

Science

Sun block

Chasing the total eclipse across the Pacific Ocean

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What is the most beautiful natural phenomenon that you have ever seen? A brilliant rainbow set against a distant storm, or a blood red sky just after sunset, perhaps? But anyone who has experienced the diamond ring effect that heralds the start of a total solar eclipse will agree it puts all others in the shade.

About once every 18 months, the moon passes directly between the sun and earth. As the moon moves slowly across the face of the sun, it casts a shadow on the earth's surface about 100 miles in diameter, which is the distance from one horizon to another. As our planet spins in its daily round, the shadow rushes across land and sea at about 2000 miles an hour. Those beneath it as it passes see, for a few minutes, night brought to the dome of the sky directly overhead. Looking up myopically, you would see stars as if it were normal night, accompanied by an awesome sight: a circle of profound blackness, a veritable hole in the sky, surrounded by shimmering white light, like a black sunflower with the most delicate of silver petals. One watcher described it to me as like "looking into the valley of death with the lights of heaven far away calling for me to enter."

There is a slow build-up to the show, as the moon gradually covers the sun, which becomes a thin crescent as darkness falls. Then as totality approaches, excitement mounts. After the thrill of the eclipse you can't wait to do it again, but wait you must until that exquisite alignment of sun, moon and earth comes around once more, and when it does you must go to the thin arc where the moon's shadow momentarily sweeps across a small part of the globe.

I have just returned from seeing my fifth total eclipse, where I was reacquainted with people whom I had met on previous occasions: Polynesia in 2009, the Sahara in 2006, Zambia in 2001 and Cornwall in 1999. I had passed up on an opportunity to go to the Antarctic or the North Pole, to witness others, but our group included veterans of nearly a score of eclipses, who had visited places that they would never otherwise have seen.

For a total eclipse is only visible at special places on earth; a mere 0.5 per cent of the earth's surface is totally obscured by the moon's shadow for just a few minutes, while the remaining 99.5 per cent sees either a partial eclipse or nothing at all. Stay at home and you will miss it. No one who hasn't experienced one can understand why people are prepared to adventure to the far side of the earth, by plane and sea, to be there.

This latest eclipse was on 14th November, and lasted for just three minutes and two seconds. To experience it we had to travel to grid reference: 26 degrees and 45 minutes south and 166 degrees 46 minutes east, an anonymous spot in the middle of the Pacific Ocean. Most of the globe is covered by water, and eclipses occur over sea more often than over land. Having flown halfway around the globe to Fiji, I joined a hundred other eclipse chasers, who spent three days on a ship travelling to our rendezvous.

Among our party was Bill Kramer, veteran of some 15 total eclipses, and one of the foremost calculators and illustrators of eclipse predictions. A lanky American with a dry sense of humour who could double for Will Self, he now lives in Jamaica when not travelling to eclipses. His love affair with them began in 1972, when his father—who had never seen one himself—took Bill along to experience one at sea off the coast of Canada. They were so overwhelmed that the next year, Bill's father took him to Africa with the same purpose. "I dedicate every one to my father," he told me, as he anticipated this latest eclipse with all the excitement of 40 years of experience.

Among Bill's specialities are predicting the duration of the eclipse, its path and the nature of the diamond ring, the flash of light as the sun shines through valleys on the moon's surface at the start of totality. This is the most beautiful sight in nature, according to Bill. The sun is about 400 times bigger than the moon, and is about 400 times further away. This cosmic coincidence means that the moon can completely obscure the sun if it passes directly between our nearest star and our line of sight, causing the total eclipse. But the moon is not a perfect sphere, being covered with mountains and valleys. Just as it is about to obscure the sun, some of the moon's mountains cover the sun's disc early, while the valleys momentarily still allow the last slivers of sunlight to pass through. Bill uses charts of the moon's topography, and knowledge of its orientation, to compute which valleys will play starring roles, and thereby he predicts the position and time span of the diamond ring.

He can calculate the duration of totality to one tenth of a second. This is important for photographers and those observing the ghostly solar corona through telescopes. It is painful to look at the sun without eye protection, but being caught unawares as the sun reappears at the end of three minutes of darkness, when your eyes are fully adjusted to the gloom, can literally be blinding. The actual time of start or finish he calculates to about one second, as it depends on your location.

According to Bill, the eclipse path was due to cross the northern tip of Australia and then sweep over the Pacific Ocean, never again touching land. Trusting the ability of people like Bill to compute,



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Total solar eclipse: “like a black sunflower with the most delicate of silver petals”

our ship had travelled for two days and three nights out of Fiji on the assurance that an eclipse would occur just after 8am local time at the appointed location.

As the sun rose on that third morning, the view from our deck was of water extending to the horizon in every direction, seemingly no different than the scores of barren liquid horizons that we had traversed along the way. There was a clue that this place was special, however. Having seen nothing but sea and sky for three days—not even a vapour trail, let alone a ship—about a mile from us was a yacht, bobbing in the waves. Either this was a remarkable coincidence, or we were not alone in trusting Bill. We learned later that a cruise liner, with over a thousand passengers, had set off from Sydney hoping to include the eclipse in its itinerary, but was delayed and never made the rendezvous. They saw about 98 per cent of the sun obscured—a 98 per cent partial eclipse—interesting certainly, but not totality. Totality is something utterly different. What sights they missed.

