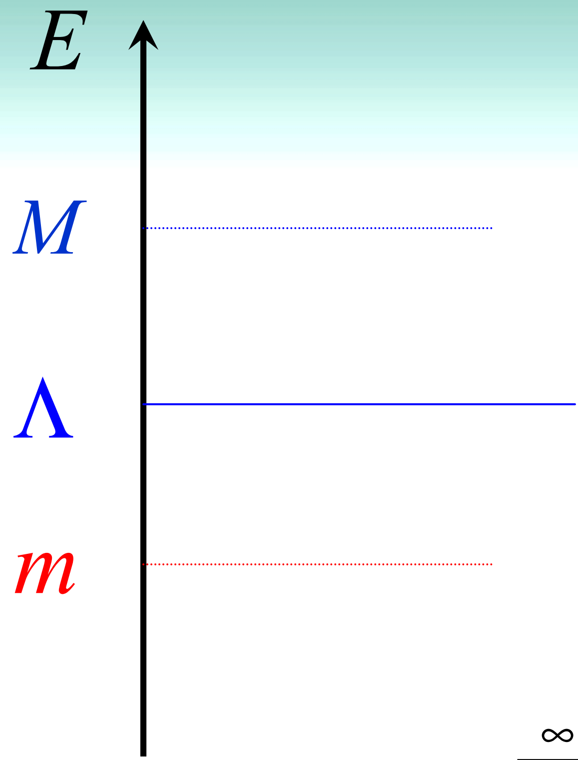
Is Nuclear EFT$^{©}$ dead?

Most definitely not!

But, before I go there...

EFT© 101



$$Z=\int D\phi_H \int D\phi_L \exp\left(i\int d^4x\, L_{und}(\phi_H,\phi_L)\right)$$

$$\times\int D\varphi\, \delta\left(\varphi - f_\Lambda(\phi_L)\right)$$

$$=\int D\varphi\, \exp\left(i\int d^4x\, L_{EFT}(\varphi)\right)$$

$$L_{EFT}=\sum_{d=0}^{\infty}\sum_{i(d,n)} c_i(M,\Lambda)\, O_i\left((\partial,m)^d\varphi^n\right)$$

renormalization-group invariance $\frac{\partial Z}{\partial \Lambda}=0$

local

underlying symmetries

$$\begin{cases} T = T^{(\infty)}(Q) \sim N(M) \displaystyle\sum_{\nu=\nu_{\min}}^{\infty} \sum_i \tilde{c}_{\nu,i}(\Lambda) \left[\frac{Q}{M}\right]^{\nu} F_{\nu,i}\left(\frac{Q}{m};\frac{\Lambda}{m}\right) \\ \dfrac{\partial T}{\partial \Lambda} = 0 \end{cases}$$

$N(M)$: normalization

$F_{\nu,i}$: non-analytic, from loops

$$\nu = \nu(d, n, \ldots)$$ "power counting"

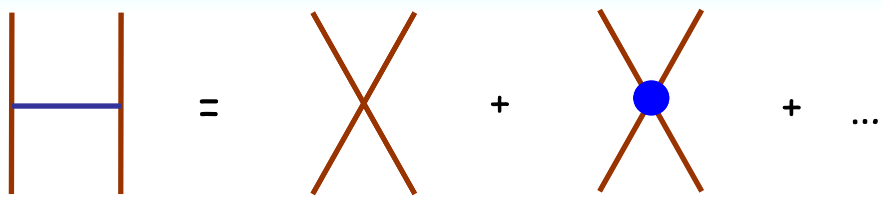
↳ e.g. # loops L

For $Q \sim m$, truncate consistently with RG invariance so as to allow systematic improvement (perturbation theory):

$$T = T^{(\nu_{\max})} + O\left(\frac{Q}{M},\frac{Q}{\Lambda}\right)^{\nu_{\max}+1} \qquad \Lambda\frac{\partial T^{(\nu_{\max})}}{\partial \Lambda} = O\left(\frac{Q}{\Lambda}\right)^{\nu_{\max}+1}$$

most common dino* misconceptions

1) EFT doesn't include the rho, omega, (insert here your pet resonance), pomeron, bagged quarks, …



