The PQFT document style users guide

JINR, Dubna

June 17, 2003

1 Introduction

The Proceedings of XII International conference on "Selected Problems of Modern Physics" (Section I), held on June 8–11, 2003 in Dubna, (1 volume) are expected to be published by the Publishing Department of the Joint Institute for Nuclear Research (Dubna). The Proceedings will mainly comprise the plenary talks. The authors of parallel session talks interested in publication in the Proceedings should present a hard copy of their contribution to the Organizing Committee for reviewing and selection.

The Proceedings will be printed from camera-ready manuscripts. Manuscripts must be prepared in the LaTeX 2_ε (preferable) or LaTeX2.09 formats. Please, use our Proceedings style files `pqft.sty` and `pqft209.sty` which are available at our web-site (`URL:http://thsun1.jinr.ru/~/pqft`). All figures should be given in EPS or PostScript formats.

In this format the page limitations of talks at plenary and parallel sessions are 12 pages and 5 pages, respectively.

The deadline for submitting papers (LaTeX files for plenary talks and hard copies with LaTeX files for parallel session talks) is **September 15**, 2003. The Organizing Committee will appreciate it very much if you could provide us with your manuscript at the Conference.

Send all questions concerning the usage of `pqft.sty` via e-mail to: `pqft@thsun1.jinr.ru`.

2 Using pqft.sty

2.1 Overview

The PQFT style contains a few definitions to the `article` style/class slightly changing the appearance of the Proceedings. All commands defined in the `article.sty` or `article.cls` files can be used as usual. The formatting of the title, authors names is changed as well as the sectioning commands. Specific information indicating that the manuscript is to be printed in the Proceedings is added to the first page of each article. The appearance of page headings and footings is also changed.

2.2 Initializing pqft.sty

The description of the page style of the Proceedings is contained in the files `pqft.sty` and `pqft209.sty`. The user should not edit them. These files are prepared as packages and must be loaded before LaTeX starts processing the main content of the document. These files should be place either in the same directory as the file with the source LaTeX code of the article or in the standard directory where the LaTeX compiler is configured to search for packages. To load a style file, the user should include specific data into the source LaTeX file. LaTeX 2_ε users should add the command `\usepackage{pqft}` in the article:

```
\documentclass[12pt]{article}
\usepackage{pqft}
```

while the LaTeX2.09 users should write

```
\documentstyle[12pt,pqft209]{article}
```

in the beginning of the document.

2.3 Macros

Authors are not recommended to use macro definitions for they can interfere with other definitions. All articles will be compiled in one file and processed as a whole.

2.4 The title, authors, and institution

The content of an article begins with the command `\begin{document}` as usual. The title of the manuscript should be given as the argument of the command `\title{}`:

```
\title{The title of the talk}.
```

(The well-known `article` style command `\title{}` is redefined in `pqft.sty`.)

The authors' names are introduced by the command `\author{}`. The argument of `\author{}` must be a comma-separated list of names followed by the `\inst{}` command. The names should begin with initials followed by the last name. Initials should be separated by blank spaces or tildes, a blank space or a tilde should separate initials from the last name:

```
\author{I. I. Author1\inst{1}, J. J. Author2\inst{2},
K. K. Author3\inst{1,2}}.
```

The arguments of the command `\inst{}` should be the numbers associated with institutes (see the command `\institutes{}` below). If a co-author is affiliated in several institutes then write a comma-separated list of the corresponding numbers (e.g. `\inst{1,2}`).

The institution of authors is given by the command `\institutes{}`. It accepts as an argument the numerated list of authors' institutions. Each institute data should begin with the `\inst{#}` command, where `#` stands for the number of the institute in the numerated list:

```
\institutes{\inst{1} Institute 1 \inst{2} Institute 2}.
```

2.5 Abstract

Each manuscript is supposed to have a short abstract. It should be introduced as an argument of the command `\abstract{`⟨*The abstract contents*⟩`}`. The abstract should not contain empty lines.

