

AURORAE IN AUSTRALIAN ABORIGINAL TRADITIONS

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Abstract: Transient celestial phenomena feature prominently in the astronomical knowledge and traditions of Aboriginal Australians. In this paper, I collect accounts of the *Aurora Australis* from the literature regarding Aboriginal culture. Using previous studies of meteors, eclipses, and comets in Aboriginal traditions, I anticipated that the physical properties of aurora, such as their generally red colour as seen from southern Australia, would be associated with fire, death, blood, and evil spirits. The survey reveals this to be the case and also explores historical auroral events in Aboriginal cultures, aurorae in rock art, and briefly compares Aboriginal auroral traditions with other indigenous groups, including the Maori of New Zealand.

Keywords: Cultural Astronomy, ethnoastronomy, geomythology, Aboriginal Australians, *Aurora Australis*, and Space Science

1 INTRODUCTION

Oral tradition and material culture are the mechanisms by which knowledge about the natural world is transmitted to successive generations of Aboriginal Australians. These traditions contain a significant astronomical component (Haynes, 1992; Johnson 1998; Norris and Hamacher, 2009) useful for navigation, calendars, and food economics (Clarke, 2007; Hamacher, 2012: 71-86; Hamacher and Norris, 2011c). Aboriginal people would move from place to place within their country to seek out food sources and shelter throughout the year. The motions and positions of celestial bodies with respect to the surrounding landscape were of great importance to this end, signaling the changing seasons and the availability of particular food sources. For example, the heliacal rising of the star Fomalhaut signals the coming of the autumn rains to the Kurna people of the Adelaide plains (Hamacher, 2012: 79-82). Another example is the acronychal rising of the celestial emu (traced out by the dust lanes of the Milky Way between Crux and Sagittarius) signaling the start of the emu breeding season, when emu eggs are used as a food source (Hamacher, 2012: 71-75; Norris and Hamacher, 2009). Astronomical traditions also contain a social component (Johnson, 1998). Celestial objects serve as mnemonic devices for remembering laws and customs and inform traditions regarding marriage classes, totems, and ceremonies (Clarke, 2007; Hamacher, 2012; Fuller et al., 2013).

The study of the astronomical knowledge and traditions of Aboriginal and Torres Strait Islander people—part of the inter-discipline of *cultural astronomy*—is a growing subject of public and academic interest in Australia. One component of ongoing research in Australian cultural astronomy involves the investigation of transient celestial phenomena. This includes studies of variable stars (Hamacher and Frew, 2010), eclipses (Hamacher and Norris, 2011a),

comets (Hamacher and Norris, 2011b), meteors (Hamacher and Norris, 2010) and cosmic impacts (Hamacher and Norris, 2009; Hamacher and Goldsmith, 2013) in Aboriginal traditions.

The main goal of this research paper is to investigate the knowledge and traditions relating to the *Aurora Australis*. This includes understanding how the phenomenon was and still is perceived by Aboriginal people; how knowledge of aurorae are incorporated into astronomical traditions; and how the aurora is represented in material culture (i.e. artefacts or rock art).

We begin by discussing the background theory and methodology of this study, followed by a discussion of the physics of aurorae and the solar cycle. We then discuss how previous studies of transient celestial phenomena can be combined with the physical properties of aurorae to predict how Aboriginal people might perceive this phenomenon. Next, we explore the Aboriginal traditions related to aurorae, including explanations of the phenomenon. We also investigate oral traditions for historical auroral events to determine if Aboriginal people noted or predicted the reoccurring frequency and intensity of aurorae over the 11-year solar cycle. We then search for possible representations of aurorae in rock art and discuss how Aboriginal auroral traditions compare with those of the Maori of New Zealand and other indigenous groups that live in or near auroral zones.

2 THEORY AND METHODOLOGY

The cross-disciplinary field of cultural astronomy, including the sub-disciplines of archaeoastronomy and ethnoastronomy, is a social science informed by the physical sciences; it is a science asking social questions (Ruggles, 2011). There is currently no all-encompassing theoretical framework for cultural astronomy and attempts to develop one have thus far been unsuccessful (Iwaniszewski, 2011). Cultural astronomy currently relies on the methods and

theories of the academic disciplines from which it draws. Generally, these include archaeology, anthropology and history. In this paper we draw from historic, ethnographic, linguistic and archaeological records. We reviewed the literature for any sources containing references to aurorae (including 'southern lights' or 'sky glow') in