$$\frac{1}{q^2+m^2} = \frac{1}{m^2} - \frac{q^2}{m^4} + \ldots$$

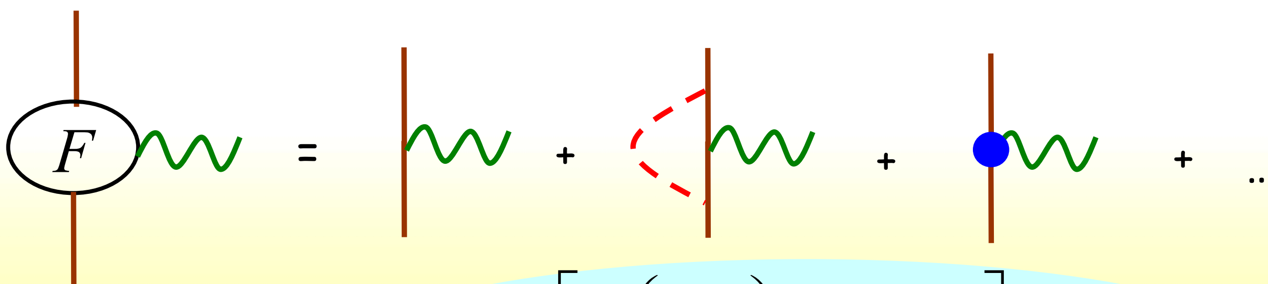
$$\rightarrow C_0 + C_2 q^2 + \ldots$$

a.k.a. multipole expansion

e.g. Fermi theory

but **not** any "effective model" *is* EFT

2) Cutoff should be set by nucleon size



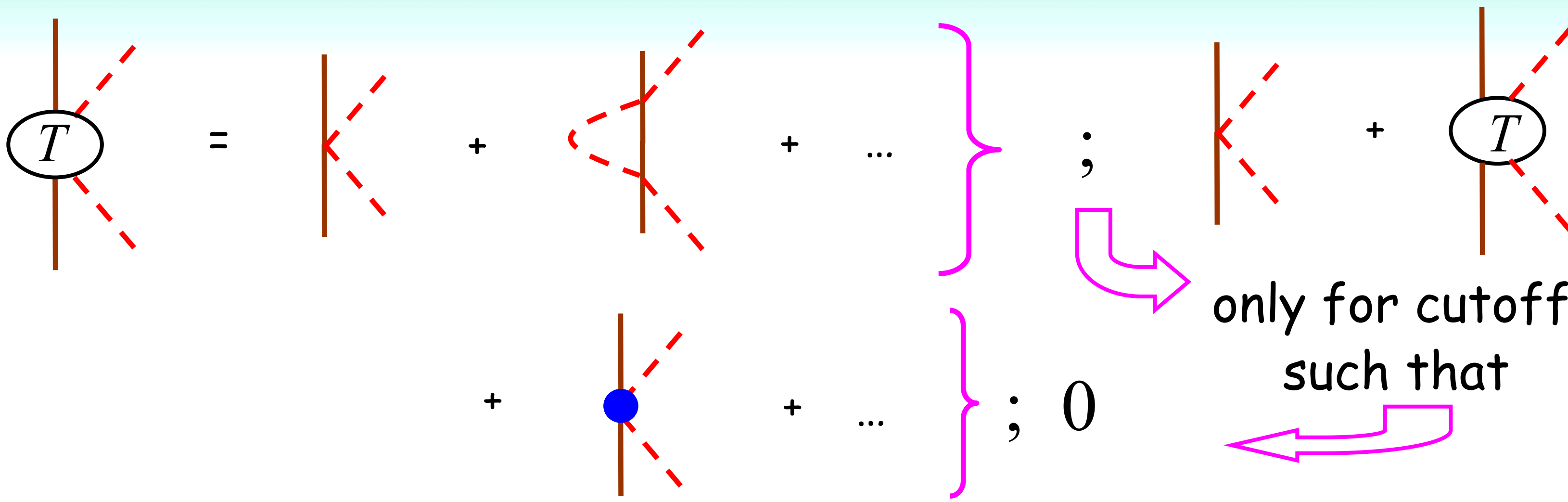
$$F(q^2) = 1 + \frac{q^2}{(4\pi f_\pi)^2}\left[f\left(\frac{q^2}{m_\pi^2}\right) + \#\ln\frac{\Lambda}{q}\right] + c_2(\Lambda)\, q^2 + \ldots$$

$$= -\frac{1}{6}\langle r^2 \rangle q^2 + O\left(\frac{q^4}{m_\pi^4}\right)$$

c.f. "highly non-linear behavior", "Wilsonian RG", other psycho-sociological mambo-jambo

* Should not be interpreted as excluding other animals.

