Introduction

Only the Earth doth stand forever still:
Her rocks remove not, nor her mountains meet;
(Although some wits enrich'd with learning's skill
Say heaven stands firm and that the Earth doth fleet
And swiftly turneth underneath their feet)
Yet, though the Earth is ever steadfast seen,
On her broad breast hath dancing ever been.

(Sir John Davies, *Orchestra, 1596*)

Whether day ended 400 years ago in Sir John Davies's time, or as it does today, the night sky that has attracted people for thousands of years begins another nightly show. For committed astronomers, amateur or professional, that darkening sky is all that is needed to get our juices flowing. Others require a little more, not just a static display that changes subtly from hour to hour, but something startling, something that crashes upon the celestial stage. A bright meteor, or an eclipse, can spark a lifelong interest in the sky. Eclipses are predictable, and there is usually nothing subtle about them. We can take the experience of an eclipse and put it into a bottle of fond memories. Eclipses show that the sky does change, that the sky is the show that never ends. Eclipses can inspire, and that is why I wrote this guide to getting the most from them.

An eclipse journey

Eclipses are so interesting that some people travel the world to catch them. My wife Wendee and I did this quite literally in late 2003, when we flew

across the Atlantic from our home near Tucson, Arizona. Our first stop was London, the city of Shakespeare. Shakespeare knew eclipses, mentioning them and their implications several times in his writing. But our homage to Shakespeare was brief. We boarded another plane and landed half a day later deep in the southern hemisphere in Cape Town, South Africa. Even that city, famous as the place where, in the early nineteenth century, John Herschel and the Cape Observatory opened our vision of the southern sky, was but a stop on the way as we continued southwards down the line that divides the Indian from the south Atlantic oceans. We crossed the Antarctic Circle and still sped southwards, until our plane touched down on thousands of feet of ice. Finally, we were there: the Russian science station in the land of the midnight Sun.

But if the weather stayed clear, this would be no ordinary midnight Sun. The sky was the steadiest I had ever seen – the spots I saw through my 3.5-inch Questar telescope were so steady they looked like drawings. As the Sun began to set, we headed off across the ice to our viewing location and arrived there about 45 minutes later. Still the Sun was setting. We set up our telescopes and watched as the Sun touched the horizon. The Sun continued to set. An hour later, it was still setting. Then the tiniest nick appeared in its side. It was the Moon's first bite that would rapidly get bigger and culminate in total eclipse. Twenty minutes later, the Sun reached its lowest point on the horizon and began to rise again. With seven minutes left before the onset of totality, I noticed faint but definite shadow bands crossing the sunlit area of snow in front of us. They appeared as quite regular waves of dark lines moving away from the Sun at the rate of a meter per second. As totality drew nearer, these bands darkened and grew more obvious. I saw the same effect after totality, with the bands moving in the same direction – so the total shadow band viewing time was about 12 minutes.

At two minutes before totality, the Moon's umbral shadow approached rapidly from a point just to the northeast of the Sun. At this point I made a big mistake. In order to access the telescope's filter and also take photographs, I removed my gloves. By the time totality ended less than 3 minutes later, both thumbs and several fingers were mildly frostbitten and severely painful. But the consequences of that cold had to wait. For as I looked again toward the disappearing Sun I saw the strangest natural scene I've ever encountered. Ahead of me was an expanse of snow and ice which met the horizon where a huge inverted cone of darkness soared into the sky. Due to the low Sun angle