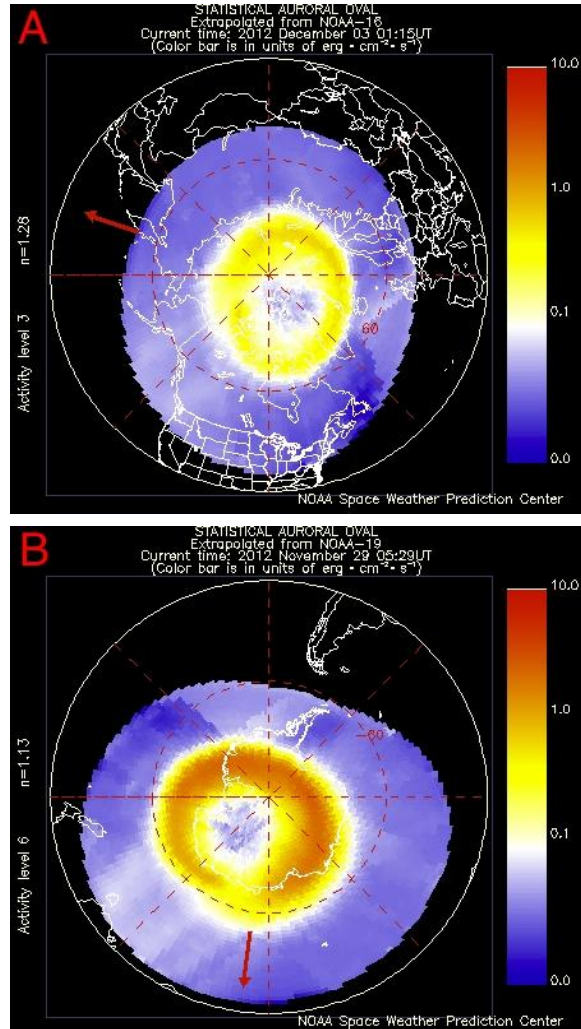


Figure 1(a) (upper): A snapshot of the extent and position of the auroral zone in the northern hemisphere at 23:06 UT on 2 December 2012. Figure 1(b) (lower): A snapshot of the southern auroral zone at 05:29 UT on 29 November 2012. Both were relatively quiet days in terms of magnetic disturbance. Under more disturbed conditions the auroral zones are thicker and displaced equator-ward. The plots are derived from measurements obtained from the NOAA POES satellite showing the power flux of auroral activity (0 to 10 $\text{ergs cm}^{-2} \text{sec}^{-1}$). Plots taken from the POES Auroral Activity page on the National Weather Service's Space Weather Prediction Centre, NOAA. URL: <http://www.swpc.noaa.gov/pmap/>

Aboriginal cultures. These sources included ethnographies, archaeological surveys, historical documents, stories, songs, magazines, newspaper and journal articles, audio and video sources, reputable web sites, post-graduate theses, rock art and other artistic forms.

Since this research addresses both Western science and Aboriginal traditions regarding au-

rorae for a wide audience of readers, it is important to describe the phenomenon from both perspectives. For this reason, a brief, non-mathematical description of auroral physics is provided in the next section. This information is then combined with previous cultural studies of transient celestial phenomena to predict how Aboriginal people, as reported in the literature, perceive aurorae.

3 THE PHYSICS OF AURORAE

Aurorae are light displays, generally seen at high (i.e. polar) or middle latitudes, caused when energetic charged particles in near-Earth space bombard the atmosphere, increasing the energy of oxygen and nitrogen molecules, which then emit visible light. The entire process is governed by solar activity, and in particular the solar wind, which normally is blocked from reaching the Earth's surface by the Earth's magnetic field. However, due to the configuration of the magnetic field, solar wind energy can access low altitudes near the Earth's magnetic poles, where magnetosphere particles (mostly electrons and protons) can be accelerated along field lines into the upper atmosphere (>80 km above sea level). These particles impact with and energize oxygen and nitrogen molecules, which then release photons (particles of light). The photons are released in discrete packets of energy, which correspond to different colours of the electromagnetic spectrum. Oxygen atoms, liberated from their molecules by collisions, are excited to higher energy levels. They give up energy by going back to lower levels (de-exciting) either in large steps, with the emission of green light, or in smaller ones, with emission of any of several wavelengths in the red. Nitrogen emissions are due to nitrogen molecules, either neutral or ionized, giving up energy at any of a number of wavelengths in the red, blue or violet.