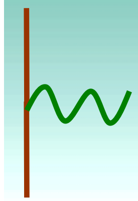
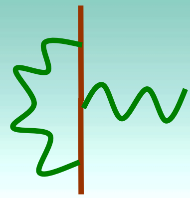
3) Part of something small can always be iterated

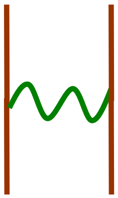
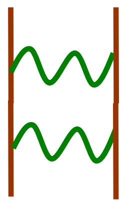


but can only be done in one channel…

4) If you iterate pions you are loose the link with ChPT

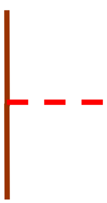
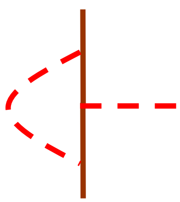
No more than the link you loose with QED when you iterate photons.

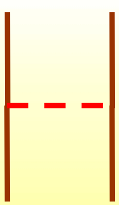
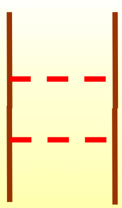
 $: \; e$  $: \; e^3 \frac{Q^4}{(4\pi)^2}\left(\frac{1}{Q^2}\right)^2 : \; e\alpha$

 $: \; \frac{e^2}{Q^2}$  $: \; e^4 \frac{Q^3}{4\pi}\left(\frac{\mu}{Q^2}\right)\left(\frac{1}{Q^2}\right)^2 : \; \frac{e^2}{Q^2}\frac{\alpha\mu}{Q}$

} resum for $Q \lesssim \alpha\mu$

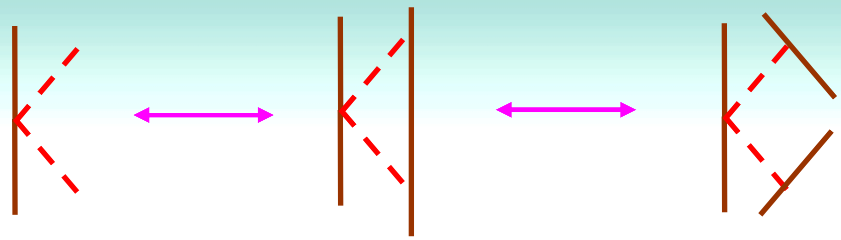
Weinberg '79 '90

 $: \; \frac{Q}{f_\pi}$  $: \; \frac{Q^4}{(4\pi)^2}\left(\frac{1}{Q^2}\right)^2\left(\frac{Q}{f_\pi}\right)^3 : \; \frac{Q}{f_\pi}\left(\frac{Q}{4\pi f_\pi}\right)^2$

 $: \; \frac{1}{f_\pi^2}$  $: \; \frac{Q^3}{4\pi}\left(\frac{\mu}{Q^2}\right)\left(\frac{1}{Q^2}\right)^2\left(\frac{Q}{f_\pi}\right)^4 : \; \frac{1}{f_\pi^2}\frac{\mu}{4\pi f_\pi}\frac{Q}{f_\pi}$

} resum for $Q \gtrsim \frac{4\pi f_\pi}{\mu} f_\pi$

5) There is no predictive power in EFT



i.e., physics is not limited to A>1

6) Power counting should work in every little corner of phase

$p^0 \sim |\vec{p}|$

or

$p^0 \sim \dfrac{\vec{p}^{\,2}}{m_N}$

will not hold everywhere, only genericallly

e.g., at threshold

7) EFT should work for high-energy observables and/or non-observables ("because I said so")

Nope.

… (too many to list'em all)

Is Nuclear EFT© dead?

