



The nucleon as a holographic Cheshire cat[☆]

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Abstract

The Cheshire cat principle emerges naturally from the holographic approach of the nucleon in terms of a bulk instanton. The cat hides in the holographic direction. I briefly review the one-nucleon problem in the holographic limit.

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1. In memorium

This paper is dedicated to the memory of Gerry Brown who has been my mentor and colleague for the past three decades. One day in the fall of 1982, my advisor Michel Baranger informed me that he has invited Gerry Brown to give a talk at MIT and meet me. He indicated briefly that Gerry was an old friend of his, that competed historically with him in the early days of the Lamb-shift calculation. (Later I learned from Gerry that Baranger beat him on the 10 Mega-cycle correction to the Feynman and Schwinger Lamb-shift landmark calculation. However, Gerry was always very proud of his higher-order corrections to the Lamb-shift in Coulombic atoms. He would always go in great details and pride about how he carried this important and difficult calculation, and also the physical effort it took him shuttling back-and-forth in Birmingham between the computing facility and his office.)

I met Gerry in the fall of 1982, the morning after a tumultuous talk at the Laboratory of Nuclear Science at MIT where Gerry was talking about the excited states of the little bag model. Needless to say that little bags were not popular in the large bag sanctum that afternoon.

[☆] To appear in *Gerry Brown memorial volume*.

The meeting with Gerry took place in Feshbach office with Baranger and later Kerman present. I had a very good time discussing my several research projects with Gerry on the board. We departed at lunch and Gerry wished me well in my work.

Just after the new year in 1983 and out of the blue, I received a letter from Gerry offering me a 3-year position in Stony Brook. I was stunned since I have not applied to any place, let alone thought about graduating after just 3 years at MIT. After consulting with Baranger, I wrote back to Gerry accepting his offer. Upon graduation in the Spring of 1983, I was also offered an NSF NATO fellowship at the Niels Bohr Institute. Gerry immediately indicated that I should take it and his offer would still be valid at the end of the fellowship. He also mentioned that he will be in Copenhagen in the fall of 1983 as part of his dual appointment at the Nordic Institute.

In the summer of 1983 I flew from Boston to Copenhagen a country I never visited before. I arrived at the Niels Bohr at around noon time. Upon checking at the secretarial office, I was informed that Gerry has asked that I wait for him to be picked up. Soon after the secretary entered the sounding Morse-like call code on the famed inter-phone at the Niels Bohr, Gerry showed up to welcome me in this new place. He helped me carry my suitcase across the hall-ways of the institute introducing me to luminaries of the place. We only stopped by Mottelson office for an official introduction as I was going to be their NSF fellow for the next year. After leaving my suitcase in Gerry office we headed to the cafeteria where two tables were full of Gerry students, postdocs and collaborators. I was stunned by the number of people around him.

After lunch Gerry asked me to follow him to his office. There we started chatting about some physics, while in typical Gerry style he pulled out two papers from his brief-case and handed them to me. He said that on his way to Copenhagen he passed by Princeton and there he met Witten and Nappi who told him about their new work on the Skyrme model. The two papers were the by now famed work by Witten and also Adkins, Nappi and Witten on the Skyrmion. Gerry asked me to explain them to him. While, I was about to be briefed on the logistics of the place Jim Lattimer and Gerry Cooperstein came in. I told Gerry that I would be able to figure out the place and left.

The following many weeks I had the pleasure to discuss the papers with Gerry and his students and collaborators. It was the beginning of a great journey by Gerry side. I owe much to Gerry in terms of mentoring, supporting and counseling during all my years with him. Gerry sense of physics and wit is unmatched. More importantly his humanity as measured by the amount of care and kindness he has shown to many of his students and collaborators is legend. For Gerry we were part of his family. For me he was one of the last eagles.

2. Introduction

Historically, quark bag models were simplified models of hadrons consisting of free quarks and gluons confined to a bag because of asymptotic freedom, and dressed up by mostly pions to account for the pion tail of baryons. The bag radius was initially considered measurable, with the current Jefferson facility being tasked to measure it. Two competing pictures emerged: the original MIT bag model with a large bag radius surrounded by a bare vacuum, and the Stony-Brook bag model with a small bag radius surrounded by pions [1].

It turns out that this delineation is unphysical at low energy, as demonstrated in the Cheshire cat principle [2]. Quantum effects and anomalies cause most of the charges (fermionic, axial, etc.) to leak making the bag boundary immaterial [3], much like the smile of the Cheshire cat in “Alice in wonderland” [4] (Fig. 1). The Skyrme model is an example of this principle whereby the unphysical bag radius is reduced to zero size [5] (Fig. 2).

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