Effective quark potentials from Unitary Clothing Transformation Method.

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Contents

1. Problems of conventional QFT, motivations for new methods;
2. Alternative approaches. Clothed particle representation;
3. Implications to mesodynamics and QCD;
4. Conclusion and outlook;

Still, we've got some problems	Where it comes from?	Where we may aim to?
Field-theoretical interactions are unphysical and produce infinities in the S-matrix. **Renormalization procedure assumes moving infinities from S-matrix to Lagrangian** and so to dynamical generators – Hamiltonian, boost.	The QFT – even after renormalization procedure – does not operate physical (observable) particles. Being assigned new masses and couplings, they are still 'bare' particles with unobservable properties.	Theory must operate observable objects – particles with physical properties – physical interactions, observable dynamics (time evolution), observable masses and couplings (Greenberg, Schweber)
Not all quantum fields have desired properties. **Massless spin-1 fields are not Lorentz 4-vectors.** Only gauge-invariant couplings are allowed (Weinberg).	Quantum fields are not fundamental ingredients of nature, they are auxiliary tools for building Lorentz-invariant S-matrix.	In fact, we do not need manifestly covariant Lagrangian for ensuring Lorentz-invariance of the S-matrix. The necessary and sufficient requirement is the fulfillment of the Lie algebra. (Kazes, Stefanovich)
We also may want to include non-local fields, non-local interactions in the theory (mesodynamics, ultraviolet cutoff) in a consistent manner.	Non-local fields violate micro-causality causality principle and so – S-matrix relativistic invariance (Efimov)	We can acquire much more freedom abandoning the conventional field-theoretical formalism and the concept of quantum fields.

Conventional QFT

Construct quantum field for each type of particle

Compose Lorentz-scalar, gauge-invariant interaction density that satisfies causality requirement

Add few infinite constants to it

Obtain the Lorentz-invariant finite S-matrix

Clothed Particles Representation (CPR)

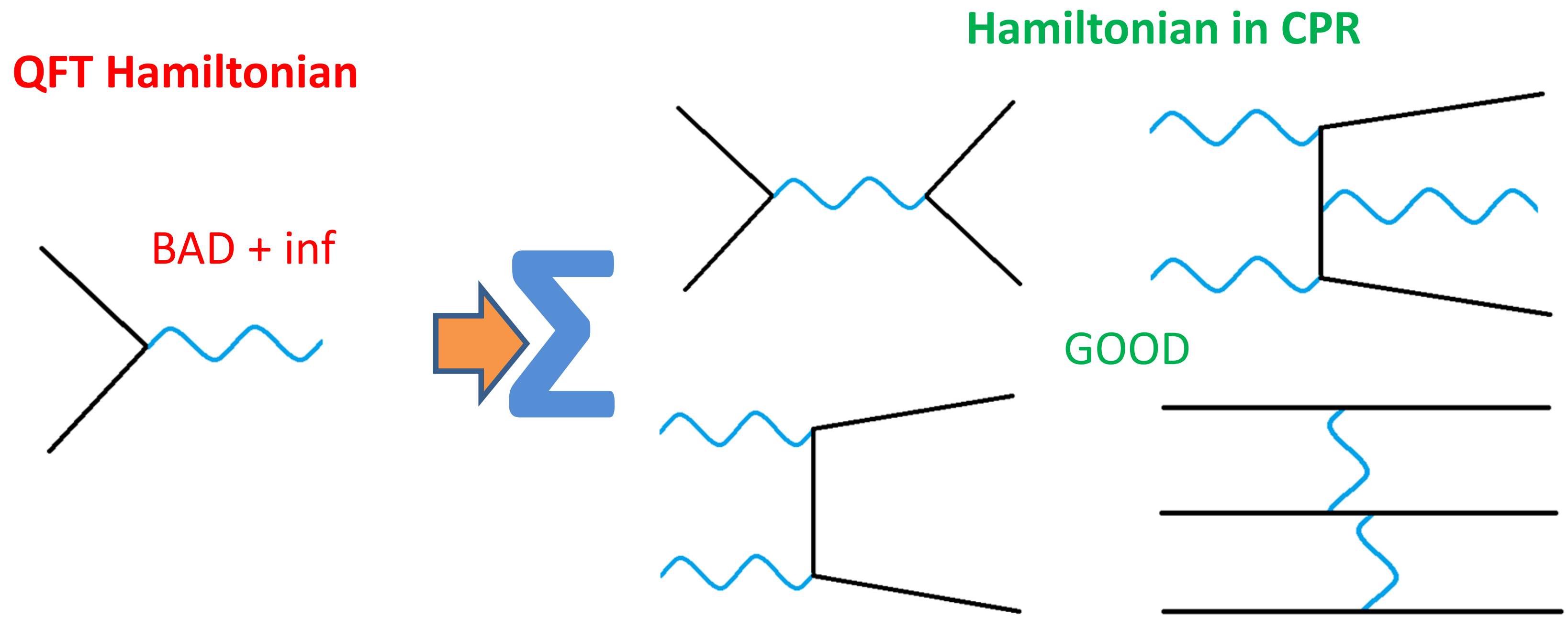
Move to clothed particles representation via dedicated Unitary Clothing Transformation

Obtain finite physical S-operator and finite physical dynamical generators: Hamiltonian, boost, etc.