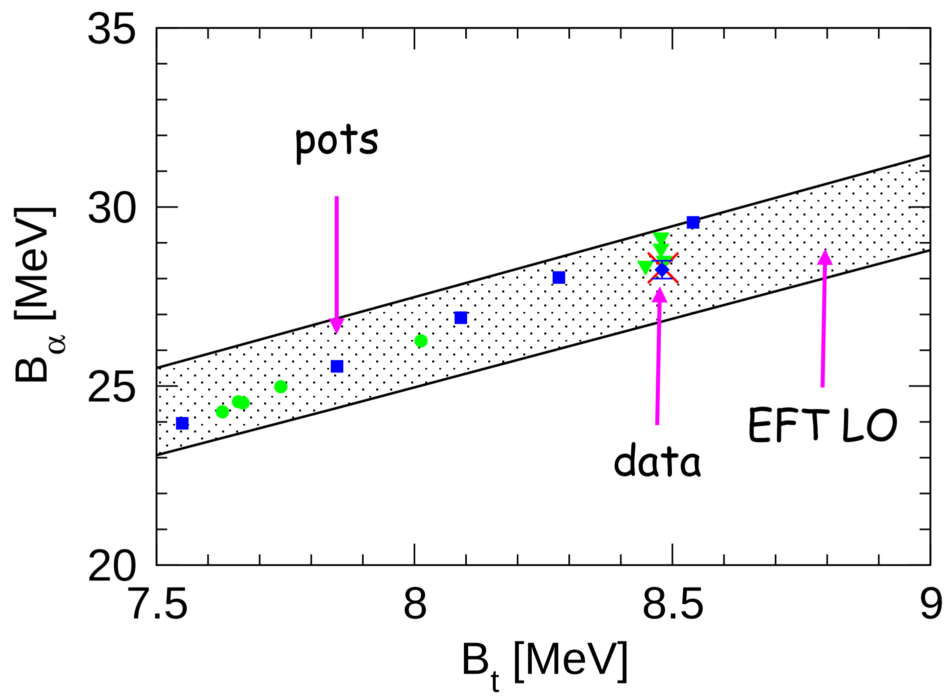
Most definitely not!

e.g.

any theory: Hemmert An extra criterion to promote counterterms?

pionless theory: Griesshammer A method to pro/demote counterterms

Platter *et al.* '04



Stetcu NCSM without a twist…

pionful theory:

Nogga
Epelbaum

- Promotion of counterterms in LO;
- Perturbative treatment of subLO ?

Issue: correct renormalization of singular potentials

Beane, Bedaque, Childress, Kryjevski, McGuire + v.K. '01

Pavon + Ruiz '04

$$V(r) \overset{r?\ R}{\longrightarrow} -\frac{\lambda}{2mr_0^2}\frac{f(r/r_0)}{(r/r_0)^n}$$

S wave

$$\psi_n\left(r : \ r_0 \ ? \ \ R\right) \equiv \frac{u_n(r)}{r} \qquad u_n(r = \ r_0) = \left(\frac{\lambda}{(r/r_0)^n}\right)^{-\frac{1}{4}} \cos\left(\frac{\sqrt{\lambda}}{(n/2-1)(r/r_0)^{n/2-1}} + \delta_n\right) + \mathrm{K}$$

if no counterterm, will depend on cutoff R

What happens in higher partial waves?

Similar phenomenon ⇨ new counterterm to avoid model dependence

Other issues:

Pavon   Anomalously small counterterms in some waves?

Higa   Can formally subleading terms be seen at large distances?

Gardestig   Brave in-progress calculation of $np \to d\pi^0$

(Where are the dinos?)

Are conventional pots any less dead?

mostly developments in few- and many-body applications: later
PWA13

quackless theory: Rentmeester

advances!

- New database
- Long-range physics believable
- Changes outside error bars at high energies but minor at low?!
- No Adnorm!!
- ...

quackful theory: oops, sorry, no youngsters here

What is the point of V_{lowk} ?