The colour of an aurora to an observer on the Earth's surface is dependent on the aurora's altitude. The time for oxygen ions to emit green light is only three seconds, while the time needed to emit red light is up to two minutes. Oxygen is more abundant in the upper atmosphere where collisions between molecules are low. Because of this, red colours dominate in the lower atmosphere, where the air density is higher and collisions are more frequent.

Aurorae are referred to as *Aurorae Borealis* in the northern hemisphere and *Aurorae Australis* in the Southern Hemisphere. Although aurorae technically can be seen from many places on the Earth, they tend to be most active in oval ring-shaped regions located in each hemisphere about 10°-20° equator-ward from the Earth's magnetic poles. The South Magnetic Pole was

~150 km off the coast of Antarctica towards Tasmania (64.497° S, 137.684° E) in 2007, and the North Magnetic Pole was ~740 km north-west of Ellesmere Island in northern Canada in 2012 (85.9° N, 147.0° W) (NOAA, 2012). The magnetic poles are not antipodal, and they wander at a relatively high rate: currently 10-15 km yr⁻¹ in the south and 45-62 km yr⁻¹ in the north (Zvera, 2012).

The width and location of the auroral zones varies with the intensity of disturbance of the geomagnetic field, and the location over time of the wandering geomagnetic poles. In the Northern Hemisphere, the auroral ring generally covers Alaska, Canada, northern regions of the United States, northern Europe and Siberia (Figure 1(a)). In the southern hemisphere, the auroral zone generally covers Antarctica and the southern fringes of Australia and New Zealand (Figure 1(b)). Under average, magnetically-undisturbed conditions, observers from southern Australia and much of New Zealand only have a slight chance of witnessing an aurora (Bond and Jacka, 1962; McEwan, 2006).

The intensity of the solar wind and hence the rate and level of magnetic disturbance at the Earth depends on the Sun's magnetic activity. This activity waxes and wanes during the solar cycle, the duration of which is approximately 11 years. Periods of high solar activity are marked by an increase in sunspots, which denote a rise in the Sun's magnetic activity. This increase in activity leads to larger and more frequent solar eruptions, such as coronal mass ejections, causing more frequent and intense magnetic storms at the Earth. During solar maxima, aurorae are therefore more frequent and intense. Major coronal mass ejections can cause aurorae to be visible from areas of the Earth that rarely witness such a phenomenon. For example, a major solar event on the night of 25-26 September 1909 caused aurorae that were visible in both hemispheres, with aurorae visible as far north as Queensland (Duncan-Kemp, 1952: 44). The physics of solar-terrestrial magnetism and aurorae are more complex than is described in this section, and curious readers should explore Carlson and Egeland (1995), Chapman (1970) and Jones (1974) if they wish to learn more.

4 PREDICTIVE ETHNOASTRONOMY

As listed above, on page 207, we have surveyed a range of transient celestial phenomena in Australian Aboriginal cultures, and each of these studies revealed similarities in the ways these types of phenomena are incorporated into Aboriginal traditions. In a majority of cases, transient astronomical events were seen negatively and often were associated with evil spirits, black

magic, or omens of war, death and disease. Studies like these help cultural astronomers in their efforts to develop a theoretical base for the discipline. These studies are useful for informing us on how humans think about the natural world and how they develop knowledge to explain it.

By combining these studies and taking into account the physical properties of aurorae it may be possible to predict how people interpreted this phenomenon and which groups of people would likely have traditions about it. Six primary attributes relate aurorae to human perception:

1. The location on the Earth from which aurorae are visible;
2. The probability of witnessing an aurora;
3. The direction from which aurorae are visible to an observer;
4. The physical appearance of an aurora;
5. The colour of the aurora; and
6. The intensity of the aurora.

Technically, aurorae can be seen from many places on the Earth, but seeing one from an area far from the auroral zone is extremely rare. Since the southern fringes of continental Australia, Tasmania, and the South Island of New Zealand are near and under certain conditions within the edges of the southern auroral zone, we expect that aurorae will be incorporated into the traditions of indigenous communities in these regions. Since aurorae are primarily seen toward the south, we expect that indigenous knowledge of this phenomenon relates to this direction. In many Aboriginal cultures, the direction of an astronomical phenomenon is significant. For example, meteors denote the direction of an enemy in the traditions of Aboriginal people near the Tully River, Queensland (Roth, 1984: 8) and to the Ngarigo people of south-eastern New South Wales (Howitt, 1904: 430). To the Arrernte of the Central Desert, the tail of a comet points toward the direction of a neighboring community in which someone has died (Spencer and Gillen, 1899: 549).