Greenberg ,Schweber approach

The Clothed Particle Representation in QFT

Representing the QFT Hamiltonian (and simultaneously all generators of Poincare group) in terms of new particles is accomplished via order-by-order unitary tansformations.



One-clothed-particle states are the eigenstates of the Hamiltonian, represented in terms of clothed particle operators. Along with removing bad terms from H, the renormalization is automatically done. What remains in H is the family of the relativistic interactions between clothed particles. Stress that now H cannot be represented in terms of fields.

We obtain simultaneously physical finite Hamiltonian (as well as boost operator) and relativistic S-matrix.

Conventional QFT

Construct quantum field for each type of particle

Compose Lorentz-scalar, gauge-invariant interaction density that satisfies causality requirement

Add few infinite constants to it

Obtain the Lorentz-invariant finite S-matrix

Abandon the concept of fields

Construct particle interactions from scratch, relying only on relativistic invariance.

Obtain finite physical S-operator and finite physical dynamical generators: Hamiltonian, boost, etc.

Kazes approach

Calculate finite physical dynamical generators: Hamiltonian, boost, etc. from known S-operator

Stefanovich approach

Theoretical implications.

Bound states, nuclear physics and mesodynamics.

1. Since non-local extensions do not violate Relativistic Invariance in our particle algebraic approaches, it possible to apply it to the nuclear physics and mesodynamics.
Here, one is able to consistently introduce, e.g., nucleon form-factors and UV-cutoffs and, thus, treat nuclear systems as few-body systems.

2. Having at hand physical operators of Hamiltonian and boost is extremely important in describing the evolution of bound states.

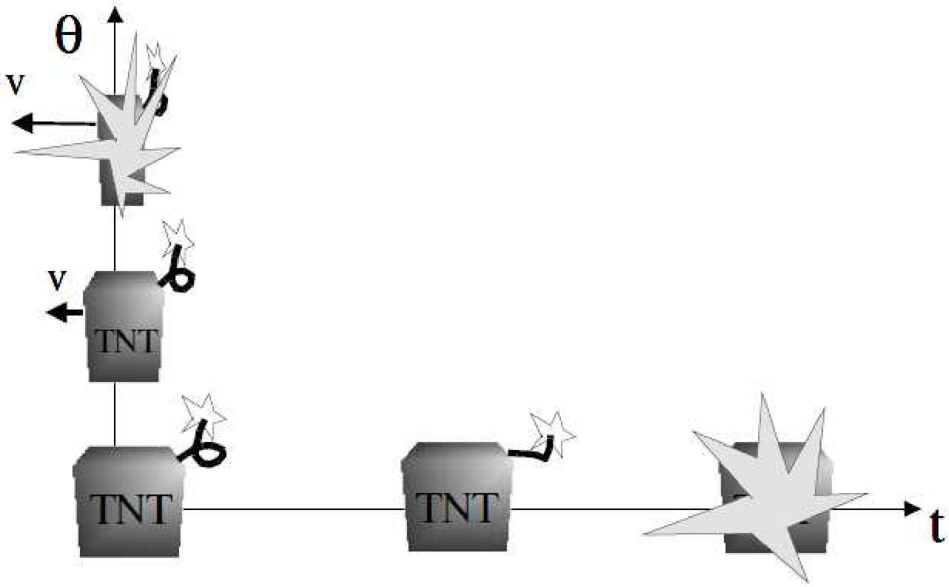
3. The approach has been applied to nucleon-nucleon scatterring (Shebeko, Dubovik), the theory of deuteron and 3N forces for nuclear physics.