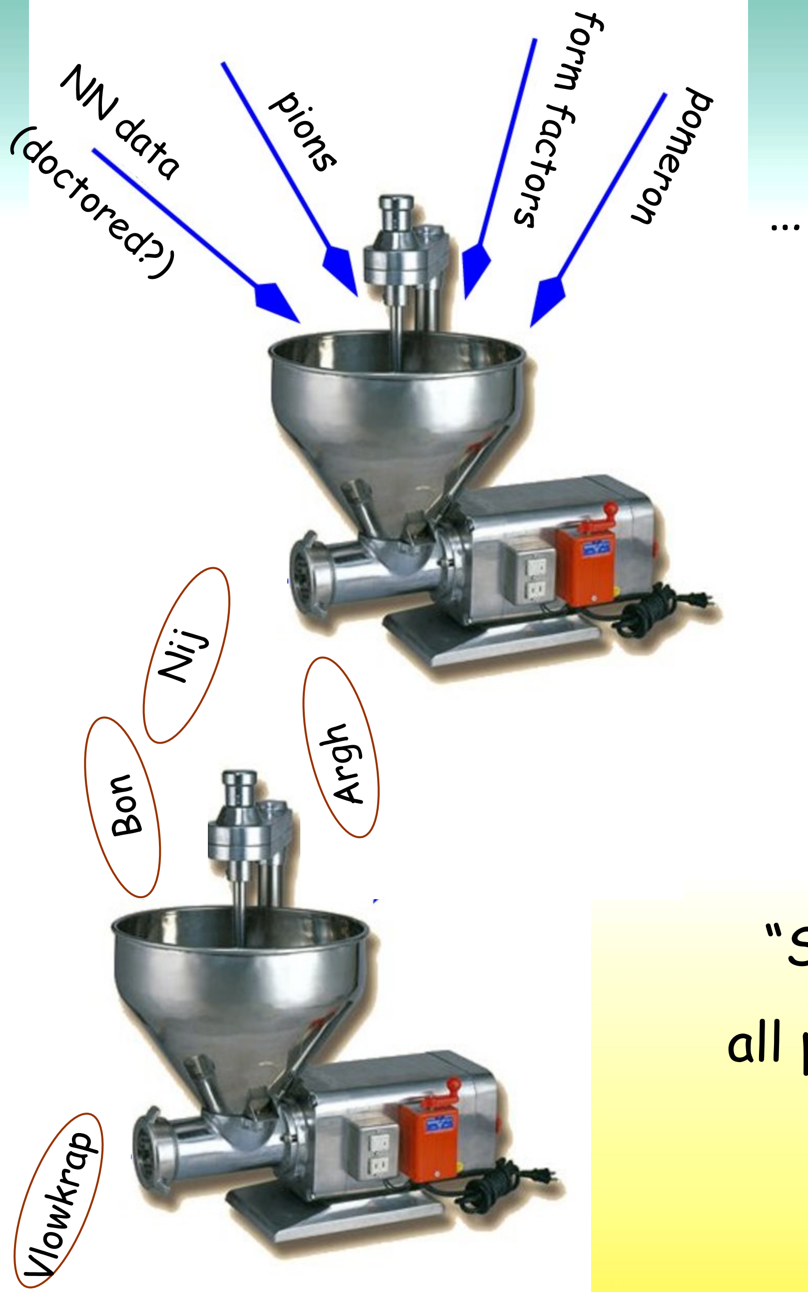
Schwenk
Coraggio

1) The lowdown on Vlowk
2) Low k and many bodies

WARNING

The following contains reenactment of real events;
it contain scenes some viewers may find objectionable;
viewer discretion is advised.

Adapted from
Kaplan '98



Repackaging

"Stop fighting:
all pots the same"

But world not only nuclei!   (And even if it were: 3-body forces? MECs?)

A nicer view
(I think …):

EFT pot
at Λ

RG

inspired by
Machleidt '05

EFT pot
at $\Lambda' < \Lambda$

Reduces $1/\Lambda$ errors?!
Could be useful.

Many-body systems- claim: best is $\Lambda \approx 400\ \mathrm{MeV}$

Ideally:

controlled expansion where at each order cutoff effects to go as

$1/\Lambda^n,\ n > 0$ ⟹ want large Λ

Suspicious of any approximate scheme without this property…

However:

LO non-perturbative and needs complicated sum of infinite number of diagrams, to be done numerically

⟹ Cancellation between cut-off sensitive effects might be difficult…

{ Intriguing but dubious for Hartree-Fock
Probably useful in "exact" methods

Few- and Many-Body Developments?

Deltuva	breakthrough in momentum-space treatment of pd
Lazauskas Marcucci	nd/nt puzzle and new three-body forces?
Quaglioni	great progress in FSI in photo/electrodisintegration of light nuclei

+ stuff above

My conclusions?

EFT + low cutoffs + new few- and many-body methods:

great potential for the next couple of years,

till we meet again

But…

Sitting duck, Trento, 1999

… as usual,

progress most likely to come from

independent, even stubborn, yet intellectually honest, work