Preface

These are amazing structures: thousands of optical sensors deployed on kilometer-long strings, distributed throughout a volume that dwarfs the largest office block and interred deep in Antarctic ice; a gigantic tank of liquid argon, surrounded by ancient Roman lead and state-of-the-art photodetectors, sitting at the bottom of one of the world's deepest mines; a host of giant antennae placed on an almost inaccessible mountain top; a group of cables, each about the length of the Empire State Building and containing hundreds of photomultipliers encased in glass spheres, anchored to the Mediterranean seabed by underwater robots; and satellites – lots of them – orbiting Earth while they stare, unblinking, out into space. These constructions are cathedrals of science, all of them examples of a new type of astronomical telescope.

For a couple of years as a schoolkid I was obsessively interested in two things: telescopes and cricket. I joined the local amateur astronomy society, which gave me the chance to observe with a half-decent instrument. On those occasions when the telescope's availability coincided with a cloud-free sky (unfortunately, being in England, these were almost non-intersecting sets of events) I marvelled at the sights such an instrument afforded. And each time was the thought: "If I can see all this using a mirror that's the width of a cricket wicket, what could I see with a mirror that's the width of a cricket pitch?" (For US readers, a cricket pitch is 10 feet, or 3.05 m, wide.)

Later, when I began to study physics at university, I learned that professional astronomers already had access to a telescope bigger than the width of a cricket pitch: the 5 m Hale telescope at Palomar had been completed decades earlier. The view through Hale was indeed impressive: astronomers had already used it to study distant galaxies, to get glimpses of enormously energetic objects, and to firm up the notion of an expanding Universe. But

I learned that the view through even the world's largest telescope was never really sharp enough. In studying physics I was learning about a subject in which experiments could test theory to eight decimal places. Cosmology, on the other hand, seemed hopelessly imprecise. Basic parameters were quite uncertain, with cosmologists bickering over whether the Universe was ten billion years old or twenty. The telescopes of my boyhood imagination, it turned out, simply weren't powerful enough to do the job required.

And then it changed. About two decades ago astronomy and cosmology entered a Golden Age. Space-based telescopes such as Hubble and COBE transformed the field. Cosmology became a precision science. This Golden Age continues, and it's going to get even more glittering over the next few years: a plethora of giant telescopes – some of them in space; some of them hidden deep beneath ice, sea or rock; most of them bearing no resemblance at all to the traditional optical telescope – will soon start to observe. These marvels of technology will give humankind new eyes through which to study the Universe. And there's much to study. One of the lessons from the Golden Age is that the Universe is much stranger than previously thought. Mysteries abound: what's causing the Universe to blow itself apart? Why can't we see most of the matter in the Universe? Where *is* everybody?

This book is an introduction to a dozen of the most interesting mysteries over which astronomers are puzzling – and it's a guide, too, to the powerful new telescopes that will help solve those mysteries. Since the subject matter is so fast-moving, it's inevitable that there'll be interesting developments even as the book is being printed. For the latest on these questions please visit my website, stephenwebb.info, where I'll post regular updates.

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I'd like to thank several people who have helped me in the writing of this book. Clive Horwood and everyone at Praxis Publishing have, as always, been extremely supportive. I'd particularly like to thank Dr John Mason, who made innumerable insightful comments and suggestions on an early draft; needless to say, any errors that remain are entirely of my own making. Several people helped me to source photographs and images; in particular I would like to acknowledge Hanny van Arkel, Steve Criswell, Emma Grocutt, Bill Harlan, Luigi Ottaviani & Roberta Antolini, and Martin White.

Finally, I would like to thank Heike and Jessica for showing so much patience with me over recent months. I would never have been able to finish this book without them.

Springer

http://www.springer.com/978-1-4614-2193-1

New Eyes on the Universe
Twelve Cosmic Mysteries and the Tools We Need to Solve Them
Webb, S.
2012, X, 371 p. 50 illus. in color., Softcover
ISBN: 978-1-4614-2193-1