Thesis advisor's report on the PhD thesis of Tomáš Brauner "SPONTANEOUS SYMMETRY BREAKING IN STRONG AND ELECTROMAGNETIC INTERACTIONS"

The essence of the thesis of T. Brauner is in his four reprinted research papers. For self-consistency I express my attitude to this part of the thesis by essentially quoting from my recent letter of recommendation for T.B. The recommendation supports T.B.'s application for the postdoctoral position. Everybody understands that the emergent violation of causality is a practical necessity. The task is, however, the same: To evaluate properly the quality of T. Brauner's scientific work.

Paper [I]: At the beginning of our collaboration it seemed to me obvious that somebody should elaborate on a color superconductor with color-sextet condensate, for at least two reasons: First, the pattern of spontaneous gauge SU(3) symmetry breaking with the Higgs sextet was not known. Tom's independent analysis which he worked out very quickly (presented as the Section II of [I] is, according to my standards, exquisite and ready for being used as an advanced exercise solved with high clarity. Second, although the naive one-gluon exchange between two quarks is repulsive in the color-sextet channel, it was worth of trying to argue in favor of an alternative mechanism for the attraction in this channel, in particular at moderate baryon densities where the interaction between all relevant colored excitations is expected to be strong. At this point I have first recognized Tom's rather characteristic property: He does not like tinkering with vague physical ideas. He likes formulating the problem to be solved in a solid theoretical framework. Finally we have found arguments for the relevance of spin-zero color-octet gluon-gluon composites which Tom could swallow.

Paper [II]: After several trials to accept life without elementary scalars in an effective field theory description of electroweak interactions I changed, at least temporarily, the religion: The family-distinguishing Yukawa couplings which naturally break explicitly all unwanted global symmetries of the electroweak lagrangian in the symmetric phase deserve admiration. Again, I had a hard time to convince Tom by heuristic semi-quantitative computations that the dynamical electroweak SU(2)×U(1) symmetry breaking is possible without introducing the 'wrong sign' scalar field mass term, solely due to the Yukawa interactions of massless fermion fields with heavy scalars. His many critical remarks lead us to many improvements of the rough idea, and to its formulation in terms of a concise and elegant field-theory formalism. From the response to our manuscript (paper [V]) submitted to Phys. Rev. Letters we concluded that in order to sell the idea we have to proceed in steps, and to start with a detailed example with global Abelian chiral symmetry.

The first step was apparently successful (paper [II]): We have demonstrated that the chirally invariant Yukawa interaction of a massless fermion field with a massive complex scalar field degenerates, above a (large) critical value of the coupling constant, the fermion mass. We were deliberately humble in presenting our findings. This time the referee report was more encouraging: "I'd even wish to remark that the authors only partially succeeded in expressing the importance of their results, a more eloquent style in writing this paper would have been an improvement."

Paper [III]: As usual, some time ago I started to spread out the challenge to understand subtleties associated with the Nambu-Goldstone (NG) excitations in Lorentz-noninvariant field theory models. All of the sudden Tom came with an exhausting, elegant and crystal-clear analysis of the properties of the NG boson spectrum in sigma models with chemical potential. Not surprisingly for me the paper was quickly accepted for publication.

Paper [IV]: Genesis of this paper is similar: Studying the two-color QCD is already for some time on our research list. All of the sudden Tom came with an exhausting, elegant and crystal-clear analysis of the chiral perturbation theory for this strongly interacting world using its novel and physically transparent, parametrization. Not surprisingly for me also this paper was quickly accepted for publication.

The four reprinted original papers are preceded by a guide.

First, what this guide is not. With my full approval it is not a detailed manual on technical aspects of the thesis. Here I hurry up to confirm that in the field theory apparatus T. Brauner is excellent. For color superconductivity, however, there is a plenty of nice and detailed technical reviews. On the other hand, the suggested dynamical electroweak symmetry breakdown as well as the physics of 'anomalous' Goldstones are still in exploratory stages. Their nontrivial technical quantum field theory aspects are still in progress.

I find the guide truly pretty and valuable primarily to those familiar with the subject. Honestly evaluating each word, the text is distinguished by clarity and convincingly manifests its author's understanding of the subject and his maturity as the theoretical physicist.

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Nuclear Physics Institute, Academy of Sciences of the Czech Republic
25068 Rez (Prague), Czech Republic
e-mail: hosek@ujf.cas.cz