

I. INTRODUCTION AND ADMINISTRATIVE OVERVIEW

1. Research

Abstract: Theoretical research is proposed with the goals of 1.) understanding particles such as protons and neutrons in terms of the fundamental theory of Quantum Chromodynamics (QCD), 2.) understanding the mass spectrum of particles, called hadrons, that can be formed from the binding of quarks and gluons, and 3.) understanding the origin of the forces between hadrons such as those that cause neutrons and protons to bind into nuclei.

The Theoretical Quarks, Hadrons and Nuclei group at the University of Maryland carries out a very broad research program centered on the study of hadronic physics. Its main goal is the understanding of the structure of particles such as protons and neutrons, and their interactions, in terms of the fundamental theory of Quantum Chromodynamics. For that we explore an array of analytical and numerical non-perturbative techniques in field theory and their impact on nuclear phenomenology. It also includes substantial effort in related areas such as neutrino physics, cold atoms, dark matter and non-perturbative techniques for gauge theories.

This progress report thus includes a large number of specific topics. They are organized below under the names of the faculty members more directly involved in each project but, given the highly interactive nature of our group, more than one group member may be involved in any of these topics. In addition, our postdocs (and students) are given the freedom and encouragement to pursue their own projects and have been very successful at that. Following the faculty sections are the reports of our postdoctoral research associates on studies they are carrying out independently.

2. The Theoretical Quarks, Hadrons and Nuclei Group at Maryland (TQHN)

A. Personnel and the Evolving History of the TQHN

The faculty of the TQHN presently consists of Professors Xiangdong Ji and Thomas Cohen, Associate Professor Paulo Bedaque and Research Professor Stephen Wallace.

Professor Cohen continues as the director of the Maryland Center for Fundamental Physics (MCFP). This center is one of the largest theory centers in the country and includes research in particle theory, cosmology and gravity as well as nuclear physics. The Center is supported with state funding which will increase over the next few years. MCFP provides support for students, postdocs, visitors, workshops, *etc.* We have been able in many instances to use our DOE grant to leverage additional resources from the MCFP.

In addition to his duties at Maryland, Prof. Ji is Dean of Physics at Shanghai JiaoTong University. The position in Shanghai is part-time requiring Prof. Ji to spend approximately 1/3 of his time in China. As a result of this position, Prof. Ji's teaching load at Maryland has been reduced and his available time for research in nuclear physics has been essentially unaffected. This connection to China is extremely valuable in terms of international scientific collaborations and is of great benefit to the TQHN Group. We are able to attract some of the very best Chinese students and postdocs to Maryland; these are typically supported through Chinese sources.

In Fall of 2011, Dr. Ilmo Sung will begin his second year of a two-year term as a postdoctoral research associate. Joining the group as a postdoctoral research associate will be Amy Nicholson

from the Inst. for Nuclear Theory, University of Washington, having completed her Ph.D. under the supervision of Dr. David Kaplan.

Haipeng An graduated in Spring 2011 and is currently working with Prof. Ji as a faculty research assistant. In the Fall he will join Perimeter Institute in Canada as a postdoctoral research associate. The graduate students in the group include Evan Berkowitz (advisor: Prof. Bedaque), who has been awarded a SURA fellowship for academic year 2011-2012, and Vojtech Krejcirik and Prabal Adhikari (advisor for both: Prof. Cohen). In addition, Yang Xu, a third-year graduate student from Peking University, was awarded a scholarship from the China Scholarship Council supplemented with support from Peking University to pursue her studies in the U.S. as a joint Ph.D. student at the University of Maryland under the supervision of Prof. Ji. We expect a new incoming student, Vivek Saxena, in the Summer of 2011 (advisor: Prof. Bedaque). Yong Zhao is a summer research graduate student working with Prof. Ji for Summer 2011.

Since Summer 2010, Prof. Cohen is advisor to undergraduate student, Mark Strother, who was on a scholarship in 2010, and is supported by the grant for Summer 2011. In Summer 2011, three high school students, Nilay Kumar, Geoffrey Ji, and Alec Jamogochian are working on projects with Prof. Cohen. Professor Bedaque is also advising a high school student, Nathan Ng. Although the high school students are not supported by the group, they contribute notably toward their faculty's research projects.

A list of all TQHN personnel, graduate student tracking information and career history of recent research associates and graduate students follow the faculty biographical sketches.

The group's activities are supported by one full-time administrative assistant (Loretta Robinette). She provides logistical assistance, coordination of group events, and some administrative requirements related to the grant's operations for the faculty, postdocs, students and visitors; maintains our inventory and oversees repair service requests for over 20 computers and printers; assists with the technical aspects and editing of research-related documents and DOE reports; is our group's webmaster; and assists with arrangements for workshops. The Department of Physics provided \$3,000 for secretarial support in the 2010-2011 academic year and will provide the same amount for the next year.

B. Research Environment

We have strived to maintain an informal, highly interactive atmosphere in the nuclear theory group. On a typical day there will be discussions on the blackboard involving several members of the group. During Spring and Fall we have our weekly nuclear seminar program (held jointly with the experimental group) and periodic MCFP colloquia. The interactions with the rest of the MCFP is likely to increase when, in about two years, the TQHN group will move together with all the other members of the MCFP, to the top floor of the new "Physical Sciences Complex", a state-of-the-art facility housing also the Astronomy Department. This environment, in addition to all the activities in the other parts of the Department, makes our program very attractive to graduate students and postdocs.

C. Visitors Program

We maintain an active visitors program with seminar speakers and collaborators at all stages of their careers visiting Maryland from a few days to a year at a time. Associate Prof. Yu Jia is visiting

from IHEP, Chinese Academy of Science, Beijing, and is supported by the grant for six months in 2011. He is collaborating with Profs. Ji, Bedaque and Cohen on quantum chromodynamics, heavy quarkonium physics and effective field theory.

Altogether we had 48 national and international visitors in 2010-July 2011 including seminars speakers whose expenses were either covered by the experimental nuclear physics group or shared with nearby George Washington University. Their presence contributes enormously to the vitality of our group. We have also been able to reduce costs in our seminar program by scheduling local colleagues.