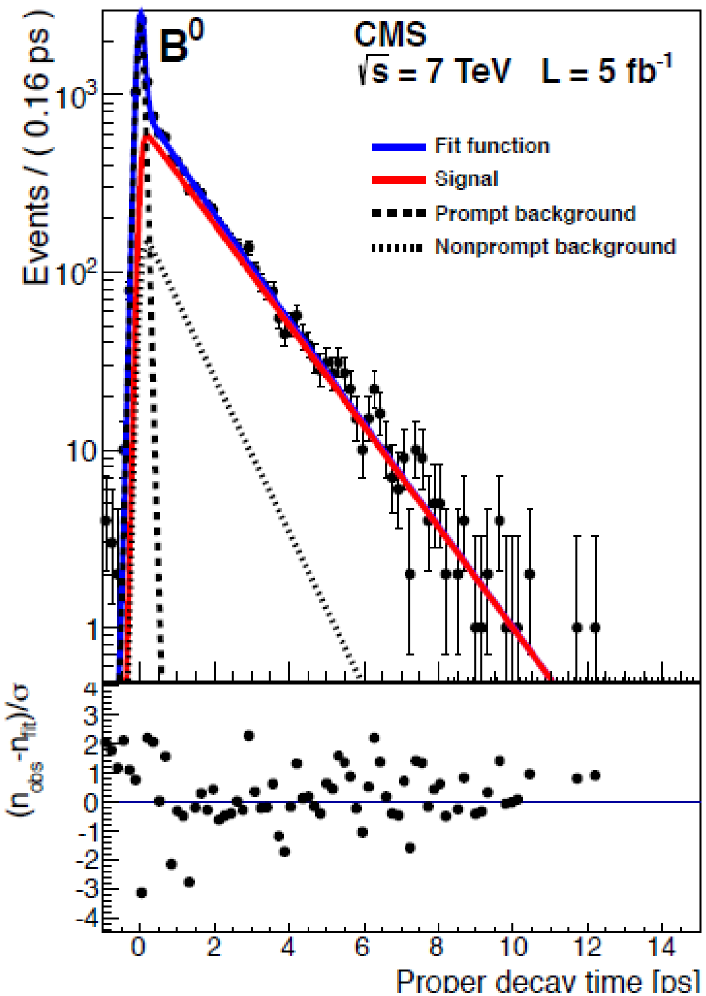
Experimantal implications.

Lifetime of composite particles (Stefanovich).

In CRP the boost operator depends on particle interactions as well as Hamiltonian (time evolution) operator.

It was stressed that possible observable effect stemming from this fact may consist in dependence of lifetime (or decay width) of composite particles on their speed.



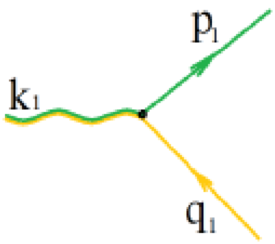


These type of effects violate microcausality axiom of QFT (Stefanovich) however – this violation does not affect relativistic invariance in CPR.

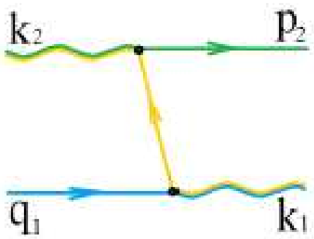
E. Stefanovich, arXiv:physics/0504062

Theoretical implications.
Quark-gluon potentials from QCD.

We transform quark/gluon creation-annihilation operators and let **only interactions between color-neutral states** of new (clothed) quarks/gluons.



BAD



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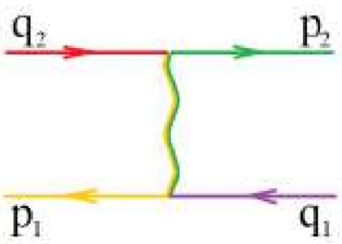

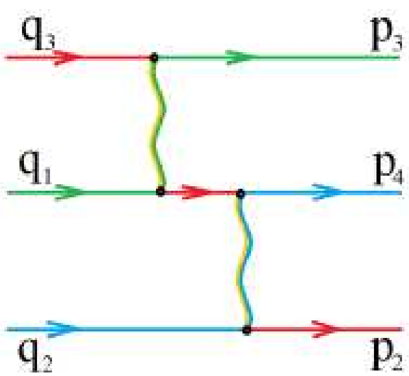

This procedure would lead us to Hamiltonian in (as we call it) “clothed color” representation.

Elimination of operators with non-empty energy shell gives birth to the relativistic “confinement propagators”, having poles, responsible for confinement of quarks and gluons within color-neutral states.

As the byproduct - the mass and coupling renormalizations are implemented.
The masses of clothed quarks are expected to be close to constituent masses, and the coupling strength is reduced at high energy transfers.
The confinement propagators are responsible for confinement at low energy transfers.

This effective theory can not be formulated in terms of fields!

Work is in progress now… I.Yeletskikh, arXiv:1404.4383

Conclusions

1. Quantum fields are convenient auxiliary tools for building QFT. However – they have some fundamental undesirable properties. It is possible to build a spectrum of (effective) relativistic quantum theories, that cannot be formulated in terms of fields.

2. The requirement of microcausality is not physical and it does not affect relativistic invariance. It is possible to make non-local extensions to our theory without affecting relativistic invariance (macrocausality, or 'cluster separability').

3. The principle of gauge invariance is (probably) not a fundamental principle of nature. We always have to question it's predictive power…

4. A number of theoretical and experimental implications suggested.

Thanks for attention