The appearance of aurorae is broken into two basic categories: diffuse and discrete. As the name suggests, diffuse aurorae lack clear patterns and generally appear as a glow. They are formed when interactions between wave-particles scatter electrons parallel to the magnetic field lines. Discrete aurorae, on the other hand, appear in various shapes, such as draperies ('curtains'), rays or arcs. They are formed due to electrons accelerating parallel to the Earth's magnetic field lines in the atmosphere. Both diffuse and discrete aurorae can appear to move, with draperies being among the most obvious and dramatic examples (see Livesey,

2001). We might expect that oral tradition describe these different types of aurorae.

Unlike the Northern Hemisphere, no inhabited land lies under the highest flux areas of displays visible from Australia. The aurorae visible from Australia tend to be high altitude and are generally visible lower on the horizon (i.e. not overhead). Since high altitude aurorae are dominated by oxygen-red (as discussed in the previous section), a majority of aurorae visible from Australia are reddish in colour (Figure 2). However, in low light conditions, the human eye cannot discern colour and the aurorae appear a faint white. This is different from the bright white displays that are visible under very active conditions. Aurorae can appear to be a range of colours, including red, pink, orange, green and white. Aurorae visible from lands under the higher flux regions of the northern auroral zone tend to reflect this range of colors, particularly white and green, and can be seen directly overhead. From studies of transient celestial phenomena in Aboriginal traditions, red was often associated with blood, fire and death. For example, the red colour of the Moon during a total lunar eclipse was commonly associated with blood, fire and evil (Hamacher and Norris, 2011a). In Lardil traditions on Mornington Island, red- or blue-coloured meteors were associated with sickness, while white meteors were signs of good luck (Hamacher and Norris, 2010). In Aboriginal cultures near Ooldea, South Au-

stralia, the red stars Betelgeuse and Aldebaran signified fire that was cast between celestial beings engaged in battle (Hamacher, 2012: 17-18). Therefore, we expect accounts of aurorae in Aboriginal traditions to relate to blood, fire, war and death.

Aurorae also vary in visible intensity. Some are faint to the naked eye, while sometimes under very active conditions they may be bright enough to enable an observer to read a newspaper at night. We therefore expect that peoples' reactions to bright aurorae are more severe than fainter aurorae. If they relate to negative attributes, such as blood or fire, intense (bright) aurorae would probably induce a reaction of fear and panic more so than aurorae that are of low intensity. While we are confident that not all perceptions of aurorae will be negative, we expect this to be largely the case, based on previous studies of transient celestial phenomena in Aboriginal traditions (c.f. Hamacher and Norris, 2009; 2010; 2011a; 2011b).

A survey of auroral traditions from across the world (e.g. Eather, 1980; Falck-Ytter, 2000; Section 9 of this paper) suggests that in areas where aurorae are a frequent occurrence, they possess benign attributes. But in areas where they are less frequent, they tend to be associated with evil, omens and death. Since far southern Australia is at the edge of the auroral zone, we expect aurorae to be generally negative in perception since they are infrequent.



Figure 2: An *Aurorae Australis*, as seen from Victoria, Australia, on the night of 22 January, 2012 (courtesy: Alex Cherney).

5 AURORAE IN ABORIGINAL ASTRONOMICAL TRADITIONS

We analysed the sources of data mentioned in Section 2 and found they reveal major themes in the perceptions of aurorae, as predicted in Section 4. Not all views were associated with negative attributes, but most were associated with blood, fire and death. Aurorae cause great fear in the people who witness them and in some communities they are taboo—only to be viewed and interpreted by initiated elders. Interpretations of auroral displays vary widely, even within the same communities.

Stories or accounts of aurorae were found in all Australian states and territories (Figure 3), but most of the accounts and oral traditions are from Aboriginal groups in Victoria and South Australia. All accounts were from regions south of the Tropic of Capricorn. The data are broken

down by theme in Subsections 5.1-5.3. This study produced 26 literary sources representing five unidentified Aboriginal groups, and thirteen identified groups. Of the five unidentified groups, three were from Tasmania and one each from Queensland and New South Wales. The Queensland community is probably Yarluyandi, but this is not certain.