Each total eclipse is different. Seeing my first, under cloud in Cornwall in 1999, was profound; the shadow of the moon was spread above us, like seeing the film from behind the cinema screen. Zambia on 21st June, midwinter’s day, was entirely different not least because the sky was clear. On that occasion I realised the profound effect that an impending eclipse can have on those

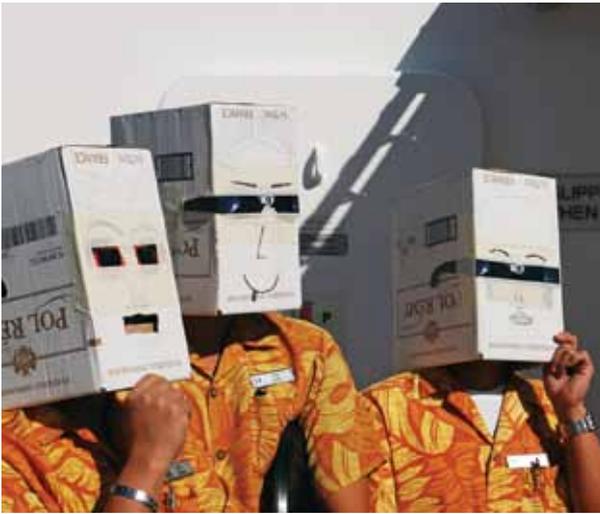
who are not well informed. “Who’s arranged this eclipse?” was the first question I was asked, as soon as the locals in the Lower Zambezi National Park discovered why I was there. “Is this the government doing it to make money?”

I said it was a natural phenomenon. “If it’s natural how do you know it’s going to happen?” they asked. I explained, and they all agreed they understood, one of them adding: “I still don’t believe it will happen but if it does then I will believe in science.”

And now, 11 years later, trusting in science, I am on a ship in the anonymity of the south Pacific, hundreds of miles from any land. About an hour before the main event was due, someone shouted “first contact,” which is astronomer-speak for “the moon has begun to cross the sun.” Through binoculars, suitably protected against the glare, a small nick could be seen disturbing that perfect circle, and it was growing. For me, this is one of those moments where I feel humbled by the ability of science to predict: on this day, at this particular time and place, the moon will begin to be in the direct line of sight to the sun.

In the final minutes before totality, a host of unusual phenomena begin to assault the senses.

As a disc of pure blackness began to slide across the face of the sun, dusk began to fall. But it was a strange twilight. In Zambia I had seen turtle doves begin to fly low across the trees and ▶



Left, eclipse chasers shield their eyes using home-made devices; right, “as totality approached, there was an intense sense of anticipation”

vultures coming in to roost, circling lower and lower like at normal sunset, except that darkness was so sudden the vultures landed in the dark. For us humans, also, it was strange: the light got dimmer but the shadows didn’t lengthen. Here at sea, the only apparent animal life consisted of the expectant humans, gazing in wonder as the crescent remnant of the sun got thinner and thinner.

As totality approached, there was an intense sense of anticipation. The air cooled, and then, in the west, a wall of darkness, like a gathering storm, rushed towards us: the moon’s shadow. No wonder the ancients were terrified. In an instant we were enveloped by the darkness as the last sliver of sun disappeared and, as from nowhere, a diamond ring flashed around a black hole in the sky, vibrant, like a living thing.

As I looked around, the night was revealed to be only in a dome above us, floating on a purple haze, which in turn rested on a 360 degree sunset. It was an awesome sight, as if we were witnessing the end of the world, its energy having been sucked into the depths of infinite space above us, a vision that was simultaneously ghastly, beautiful, supernatural.

You take from a total eclipse what you bring to it. A spiritual person will see this three minutes of ecstatic wonder as confirming the infinite power of the creator, some deeply religious observers even having visions of iconic images in the shimmering corona surrounding the black hole in the sky. Others marvel at the ability of science to predict where and when this singular event will occur.

Historically, it was during total eclipses that it was possible to study the sun’s corona. This ephemeral regime of hot gases extends out far beyond the visible surface, but is normally swamped by the intensity of the sunlight. During totality, when normal light is dimmed, it is the corona that is seen in its full glory. Electrically charged particles form wispy tendrils, which reveal the magnetic fields surrounding the sun, much as iron filings reveal the fields surrounding a magnet in a laboratory demonstration. Nowadays, the corona is studied by experiments in satellites, which are capable of making artificial eclipses by blotting out the bright sun with specially designed shades. Even so, it is only during total eclipses that the innermost regions of the corona can be studied, and this is probably the main scientific interest of total eclipses today.

The most famous scientific experiment during an eclipse is that performed by Sir Arthur Eddington in 1919, which proved Einstein’s general theory of relativity. According to Einstein, light

is deflected by a gravitational field. The sun is the main source of gravity in the solar system and, if Einstein was correct, should deflect the light arriving from distant stars. During a total eclipse, the position of a star adjacent to the sun was found to be moved slightly from its expected position. The amount was, according to Eddington, in agreement with Einstein’s theory. Subsequently people have debated whether Eddington’s experiment was really as sensitive as believed at the time. It is hard to imagine anyone having the sangfroid to perform a delicate scientific measurement during such a singular event.

The sound on a video recording of the eclipse revealed unexpected delights: people gasping and screaming as if partaking of a mass orgy. Some broke into a form of Jamaican patois that shouldn’t be repeated in polite society. Bill later described the experience as, “like going to a Grateful Dead concert but without the drugs.”

Three minutes later—at least, that’s what my watch said, but the intense experience seemed to have lasted just a few seconds—a second diamond ring flashed as totality ended, and little red flickers called “Baily’s beads” could be seen running around the limb of the moon as gaseous prominences on the sun’s surface were momentarily visible. Daylight returned with a rush. And a booby flew over our heads. Unknown to us all, there had been birds roosting on the ship, and they had awoken as from a catatonic sleep. Life returned to normal, Bill Kramer dedicated one more eclipse to his father, and our plans to see the next one began.

Inspired by Bill’s father, I plan to take my children and grandchildren to see a total eclipse. What more inspiring legacy could there be? Now let’s see: west Africa 2013, Faroe Islands 2015, USA 2017... 

