Visitor report

Germany and U.S. Nuclear Theory Exchange Program
for QCD Studies of Hadrons and Nuclei (GAUSTEQ)

1. NAME AND HOME INSTITUTION OF TRAVELER:

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2. POSITION OF TRAVELER:

Faculty

3. DATES OF TRAVEL:

17. June – 1. August 2012. This includes periods for which no GAUSTEQ support was requested.

4. INSTITUTIONS VISITED

18. June – 27. June, 2012: Bochum, Germany (no GAUSTEQ support requested)
28. June – 17. July, 2012: Pavia, Italy (no GAUSTEQ support requested)
18. July – 31. July, 2012: Mainz, Germany (supported by GAUSTEQ)

5. SCIENTIFIC CONTACTS AND COLLABORATORS:

First period: Ruhr-Universität Bochum, Germany (no GAUSTEQ support)
Discussions about the latest developments in theory of generalized parton distribution functions (GPDs) and transverse momentum dependent parton distribution functions (TMDs), and their non-perturbative and chiral properties with Maxim Polyakov, Evgeny Epelbaum and their collaborators. Theory seminar by PI: "The D-term, its sign, and stability," June 22, 2012.

Second period: Università di Pavia, Italy (not supported by GAUSTEQ program)
Discussions about non-perturbative properties of GPDs and TMDs in effective models of hadrons. In particular studies of time-reversal odd (T-odd) TMDs, especially the Boer-Mulders function in the pion, their evolution properties, and phenomenological applications with Barbara Pasquini in Pavia. Theory seminar by PI: "Energy-Momentum Tensor, D-term, and Stability," July 17, 2012.

Third period: Gutenberg Universität Mainz, Germany (GAUSTEQ support requested)
Discussions of phenomenological applications of GPDs and TMDs in the context of the experimental programs at Jefferson Lab and the FAIR project at GSI with Marc Vanderhaeghen, Nikolai Kivel and their collaborators in Mainz. Non-perturbative calculations on the basis of lightcone quark models for the Drell-Yan process with Barbara Pasquini who came from Pavia to Mainz during this period. Theory seminar by PI: "What can we learn from the D-term about the nucleon," July 30, 2012.

6. TOPICS DISCUSSED DURING VISIT (focus on the Mainz period supported by GAUSTEQ):

During the stay in Mainz the PI discussed with the host Marc Vanderhaeghen and Barbara Pasquini (visitor from Pavia and long-term collaborator of the host) the opportunities of the experimental research programs at JLab and FAIR.

In the past results from non-perturbative calculations in lightcone-constituent quark models were successfully applied to the description of observables on azimuthal spin asymmetries in semi-inclusive deep-inelastic scattering [1, 2]. The results of these calculations compare well to available data, and played important roles in proposals of new JLab experiments [3–7] (to which the PI and B. Pasquini made contributions). While electron-nucleon scattering experiments provide important insights, crucial tests of the TMD factorization approach are only possible through combined studies of data from semi-inclusive deep-inelastic scattering (e.g. at JLab) and the Drell-Yan process (e.g. at FAIR).

In the discussions in Mainz consensus was reached that presently the highest priority goal is the demonstration of the applicability of the lightcone-constituent quark model to the description of Drell-Yan data sensitive to transverse parton momenta. Of particular interest in this context are data from pion-nucleon scattering on the so called violation of the Lam-Tung relation. These data are sensitive to the Boer-Mulders functions in the nucleon and pion.

During the stay in Mainz the PI and Barbara Pasquini focused on evolution of the results from the low initial scale of the model to experimentally relevant scales, and calculated relevant observables. The comparison of first numerical results to available data (from CERN, Fermilab) is encouraging. The paper is planned to be finalized early next year [8]. The host, Marc Vanderhaeghen, does not appear as co-author of this work at this stage, although discussions with him in Mainz were valuable, highly stimulating, and critical for the completion of Ref. [8].

Once the applicability of the approach to the description of Drell-Yan processes is demonstrated (early in 2013 according to current estimates), numerous applications will emerge. In particular, the approach might be used to the description of observables in Drell-Yan from proton-antiproton collisions at FAIR. The PI will stay in contact with Barbara Pasquini and the host concerning further developments in this direction.