Some of the accounts of aurorae were vague or did not attribute either positively or negatively to aurorae. For example, the Nuenonne people of Bruny Island, Tasmania, call the Aurora *nummergen* (Wilson, 1999), but no associated stories or interpretations of this name are provided. A brilliant, multi-coloured aurora visible from Hobart, Tasmania, on 4 September 1851 made a crackling sound that was described by the local Aboriginal people as similar to snapping their fingers (Anonymous, 1877).

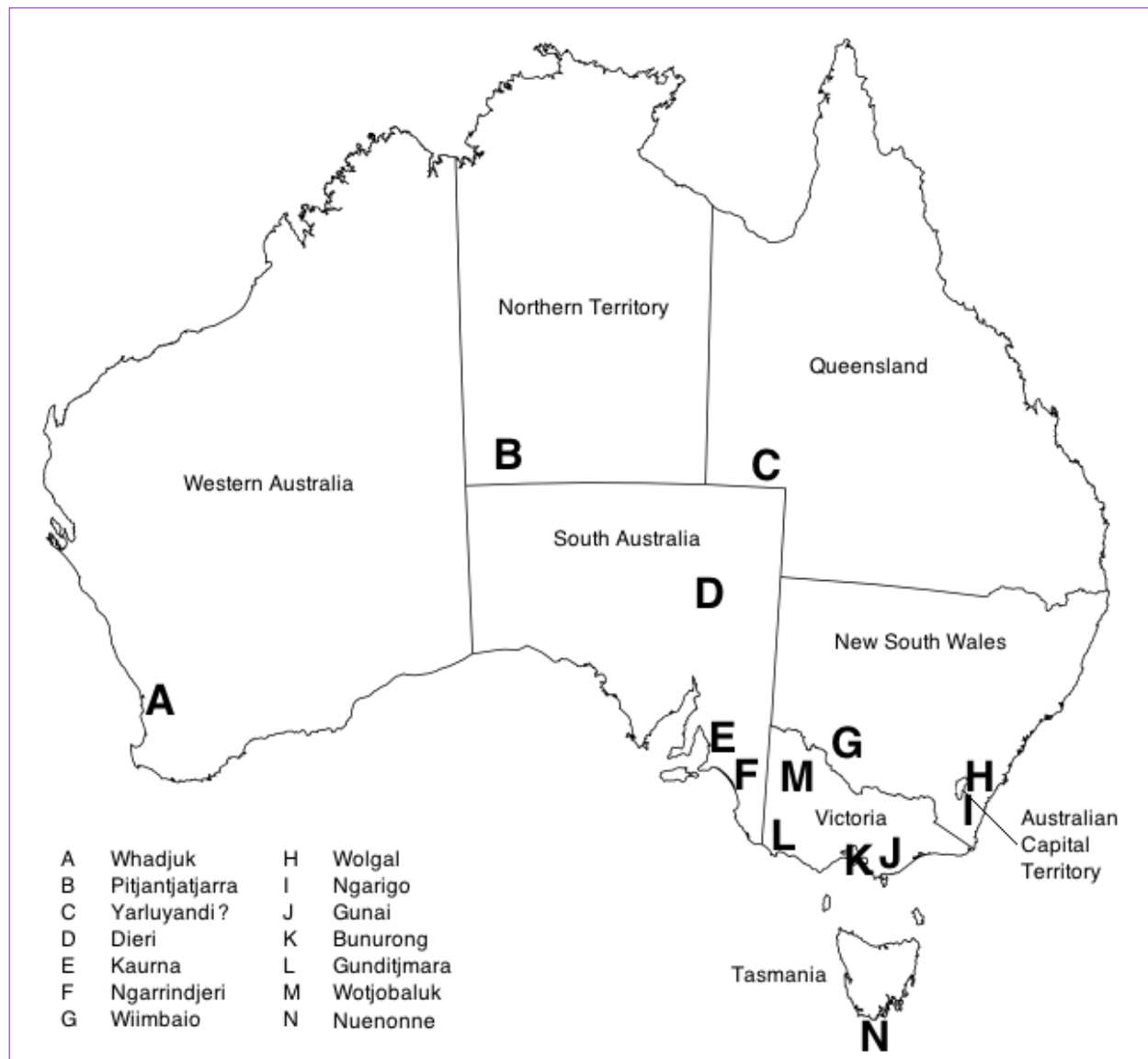


Figure 3: Places in Australia from which Aboriginal traditions describing aurorae were found. Accounts of aurorae are found in all States and Territories, although they are restricted to the southern half of the continent, consistent with the rarity of these events at lower latitudes.