2.6 Headings

The headings of the proceedings will have page numbers and abridged titles and authors' names list. The title and authors' names will not appear in the headings automatically. It is up to the author to decide how the "running" title and authors' names list will appear in the headings of pages. If the title is short, it can appear in the headings unabridged. The same rule is for the authors names. The content of the headings is different for even and odd pages. The authors names will show on even pages and the running title will appear on odd pages. The content of the headings is controlled by two commands:

```
\titlerunning{The title ...}
\authorrunning{Author1, Author2, Author3}.
```

2.7 Document structure

Each manuscript should be well structured. The author can use the structuring commands: `\section{}`, `\subsection{}`, `\subsubsection{}` as usual. Their content is slightly changed within the `pqft.sty` script and the layout will be a bit different from what the `article` style/class usually produces.

```
\section{Section name}
\subsection{Subsection name}
\subsubsection{Subsubsection name}
```

The command `\paragraph{}` is also redefined, however it is unlikely to be used for such short documents.

2.8 Citation

References for papers are defined by the command `\cite{}` as usual. As the final copy of the proceedings will contain all manuscripts, authors are recommended to use unique reference names. To avoid collisions in the reference names use the following format: `\cite{AA:II:ref}`, where `AA` are first letters in the last names of authors (or, if the author is one, the initials and the first letter of the last name), `II` is the abbreviation for the institute name of one of the authors, and `ref` is the user-defined reference.

The Reference section should begin with

```
\begin{thebibliography}{99}\itemsep=0pt
```

followed by a list of referred papers as usual, e. g.,

```
\begin{thebibliography}{99}\itemsep=0pt
\bibitem{AAA:III:barrois77} B. Barrois,
Nucl.~Phys.~B \textbf{129}, 390 (1977).
\bibitem{AAA:III:bailin84} D. Bailin and A. Love,
Phys.~Rep. \textbf{107}, 325 (1984).
\bibitem{AAA:III:iwasaki95} M. Iwasaki and T. Iwado,
   Phys.~Lett.~B \textbf{350}, 163 (1995).
\end{thebibliography}
```

The reference item should begin with authors names. The authors names should begin with initials with full-stops and separated by blank spaces or tildes. The journal name should be separated from the names by a comma. The journal name is followed by the series (if exists), the volume number (printed in boldface), comma, the first page number, and the year of publication closed in parentheses. The reference should end with a fullstop. **Users are recommended to format the references to journals in one style.** The document should be ended with the line `\end{document}` as usual.

2.9 Examples

A template file where the `pqft.sty` file is used is given here (it can be downloaded from the conference web-cite: `URL:http://thsun1.jinr.ru/~/pqft`)

```
\documentclass[12pt]{article}
\usepackage{pqft}
\begin{document}
\title{The Title of the Paper}
\author{Author1\inst{1,2}, Author2\inst{2}, Author3\inst{2}}
\institutes{\inst{1}Institute1, \inst{2}Institute2}
\maketitle
\abstract{A short description of the paper.}
\authorrunning{Author1, Author2, Author3}
\titlerunning{Title running}
\section{Introduction}
\subsection{Subintroduction}
\subsubsection{Subsubintroduction}
....
Here is the body of the article should be placed \cite{paper1}.
....
\begin{thebibliography}{99}\itemsep=0pt
\bibitem{AAA:II:paper1} D. Blaschke, G. Burau, M. K. Volkov,
and V. L. Yudichev, Eur.~Phys.~J.~A \textbf{11}, 319--327 (2001).
\end{thebibliography}
\end{document}
```