7. IMPACT ON TRAVELER'S OR HOST'S RESEARCH:

It is expected that the research conducted in Mainz will result in a publication, Ref. [8]. It is planned that the results will also be disseminated on workshops and conferences, and summarized in the respective proceedings. The results are likely to lead to further applications and developments.

8. RELEVANCE TO JEFFERSON LAB OR GSI-FAIR:

The successful research of the PI and Barbara Pasquini has lead in the past to publications [1, 2] and was incorporated in proposals of new JLab experiments [3–7]. The research conducted in Mainz will demonstrate the applicability of the lightcone-constituent quark model to the description of Drell-Yan observables sensitive to transverse parton momenta. Once the approach has been shown to work, the next step will consist in making definite predictions for Drell-Yan observables in (unpolarized and polarized) proton-antiproton collisions at FAIR. In long-term this research will contribute to the demonstration that the same T-odd effects give rise to azimuthal (spin) observables in semi-inclusive deep-inelastic scattering (at JLab) and Drell-Yan (at FAIR).

9. SUGGESTIONS/RECOMMENDATIONS FOR PROGRAM ADMINISTRATORS:

The program crucially promotes exchange of research performed at U.S. institutions and in Germany. In view of the complementarity of the experimental programs at JLab and FAIR, an exchange of ideas and collaboration is vital for both facilities. The PI is grateful for the opportunities offered by GAUSTEQ and recommends a continuation of the program along the current guidelines.

10. SUPPORT PROVIDED BY HOSTS:

The PI acknowledges support by the local hosts (in Bochum, Mainz, Pavia) who have covered all local travel expenses (train, bus, etc) as well as lodging and per diem expenses in Bochum and Pavia.

11. ACKNOWLEDGMENTS:

Support from the GAUSTEQ program will be acknowledged in Ref. [8] and other prospective publications or proceedings based on the research conducted in Mainz by including the recommended text.

12. REFERENCES CITED:

[1] S. Boffi, A. V. Efremov, B. Pasquini and P. Schweitzer, "Azimuthal spin asymmetries in light-cone constituent quark models," Phys. Rev. D **79**, 094012 (2009).

[2] B. Pasquini and P. Schweitzer, "Naive time-reversal odd phenomena in semi-inclusive deep-inelastic scattering from light-cone constituent quark models," Phys. Rev. **D83**, 114044 (2011).

[3] H. Gao (co-spokesperson/contact) *et al.*, "An update to PR12-09-014: Target Single Spin Asymmetry in Semi-Inclusive Deep-Inelastic (e, $e'\pi^{\pm}$) Reaction on a Transversely Polarized ^{3}He Target at 8.8 and 11 GeV," a Hall A Collaboration Research Proposal, JLab Experiment PR-10-006 (2009).

[4] H. Avakian *et al.*, "Transverse Spin Effects in Kaon SIDIS at 12 GeV with Transversely Polarized Target using the CLAS12 Detector," Letter of Intent to the Jefferson Lab PAC 34.

[5] H. Avakian *et al.*, "Studies of the Boer-Mulders Asymmetry in Kaon Electroproduction with Hydrogen and Deuterium Targets," a CLAS Collaboration Research Proposal, JLab Experiment PR-09-008 (2008).

[6] H. Avakian *et al.*, "Studies of Spin-Orbit Correlations in Kaon Electroproduction in DIS with Longitudinally Polarized Hydrogen and Deuterium Targets," a CLAS Collaboration Research Proposal, JLab Experiment PR-09-009 (2008).

[7] H. Gao (spokesperson) *et al.*, "Target Single Spin Asymmetry in Semi-Inclusive Deep-Inelastic (e, $e'\pi^{\pm}$) Reaction on a Transversely Polarized ^{3}He Target at 11 GeV," a Hall A Collaboration Research Proposal, JLab Experiment PR-09-014 (2008).

[8] B. Pasquini and P. Schweitzer, work in progress.