Preface

Optical interferometry uses the combination of light from multiple telescopes to allow imaging on angular scales much smaller than is possible with conventional single-telescope techniques. It is increasingly recognised as the only technique capable of answering some of the most fundamental scientific questions in astronomy, from the origin of planets to the nature of the physical environments of black holes.

Interferometry is an established technique at radio and millimetre wavelengths, with instruments such as the VLA and ALMA being the workhorses at these wavelengths. The development of interferometry in the optical (which we take here to include both visible and infrared wavelengths) has lagged behind that of radio interferometry due both to the extreme precision requirements imposed by the shorter wavelengths and to the severe effects of the Earth's atmosphere. For many years, the use of optical interferometry for scientific measurements was limited to the specialists who designed and built interferometric instruments.

At the beginning of the twenty-first century, the first "facility" optical interferometers such as the VLTI, the CHARA array the Keck Interferometer came online, with the aim of broadening the use of interferometry to the wider community of astronomers who could use it as a tool to do their science. As part of this expansion, organisations in Europe and the USA began to hold summer schools to provide an introduction to the theory and practice of interferometry to astronomers new to the topic. A number of times after giving lectures at these schools, I have had students come up to me wanting to find out more about some 'well-known' interferometric idea that I have mentioned in my talk. Often I have had to reply that there is no one place in the literature which provides this further information.

While a lot of the knowledge has been built up by the community involved in the development of optical interferometry, much of it is not written down,

or is scattered over multiple separate papers. The most useful single reference on the topic is provided by the course notes from the 1999 Michelson Summer School (Lawson, 1999), but of necessity it cannot cover the decade and more of developments in interferometry since its publication. Knowledge relevant to optical interferometry is also available in radio-astronomy textbooks (a good example is *Interferometry and Synthesis in Radio Astronomy* (Thompson *et al.*, 2008)), but finding it requires the reader to have an existing understanding of which elements of radio interferometry are relevant in practice to optical interferometry. This is because, although the same physical principles apply at both radio and optical wavelengths, many concerns which are important to the practice of interferometry in one wavelength regime do not arise in the other.

This book is mainly aimed at enabling the newcomer to optical interferometry to get 'up to speed' on the topic, providing a basic reference on the fundamental concepts applicable to present-day optical interferometry. It aims to give simple rules-of-thumb to allow a quick understanding of what is important, but also shows how a more rigorous understanding of more detailed aspects can be derived, without necessarily giving detailed derivations in all cases. The ideas are presented assuming a mathematical background at the level required for an undergraduate physics course, including concepts such as complex exponentials and random walks. Where possible, examples from the literature are given in order to relate the more abstract ideas to their practical roots.

The main intended audience for this book is students and researchers in astronomy who want to use an interferometer as a tool for doing science. This book concentrates on the most 'mainstream' application of interferometry, which is loosely termed 'imaging': this can range from measuring a few parameters of an object's appearance based on a simple model (for example measuring a diameter of a star under the assumption that it is round) to true 'aperture synthesis', reconstructing model-independent images of the object under study.

In the interests of brevity, less is said here about interferometric techniques such as nulling, polarimetry and astrometry that have undoubted scientific potential, but are less mature in their application, and as a result less readily available as a science tool for non-expert users. These techniques are evolving rapidly, and the consensus as to the best way to make them work is still quite fluid. Any useful discussion of these topics would need to cover all the possible directions of development in these modes of interferometry and might still not cover the key ideas which will turn out to be of importance to their successful establishment.

A second and overlapping audience for this book is students, instrumentation scientists and engineers who want to work on developing and building new instrumentation for interferometry. Interferometry is clearly on an upward arc, with new initiatives such as the Planet Formation Imager (`http://www.planetformationimager.org`) gaining support from a wide scientific user base. These initiatives will require the efforts of a new generation of scientists and technologists who are well-versed in the existing ideas of interferometry, but are also able to see beyond these techniques to understand what can make interferometry even more useful in the future. This book will hopefully provide a small stepping stone for such people.

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