# CONTENTS

I. Current and Pending Support ......................................................... 1
II. Abstract ...................................................................................... 2
III. Descriptive Summary ................................................................. 3
IV. Budget ....................................................................................... 4
V. Introduction ................................................................................. 9
VI. Personnel ..................................................................................... 12
VII. Institutional Setting ................................................................. 16
VIII. Progress Under Current Grant .................................................. 17
IX. Renewal Proposal ...................................................................... 19
X. References .................................................................................. 21
   Appendix A .................................................................................. 22
   Vita ............................................................................................... 22
   Bibliography ............................................................................... 22
   Bonner Prize .............................................................................. 22
   Attachments ............................................................................... 22

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VIII. Progress Under Current Grant (see also Section VI)

Sergei Ananyan has completed one nice piece of nuclear physics on "Electroweak Processes Involving (0^+0) Excitations in Nuclei" and has written this work up for publication ([R11] - attached). He is well into his main thesis problem on weak axial vector exchange currents and already has some very interesting new results. Sergei attended PANIC 1996 this Summer at William and Mary, submitted a paper, and gave a poster on his work (attached). This material will now be written up for publication. Sergei will complete his Ph. D. this Fall.

Bryan Barmore is now finishing numerical calculations on the problem of radiating meson fields in relativistic heavy ion collisions. Bryan attended PANIC 1996 this Summer at William and Mary, submitted a paper, and gave a poster on his work (attached). This material will now be written up for publication. Bryan should finish his Ph.D. in 1998.

Gary Prezeau has just started on the problem of chiral QHD with vector mesons, applying and extending the QHD-III lagrangian of [R9] (see Appendix A). Gary should finish his Ph.D. in 1998.

We have purchased a PC for the group through CEBAF and are now tied into the CEBAF computer system. We have organized a Nuclear Theory Study Group here in the Department and last year we worked through the books on "Computational Nuclear Physics" (see attached). Next year we will run a series on effective field theories and chiral perturbation theory.

Tod Bachman just completed a nice senior thesis (at no cost to the grant) on relativistic Hartree calculations of the newly-found doubly magic nuclei (100)^Sn and (132)^Sn. He received high-honors for it. With a little more work, it deserves publication. 7

Personally (jdw), my book on "Theoretical Nuclear and Subnuclear Physics" has now been published by Oxford Press ([R1] - see attached). Last academic year I taught a course on "Quantum Theory of Many-Particle Systems" that all of my graduate students took, as they did my course on "Introduction to General Relativity." I also completed a paper on "Muons and Nuclei" with Vernon Hughes which appeared as a chapter in a book on "Symmetries and Fundamental Interactions in Nuclei," eds. W. Haxton and E. Henley [R10]. A review article with Brian Serot on "Recent Progress in QHD" for the International Journal of Modern Physics E (World Scientific) is currently in preparation [R8]. Also, Bill Donnelly (M.I.T.), Ingo Sick (U. Basel), and I now have an approved program on "Nuclear

7Unfortunately, this will have to wait for awhile since Tod is currently spending 6 months hiking the Continental Divide from Mexico to Canada.
IX. Renewal Proposal

The original proposal for this grant, submitted in August, 1993, lists several anticipated future research projects. Some of these problems have been under investigation during the period of the current grant, and others remain valid as potential Ph.D. thesis projects. Because much of this material is still of current interest, and because it provides the detailed physics background for the present nuclear theory effort, the Physics Section of the original proposal has been included intact as Appendix A of this renewal proposal.

Ananyan’s progress on Problem A.1 has been discussed above; it has been substantial and forms his Ph.D. thesis. The progress of Barmore on Problem A.3 has also been discussed above; he has some very nice physics results. It is anticipated that Problem B.5 will form the second part of Barmore’s thesis. Prezeau is now well into Problem B.2. This turns out to be a very interesting problem with many possible future directions.

In my opinion, Problem A.2 remains of great current interest; it is central to CEBAF’s scientific mission. Although much good work has been done on this problem (see [R8] and e.g. [R12]), there is still plenty of room for a good, thorough, first-principles analysis at all three of the levels described in Section V. This analysis should include both \((e,e'N)\) and \((e,e'2N)\).

Problems B.1 and B.3 remain of high current interest.

Since the original proposal, a significant contribution to the solution of Problem C.3 has been made in [R13].

Some Additional Interesting New Subjects for Investigation

Although several interesting extensions and new problems have arisen in the past three years since this grant was originally funded, and more will arise as time goes by, I will be content to list three which seem to me to be of great interest:

1) Ananyan has now provided a firm theoretical foundation for the construction of two-body electroweak exchange currents in a relativistic hadronic theory that describes much of nuclear structure as we know it, and which preserves all the underlying symmetries of QCD. He has placed the previous unified analysis of electroweak processes with nuclei by Donnelly and Walecka, done in terms of one-body densities, on a firm theoretical foundation. This work should now be extended to include vector meson couplings within chirally-symmetric QHD (c.f. Prezeau’s work) and also isobar contributions within QHD (c.f. [R14]).

2) The most significant difference between the traditional non-relativistic many-body approach to nuclear physics, and that of the