

Preface

Electromagnetism immediately captured my interest when I was first introduced to it as a student at university. Complete mastery of one of the fundamental phenomena of our physical world seemed within reach, as promised in the form of Maxwell's equations [1]¹. However, the realisation of that promise was not as straightforward as I might have first imagined.

Exposure to electromagnetic theory in the period during and immediately following university, with its application to impedance imaging, left me with some skills—largely restricted to two dimensions and quasi-static fields. I found the conventional treatments at that time for fully three-dimensional time-varying fields clumsy and unpalatable. I took that to reflect my own inadequacy in grasping the methods rather than reflecting any inadequacy in the methods themselves. As it turns out, I was mistaken.

The first inkling that there might really be a simpler way came for me in 2002 with the paper of Axelsson, Grogard, Hogan and McIntosh [2]. At that time I started to seriously follow the literature relating to the theory of monogenic functions expressed in Clifford's algebra [3, 4] based on his interpretation of Hamilton's quaternions [5] in terms of Grassmann's extension theory [6, 7], and applied through the Cauchy integral [8, 9] to provide a solution to Maxwell's equations, and thereby to electromagnetic problems.

Although much is written, there are only a few works which I consider essential. First are the works of McIntosh [10, 11] providing a solid mathematical justification on the validity of the Cauchy integral in multiple dimensions for monogenic functions in Lipschitz domains. Second is the paper of Axelsson, Grogard, Hogan and McIntosh [2] giving the formulation of electromagnetic problems within the Clifford–Cauchy framework. Third is the thesis of Axelsson containing many more of the details [12].

Given that my background was in electrical engineering and the aforementioned documents were written by mathematicians, they probably would have remained

¹Section 617.

forever beyond my understanding were it not that I had worked for many years with one of the authors. With his support and guidance I was slowly able to master the concepts and cast them, finally as this book, in a form by which they can be shared with others having a background at a level similar to my own.

The works in the book follow ultimately back to Cauchy, Hamilton, Grassmann, Maxwell and Clifford rather than conventionally to Green, Hamilton, Maxwell, Gibbs [13] and Heaviside [14]² (also [15, 16]). The differences from conventional techniques are that (i) Hamilton's quaternions are used in whole to construct Clifford's algebra rather than being stripped apart to deliver Gibbs's vector calculus, (ii) Clifford's algebra is used instead of Gibbs's vector calculus and (iii) integrals are used involving Cauchy kernels instead of Green's functions.

The ultimate outcome is an integral formulation which lends itself to a more direct and efficient solution than is conventionally the case. That leads by necessity on any particular machine to either a faster solution for a given problem or the ability to solve problems of greater complexity. On the basis of efficiency alone, the new technique is destined in time to supplant at least some existing techniques.

The book is written with the intention that any who are interested can also come to master, over a much shorter time-span than in my case, techniques which offer simpler and more efficient solutions to problems of electromagnetic scattering than are currently in use.

During the development of the material and preparation of this work many people have been of assistance in various ways, either consciously or unknowingly, directly or indirectly. The various ways include the penetrating questions of students, the sound advice and encouragement of colleagues and peers, the perceptive counsel of elders and betters, the professional guidance of the editorial team, and the stoic forbearance and unfaltering faith of my immediate family.

Gold Coast
September 2015

Andrew Seagar

²Sections 51 and 66.

Application of Geometric Algebra to Electromagnetic
Scattering

The Clifford-Cauchy-Dirac Technique

Seagar, A.

2016, XXII, 179 p. 53 illus. in color., Hardcover

ISBN: 978-981-10-0088-1