# Preface

The topic of lattice quantum spin systems (or 'spin systems' for short) is a fascinating branch of theoretical physics and one of great pedigree, although many important questions still remain to be answered. The 'spins' are atomic-sized magnets that are localised to points on a lattice and they interact via the laws of quantum mechanics. This intrinsic quantum mechanical nature and the large (usually effectively infinite) number of spins leads to striking results which can be quite different from classical results and are often unexpected and indeed counter-intuitive.

Spin systems constitute the basic models of quantum magnetic insulators and so are relevant to a whole host of magnetic materials. Furthermore, they are important as prototypical models of quantum systems because they are conceptually simple and yet still demonstrate surprisingly rich physics. Low dimensional systems, in 2D and especially 1D, have been particularly fruitful because their simplicity has enabled exact solutions to be found which still contain many highly non-trivial features. Spin systems often demonstrate phase transitions and so we can use them to study the interplay of thermal and quantum fluctuations in driving such transitions. Of course there are many cases in which we can find no exact solution and in these cases they can be used as a testing ground for approximate methods of modern-day quantum mechanics. These quantum systems thus provide a great variety of interesting and difficult challenges to the mathematician or physical scientist.

This book was prompted by a series of talks given by one of the authors (JBP) at a summer school in Jyväskylä, Finland. These talks provided a detailed view of how one goes about solving the basic problems involved in treating and understanding spins systems at zero temperature. It was this level of detail, missing from other texts in the area, that prompted the other author (DJJF) to suggest that these lectures be brought together with supplementary material in order to provide a detailed guide which might be of use, perhaps to a graduate student starting work in this area.

The book is organised into chapters that deal firstly with the nature of quantum mechanical spins and their interactions. The following chapters then give a detailed guide to the solution of the Heisenberg and XY models at zero temperature using the Bethe Ansatz and the Jordan-Wigner transformation, respectively. Approximate methods are then considered from Chap. 7 onwards, dealing with spin-wave theory and numerical methods (such as exact diagonalisations and Monte Carlo). The coupled cluster method (CCM), a powerful technique that has only recently been applied to spin systems is described in some detail. The final chapter describes other work, some of it very recent, to show some of the directions in which study of these systems has developed.

The aim of the text is to provide a straightforward and practical account of all of the steps involved in applying many of the methods used for spins systems, especially where this relates to exact solutions for infinite numbers of spins at zero temperature. In this way, we hope to provide the reader with insight into the subtle nature of quantum spin problems.

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