Next is an example of a source code.

```
\documentclass[12pt]{article}
\usepackage{pqft}
\begin{document}
\title{Coexistence of color superconductivity
and chiral symmetry breaking within the NJL model}
\author{D. Blaschke\inst{1,2}, M. K. Volkov\inst{2},
V. L. Yudichev\inst{2}}
\institutes{\inst{1}Fachbereich Physik, Universit\"at Rostock,
D-18051 Rostock, Germany \inst{2}Joint Institute for Nuclear
Research, 141980 Dubna, Russian Federation} \maketitle
\abstract{The phase diagram for quark matter is investigated
within a simple Nambu--Jona-Lasinio model without vector
correlations. It is found that the phase structure in the
temperature--density plane depends sensitively on the
parametrization of the model. }

\authorrunning{D.Blaschke,  M.K.Volkov, V.L.Yudichev}
\titlerunning{Coexistence of color superconductivity...}

\section{Introduction}
\subsection{Subintroduction}
\subsubsection{Subsubintroduction}
\paragraph{Parintroductions}
 The phenomenon of color superconductivity
\cite{AAA:III:barrois77,AAA:III:bailin84,AAA:III:iwasaki95}
is of general interest,
in particular, in  studies of the QCD phase structure
\cite{AAA:III:bloch,AAA:III:alford99}
and applications in the astrophysics of compact stars.
Different aspects have been investigated so far,
whereby  models of the NJL type have been
widely employed  in studies of the
phase structure in the vicinity of
the hadronization transition.

...

\begin{thebibliography}{99}\itemsep=0pt
\bibitem{AAA:III:barrois77} B. Barrois,
Nucl.~Phys.~B \textbf{129}, 390 (1977).
\bibitem{AAA:III:bailin84} D. Bailin and A. Love,
Phys.~Rep. \textbf{107}, 325 (1984).
\bibitem{AAA:III:iwasaki95} M. Iwasaki and T. Iwado,
```

```
   Phys.~Lett.~B \textbf{350}, 163 (1995).
\bibitem{AAA:III:bloch} J. C. R. Bloch, C. D. Roberts, and S. M. Schmidt,
   Phys.~Rev.~C \textbf{60}, 065208 (1999).
\bibitem{AAA:III:alford99} M. Alford, K. Rajagopal, and F. Wilczek,
   Nucl.~Phys.~B \textbf{573}, 443 (1999).
...
\end{thebibliography}
```

And the output produced by LaTeX 2_ε.

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Proceedings of XII International Conference on Selected Problems of Modern Physics, Section I, Dubna, June 8–11, 2003.

Coexistence of color superconductivity and chiral symmetry breaking within the NJL model

D. Blaschke [1,2], M. K. Volkov [2], V. L. Yudichev [2]

[1]Fachbereich Physik, Universität Rostock, D-18051 Rostock, Germany
[2]Joint Institute for Nuclear Research, 141980 Dubna, Russian Federation

Abstract — The phase diagram for quark matter is investigated within a simple Nambu–Jona-Lasinio model without vector correlations. It is found that the phase structure in the temperature–density plane depends sensitively on the parametrization of the model.

1 Introduction

The phenomenon of color superconductivity [1–3] is of general interest, in particular, in studies of the QCD phase structure [9, 10] and applications in the astrophysics of compact stars. Different aspects have been investigated so far, whereby models of the NJL type have been widely employed in studies of the phase structure in the vicinity of the hadronization transition.

Recently, it has been shown in these investigations that for low temperatures (T) and not too large chemical potentials (μ) the two-Flavor Color Superconductivity (2SC) phase is favored over alternative color superconducting phases. According to, the Color-Flavor-Locked (CFL) phase occurs only at $\mu > 430$ MeV.

It is generally agreed that at low temperatures the transition of the matter from the phase with broken chiral symmetry to the color superconducting phase is of the first order. From the point of view of phenomenological applications, as e.g. in compact star physics, the order of the phase transition to quark superconducting matter plays an important role. The conclusion about the first order phase transition was drawn within models without vector interaction channels taken into account; the vector interaction has been considered in few papers. It was found that the presence of quark interaction in the vector

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channel moves the critical line in the in $\mu - T$ plain to larger μ. Recently it has been demonstrated that the critical line of first order phase transition in the $\mu - T$ plane can have a second end-point at low temperatures, besides the well known one at high temperatures. The latter one could even be subject to experimental verification in heavy-ion collisions [8] whereas the former could be of relevance for neutron stars. While in this feature of the phase diagram was a consequence of the presence of interaction in the vector channel, we would like to investigate in the present work the sensitivity of the phase diagram to the choice of model parameters without interaction in the vector channel. We will demonstrate that in the absence of the vector channel interaction the phase transition is not necessarily of the first order, thus revising statements in Refs..

The structure of our paper is as follows. In Sect. 2, a chiral quark model is introduced, its Lagrangian is given and the model parameters are fixed from the vacuum state in two different schemes. Temperature and chemical potential are introduced into the quark model in Sect. 3, using the Matsubara formalism. The conclusions and a discussion of the obtained results are given in Sect. 4.

