**Selected Papers, with Commentary,
of Tony Hilton Royle Skyrme**

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World Scientific Series in 20th Century Physics – Vol. 3

Selected Papers, with Commentary, of Tony Hilton Royle Skyrme

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SELECTED PAPERS, WITH COMMENTARY, OF T. H. R. SKYRME

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**This book is dedicated to Professor R. E. Peierls,
Tony's teacher and mine**

Tony Skyrme
Former Fellow, Trinity College, Cambridge. Reprinted with permission
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Taken in 1948 at Cornwall by Dr. Dorothy Skyrme.

Taken in 1958 by Dr. Dorothy Skyrme.

Preface

Some time ago, Dr. K. K. Phua, Chairman of World Scientific Publishing, asked me to edit a collection of Tony Skyrme's papers. Dr. Phua had carried out his Ph.D. work in Tony's department in Birmingham, England. I had been in Birmingham from 1950–1960, working with Professor R. E. Peierls, who also was Tony's research supervisor for many years. University people in the industrial city of Birmingham were thrown inwards upon themselves, and a great sense of comradeship developed. Certainly I felt that with the Peierls and, through them, with Tony Skyrme. Even though Dr. Phua was in Birmingham at a very different time, he and I have a friendship founded upon red brick. "Red brick" denotes, in England, the discomfort — and strength and vitality — of a university like Birmingham, as opposed to the stuffy grandeur of Oxford and Cambridge.

In the spring of 1951, while I was a boarder in the Peierls' house, Tony Skyrme phoned and said that he and his wife Dorothy were coming to Birmingham for a visit. The Peierls were away, but knowing what good friends Tony and Prof.* Peierls were, I invited the Skyrmes to stay in the Peierls' house. Little did I realize that Mrs. Peierls had dragged Prof. Peierls away on an impromptu spring vacation, so that she would be prepared to entertain 350 participants in the coming British Association for Science meeting at a buffet supper in their house. At least I, and Tony, if he was still staying there, dutifully buttered and laid the thousand or so sandwiches Mrs. Peierls prepared. Certainly we Birmingham products were all united through the strength of Mrs. Peierls.

Of course, I visited Harwell when Brian Flowers, now Lord Flowers, was director and Tony the head of theoretical physics, and participated in "skyrmeshes".

I had thought, in agreeing to edit this volume, to give some biographical material on Tony Skyrme, but each time I started, I found that Dick Dalitz had done it better, so his "An outline of the life and work of Tony Hilton Royle Skyrme" is reprinted in entirety in this book.

In the summer of 1960, I left Birmingham, taking up a professorship in NORDITA, the Nordic Institute for Theoretical Atomic Physics, in Copenhagen, at the invitation of Niels Bohr. In the autumn of 1960, Tony Skyrme gave a seminar

*Prof. was, and is, a term of endearment, not formality, with Rudi Peierls.

in Birmingham on skyrmions. Had I still been in Birmingham, I would certainly have attended that seminar. Although the concepts were so far ahead of their time, probably something would have stuck in my mind, because 20 years later, when Mannque Rho and I were in a dilemma in our construction of the chiral bag model of a nucleon, the fundamental concept in skyrmions was needed to rescue us. It took us more than a year in 1980 to resurrect it, but I want to tell that story later in my commentary on skyrmions.

The reader can ask how, aside from my common association with Birmingham, am I suited to make a selection of Tony's papers and to edit this volume? On the formal aspects of skyrmions, I am no great expert. On the other hand, there is an excellent article by Valery Sanyuk, which is reproduced in this volume. I was a "user" and I needed skyrmions, not because they were the first three-dimensional soliton, nor because of their formal beauty, but because they solved a real problem for Mannque Rho and me, as I shall describe in my commentary on skyrmions.

On the other hand, Tony did a lot of other things in nuclear physics. He proved the completeness of the Kapur–Peierls dispersion theory, although this proof was never published, as Dalitz relates. I used the Kapur–Peierls theory to construct in nuclei what is an analogue of one of the Anderson models in condensed matter physics. It was comforting to know that the theory was complete. Doubts about the completeness had been expressed.