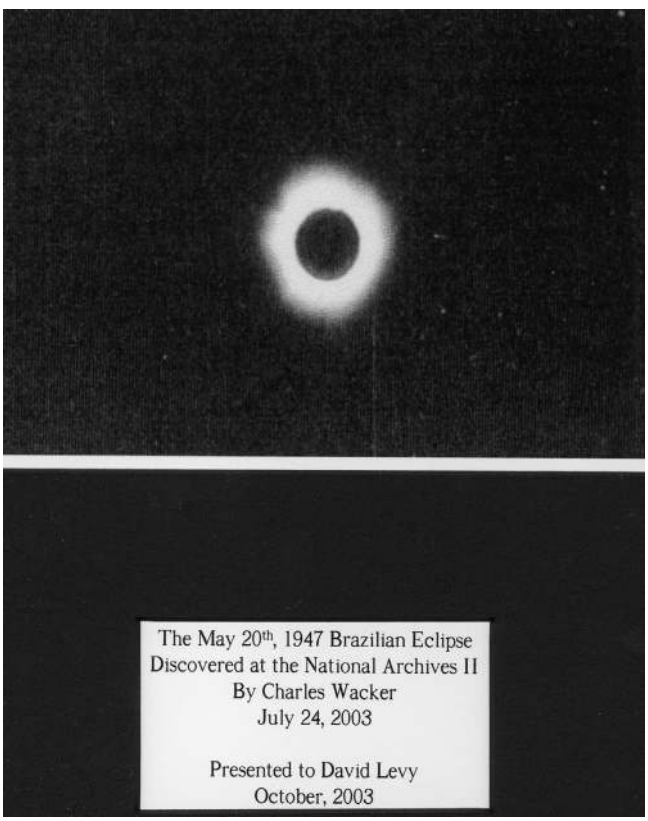

Figure 1 A total eclipse of the Sun seen from Brazil by F. Barrows Colton, May 20, 1947. Image courtesy Charles Wacker, July 24, 2003.

that shadow was darker than I had ever seen it. In contrast to the rapid partial phase, I now thought that the eclipse was creeping towards totality. Already darker than a usual eclipse, there was still a thinning crescent. Finally the corona appeared faintly, and with it an "emerald cut" long diamond ring. Within a few seconds the corona blossomed to its full brilliance. At one o'clock (going clockwise around the Sun) was a huge coronal flare.

Visualize what was going on over the field of ice that minute: the Sun was grazing the horizon – in fact a slice of the lower edge, or limb was actually still below the horizon. During the next minute the shadow at the horizon moved from south to north like the slide of some vast heavenly ruler. The corona, thanks to the Moon illusion that affects our perception of objects near the horizon, looked huge against the sky. It was that intersection of Sun, Moon, horizon, and ice that was the highlight of this eclipse.

Figure 2 All wearing special eclipse protection glasses, a large crowd waits anxiously for totality to begin on the morning of August 11, 1999 in the northwestern Atlantic Ocean, southeast of Halifax, Nova Scotia, on the *Regal Empress*. The lady second from left is Patsy Tombaugh; Len Wallach is wearing a white sweater and his daughter Joan-Ellen is standing to his right. Wendee and I are in the back row. Photograph by Roy Bishop.

A second emerald cut diamond ring ended totality, and I swung round to the east to watch the shadow speed off across an expanse of flat ice that stretched to the other horizon. The shadow quickly raced across the ice, but for 1¼ minutes on that cold day in 2003, the shadow of the Moon encountered us as we stood atop of miles of thickness of ice. As a result, we saw a darkened Sun at midnight.

Experiencing an eclipse

Whether it involves a barely perceptible shading of one edge of the Moon or a complete blocking of the Sun, an eclipse is an experience not easily forgotten. More than any other factor, an eclipse is a cosmic display of how our world interacts with its Moon and the Sun. It is a dance worthy of the sixteenth-century poet John Davies, who in 1596 wrote about the

cosmic dance in *Orchestra,* a stanza of which adorns the opening page of this introduction.

However Davies might have been aware of this beautiful interplay among worlds, the idea of a cosmic dance is expressed perfectly during an eclipse. When my parents and I, along with friend Paul Astrof, saw the beginning of the partial phase of the total eclipse of July 20, 1963, Dad looked at his watch amazed that the eclipse began exactly at the predicted time. I'll never forget his gazing through filtered glass at the tiny nick in the Sun, then at his watch. Conceivably, the 1963 eclipse could have been predicted 4.5 billion years ago, shortly after the Moon was formed out of a collision between the Earth and another world the size of Mars.

This is the magic of eclipses. In the pages that follow, I will offer inspiration, information, and indications to point your way towards a more enriching eclipse experience.

Part I THE MAGIC AND HISTORY OF ECLIPSES

1

Shakespeare, King Lear, and the Great Eclipse of 1605

> These late eclipses of the sun and moon portend no good to us.
> (Shakespeare, *King Lear*, 1.2.101–102)

The shadow of the Moon dropped swiftly out of the sky, charging along the sunrise terminator at 12,000 miles an hour. As the Sun edged higher, that velocity slowed to a more manageable 2000 mph as it tore southeast across the north Atlantic, crossed just west of England, and made landfall in southern France and northern Spain. The date: October 12, 1605. I like to think the event was observed by people all over Europe, including groups of people standing by the Thames in central London. Far out of town, King James I was out probably enjoying a day of hunting. As the day progressed, few let the almost imperceptible onset of a solar eclipse interrupt their business. But as more of the Moon moved across the Sun, by noon the sky was darkening noticeably and rapidly. Between 12:40 and 1:00 pm the sky was a twilight dark. Through breaks in the clouds, the Sun appeared as a thin curved line of light.