2 NJL model with the scalar diquark channel

In order to study the quark matter phase diagram including color superconductivity, one should generalize the concept of the single order parameter related to the quark-antiquark condensate in the case of chiral symmetry breaking to a set of order parameters when condensation can occur in other interaction channels too. The simplest extension is the scalar diquark condensate $\langle\psi\psi\rangle$ for u and d quarks

$$\delta = \left\langle \bar{\psi} i\gamma_5\tau_2\lambda_2 C\bar{\psi}^T \right\rangle \qquad (1)$$

which is an order parameter characterizing the domain where the color symmetry is spontaneously broken and the quark matter finds itself in the (two-flavor) color superconducting (2SC) state. This quantity is the most important one among other possible condensates that can be constructed in accordance with the Pauli principle . In (1) the matrix C is the charge conjugation matrix operator for fermions

$$C = i\gamma_0\gamma_2. \qquad (2)$$

The matrices τ_2 and λ_2 are Pauli and Gell-Mann matrices, respectively. The first one acts on the flavor indices of spinors while the second one acts in the

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color space.

If the electroweak interaction is discarded and only the strong coupling is in focus, the resulting quark matter phase diagram is essentially determined by nonperturbative features of the QCD vacuum state. One therefore has to resort to nonperturbative approaches to describe the behavior of particles at various conditions, ranging from cold and dilute matter up to the hot and dense one. A reliable and widely tested model to nonperturbative strong coupling QCD is provided by the Dyson-Schwinger equations , however, for qualitative studies like the one we attempt here it proves to be too complex. Therefore, we will use here a simple and tractable nonperturbative model of quark interaction, the Nambu–Jona-Lasinio (NJL) model, which has been extensively exploited for the description of the properties of the light meson sector of QCD (also to describe the CS phase and proved to be a model respecting the low-energy theorems. Before we proceed to the case of finite temperature and density, the model parameters that determine the quark interaction should be fixed. This shall be done for the vacuum state where hadronic properties are known. We will assume, according to common wisdom that, once fixed, these parameters (originating from the nonperturbative gluon sector of QCD) will not change, even in the vicinity of the transition to the quark matter. This transition is thus caused by medium effects in the quark sector only.

2.1 Lagrangian

In the present paper we restrict ourselves to the two-flavor case, leaving the strange quark and effects related to it beyond our consideration. As only two order parameters, the quark and scalar diquark condensates, are in focus during our investigation, the interaction of quarks will be represented in the Lagrangian by $SU(2)_L \times SU(2)_R$ symmetric scalar, pseudoscalar quark-antiquark, and scalar diquark vertices:

$$\begin{aligned}
\mathcal{L} &= \bar{\psi}(i\partial\!\!\!/ - \hat{m}^0)\psi + \mathcal{L}_{q\bar{q}} + \mathcal{L}_{qq}, && (3)\\
\mathcal{L}_{q\bar{q}} &= \frac{G}{2}\left[(\bar{\psi}\psi)^2 + (\bar{\psi}i\gamma_5\vec{\tau}\psi)^2\right], && (4)\\
\mathcal{L}_{qq} &= \frac{H}{2}(\bar{\psi}i\gamma_5\tau_2\lambda_2 C\bar{\psi}^T)(\psi^T C i\gamma_5\tau_2\lambda_2\psi), && (5)
\end{aligned}$$

where $\hat{m}^0$ is the diagonal current quark mass matrix $\hat{m}^0 = \mathrm{diag}(m_u, m_d)$, G and H are constants describing the interaction of quarks in the scalar, pseudoscalar, and scalar diquark channels, respectively. We work in the isospin symmetric case ($m_u^0 = m_d^0 \equiv m^0$), thus $\hat{m}^0 = m^0\mathbf{1}_f$.

References

[1] B. Barrois, Nucl. Phys. B **129**, 390 (1977).

[2] D. Bailin and A. Love, Phys. Rep. **107**, 325 (1984).

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[4] M. Iwasaki and T. Iwado, Prog. Theor. Phys. **94**, 1073 (1995).

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[6] R. Rapp, T. Schäfer, E. V. Shuryak, and M. Velkovsky, Phys. Rev. Lett. **81**, 53 (1998).

[7] M. A. Halasz, A. D. Jackson, R. E. Shrock, M. A. Stephanov, and J. J. Verbaarschot, Phys. Rev. D **58**, 096007 (1998);

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[9] J. C. R. Bloch, C. D. Roberts, and S. M. Schmidt, Phys. Rev. C **60**, 065208 (1999).

[10] M. Alford, K. Rajagopal, and F. Wilczek, Nucl. Phys. B **573**, 443 (1999)

[11] R. D. Pisarski and D. H. Rischke, Phys. Rev. Lett. **83**, 37 (1999).