I have included the Perring and Skyrme work on the alpha-particle and shell models of the nucleus. This is to show the modern reader that nuclear physics can be elegant, and that elegance is useful. These are often forgotten in the number-crunching age when huge shell model calculations devour input parameters and turn out wave functions, often untouched by the human mind.

Skyrme's work of most use to nuclear physicists is the nuclear Skyrme model. It is highly amusing to me that skyrmions were motivated, as he tells it in his "The origins of skyrmions", by the "fluid drop model of the nucleus", outlined in his papers "A new model for nuclear matter" and "Meson theory and nuclear matter", published here. By the mesonic fluid, Tony meant the π -meson field, which permeated the nucleus. In his picture, the nucleonic sources, or singularities of this field, were confined by the strong interaction between field of the fluid and sources. Two decades later, Mannque Rho and I used the strong pion field to compress the quarks in the nucleon to make the nonperturbative chiral bag, and in the process, rediscovered Skyrme's work.

From the nonlinear σ -model, invented by Tony, it has proved possible to construct the scalar interaction, composed of correlated pairs of pions coupled to angular momentum zero, the exchange of which holds the nucleus together. As noted later in my commentary on the Skyrme interaction, hard cores are present in the interaction between nucleons, and these come about from the exchange of the vector ω -mesons. These are easily introduced into the theory, coupled to the conserved isoscalar nucleon current. Tony doesn't initially give any physical significance in

terms of meson exchange that provides the fourth-order term in the Skyrme equation. "It is conjectured that in the quantized theory the value of ϵ will be determinate, possibly unity, for reasons similar to those which made $\omega Q^2 = 1/\pi$ in the model of I " from "A non-linear field theory". It is now known (see the review of Zahed and Brown, the final paper in this volume) that the fourth-order term derives from ρ -meson exchange, in zero range approximation, where the ρ -meson is the partner of the ω in a $U(2)$ symmetry.

Using the mesons discussed above, J. D. Walecka has, in many papers, constructed the theory of Nuclear Hadrodynamics, which is very much used. Skyrme was probably influenced by the earlier arguments of Bohr and Mottelson, based on the liquid drop model of the nucleus. In any case, Skyrme's fluid drop model was very useful, in that it led him to the idea of skyrmions.

In my commentary on the Skyrme interaction, I note, however, that it is useful more in the context of the nuclear shell model, more in the nature of the Landau-Fermi liquid theory, which has, as a central idea, the concept of quasiparticles.

Of course, Tony's time in Harwell was a time of great reconciliation between the various theories. J. P. Elliott, in the $SU(3)$ formalism, showed how, with the proper interactions, the shell model could reproduce the Bohr-Mottelson collective model. Perring and Skyrme, in an article reproduced here, show how the alpha-particle model relates to the shell model. As Weisskopf has explained, a model "exaggerates the particular features" one wishes to deal with, and this was true, also, of Skyrme's alpha-particle model.

It must have been incredibly frustrating for Tony that almost no one understood or appreciated his theory of skyrmions until about two decades after he invented it. It took great courage and perseverance to keep on developing the theory. I heard Morris Pryce, then professor at Oxford, and sponsor of "A new model for nuclear matter", for the Royal Society, say that "Tony was too clever for his own good".

Dick Dalitz notes about Tony that in 1985, after he was awarded the very prestigious Hughes Medal by the Royal Society, "As Tony came back to his seat, grasping his medal and with a grin all over his face, he muttered with justice, 'They none of them could understand any of it at the time.'"

I am reminded of Henry Thoreau's rejoinder, upon being asked by Ralph Waldo Emerson, when Thoreau was in jail for failure to pay taxes because of his opposition to the Mexican-American war, "Why are you here?" Thoreau replied, "Why are you not here?"

Tony was never elected to the Royal Society, although the Hughes Medal was somewhat of an apology. He gave us the most conceptually profound work from England since the war. Perhaps, looking at the Fellows of the Royal Society, he could, with reason, have reversed the Emerson-Thoreau exchange and asked "Why are you there?"

G. E. B.

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