As the Moon continued moving eastward across the Sun, it abandoned its grip just after 2:00 pm. I like to imagine a group of Londoners peering at the sky as the eclipse ended, discussing its meaning. "I heard about these eclipses," said one, "at the theatre a few weeks ago."

"King Lear," another nodded. "But weren't there two eclipses?" Indeed there were. Two weeks earlier, during the predawn hours of September 27, a deep partial eclipse of the Moon darkened the predawn sky over London. Had any of those Londoners seen the lunar eclipse also, they would be part of a rare group of people who have seen eclipses of the Moon, and of the Sun,

Figure 1.1 This is the home in which William Shakespeare was born and spent his early years. I like to imagine James Joyce's scenario in *Ulysses* that as a young boy of 9:

A star, a daystar, a firedrake rose at his birth. It shone by day in the heavens alone, brighter than Venus in the night, and by night it shone over delta in Cassiopeia, the recumbrant constellation which is the signature of [Shakespeare's] initial among the stars. His eyes watched it, lowlying on the horizon, eastward of the bear, [but westward from Polaris] as he walked by the slumberous summer fields at midnight – writing about the supernova in 1572.

(James Joyce, *Ulysses*, 1922)

— Although this story is apocryphal, it is difficult to fathom that the young Shakespeare, with his eclectic interests and zest, could have possibly missed seeing the great star of 1572.[1] Photo by David H. Levy.

separated by only two weeks. I often ask that question when I give lectures about eclipses, and even among experienced watchers of the sky, few have seen such a pair of eclipses from the same location.

Shakespeare might be in that group; at the least he knew that eclipses could happen in pairs. In *King Lear*, he describes a conversation about eclipses. The eclipse passages are a seminal discussion about the role that these transient events play, or do not play, in our lives. It begins with an argument by the

Figure 1.2 This is the building likely used as Shakespeare's school. In the sixteenth century, towns in England tended to place a substantial emphasis on the education of their children, and Stratford had one of the best schools in that part of England, complete with teachers trained at Oxford and Cambridge.

Earl of Gloucester: "These late eclipses of the sun and moon portend no good to us. Though the wisdom of nature can reason it thus and thus, yet nature finds itself scourged by the sequent effects. Love cools, friendship falls off, brothers divide."[2]

Not so, counters his son Edmund, who fires back: "This is the excellent foppery of the world, that when we are sick in fortune, often the surfeits of our own behavior, we make guilty of our disasters the sun, the moon, and stars; as if we were villains on necessity . . ."[3]

Besides the two eclipses in the autumn of 1605, a total lunar eclipse darkened the full Moon that April. But it was the eclipse of the Sun that attracted the most attention. King James I himself wrote of it in a letter to Robert Cecil, his friend and aide. In it he pokes fun at those who would attach astrological implications to eclipses: "But now I will go to higher matters and tell you what I have observed . . . the effects of this late eclipse for as the troglodytes of the Nile that dwelt in caverns, the shepherds of Arcadia dwelling in little cabins, the Tartars harboring in their tents like the old patriarchs, so I, having now remained awhile in this hunting cottage, am abler to judge

Figure 1.3 Shakespeare's Holy Trinity Church is on the west shore of the River Avon. The supernova of 1572 could have been seen toward the north, off to the right of the photograph. Photograph by David H. Levy.

of astronomical motions than ye who lives in the delicious courts of princes. The effects then of this eclipse for this year are very many and wondrous . . ."[4]

The magic of eclipses

Shakespeare was taking advantage of the eclipses to engage his audience's interest in the narrative of *King Lear*. He uses the effects of eclipses often in his writing, but in this particular play eclipses are part of the great cosmic picture of darkness and storm that Shakespeare is using to discover a relation between humanity and the cosmos. Just as Shakespeare used the eclipses of 1605 to arouse the curiosity of his audience, this book aims to use eclipses as tools to inspire a deeper interest in the sky. In October of 2005, exactly 400 years after the great eclipse, I stood in a square in the city of Barcelona. Under a mostly cloudy sky, the Sun did peek through at 2 pm, the time that it would have been in the total phase of the eclipse. My mind harked back to that distant hour as the Moon's shadow crossed over Europe. I imagined people looking up at the Sun, admiring, wondering, and inquiring.