5.1 Fire, Smoke and Ash

Since aurorae generally appear red in the sky as seen from Australia, they are commonly associated with fire. This association may include flames, smoke or ashes. For example, the Gunditjmarra people of coastal western Victoria called aurorae *Puae buae*, meaning 'ashes' (Dawson, 1881: 101). The Gunai of Gippsland, eastern Victoria, perceived aurorae as bushfires in the spirit world (Massola, 1965: 213). They also attributed them to the fire of an ancestral hero warning of a coming catastrophe (Worms, 1986: 112). When the Dieri people of Cooper's Creek, South Australia, saw an auroral display in 1869, they claimed it was a *Kootchee* (an evil spirit) creating a large fire (Smyth, 1878: 458). Similarly, the Narringeri people of Encounter Bay, South Australia, interpreted an aurora seen over Kangaroo Island (Karta) as the campfires of spirits in the 'Land of the Dead', located in the heavens (Tindale, 1974). The Narringeri considered Kangaroo Island to be the land of the dead (Berndt, 1940:182; Tindale and Maegraith, 1931). The Island was uninhabited when the first European, Matthew Flinders, arrived, but archaeological data revealed that Aboriginal people lived on the Island as long ago as 16,000 years BP but mysteriously disappeared some 2,000 years ago (Draper, 1987).

The solar eruption from 25-26 September 1909 caused bright aurorae that were visible across the northern and southern hemispheres (Silverman, 1995). On 24 September, Duncan-Kemp (1952: 44) described the appearance of bright aurorae visible from Windorah in far southwest Queensland. A group of Aboriginal people (possibly the Yarluyandi or Karuwali people) said the aurorae were the 'feast fires' of the *Oola Pikka*—ghostly beings who spoke to the people through auroral 'flames'. Only male elders were permitted to view the display and interpret their messages, as tribal law forbade women or uninitiated men from seeing the sacred lights. When aurorae appeared in the sky, the Aboriginal women would turn away.

Several accounts from the Gunai people describe aurorae as a physical manifestation of a powerful sky deity's anger. This seems to be slightly different than the 'bushfires in the spirit world' as described by Massola (1965: 213). The accounts describe the deity as *Mungan Ngour*. *Mungan* set the rules for the initiation of boys into manhood and put his son, *Tundun*, in charge of the ceremonies. Information about male initiation ceremonies was restricted to men, and was taboo to women. A person in the community revealed initiation secrets to the women, greatly angering *Mungan*. In a rage, he cast down a great fire to destroy the Earth, which the people saw as an aurora.

According to Howitt (1904: 430), the appearance of *Mungan's* Fire caused a reaction of fear, prompting the people to shout "... send it away; do not let it burn us up!" As they yelled this, they swung a dead hand, called a *bret*, at the portent. The hand served as a charm and a warning device. When a relative or close friend passed away, his or her hands were removed then smoked and dried over a fire. They were then suspended by a cord of possum fur, fingers down, around the neck over the left arm. The *bret* was believed to pinch or tap the wearer whenever danger approached. The wearer would then face in different directions, holding the *bret* in front of him. When it shook violently the man knew the direction of the danger.

Massola (1968: 162) explained that *Mungan's* fire caused everyone to turn on each other; men speared one another and killed their wives, while mothers killed their children. The aurora filled the whole of the sky from the land to the sky and was followed by a tsunami that rushed over the land and drowned most of the people (Thomas, 1906a: 219). Those who survived became the Muk-Kurnai, the 'Superior Animals'. *Tundun*, the Great Man's son, and his wife, became porpoises. The Great Man then went to the sky. After his anger subsided, he allowed the men to again carry on the ceremonies on the condition that they not tell women initiation secrets. If his laws and customs are disregarded, he shows his anger by lighting up the sky at night with the fires of the aurora (Keen, 2004: 214-215).

Thomas (1906b:143) noted that an auroral display caused the Gunai people to engage in temporary promiscuity. To avert the evil of *Mungan's* fire, elder men would exchange wives in a practice called *beamu* (Keen, 2004: 182). Howitt (1891: 101) also noted this practice, explaining it as a reversion to the ancient custom of group marriage. This practice was also found among the Dieri people (Montagu, 2004: 219). Auroral traditions among the Bunurong people of the Mornington Peninsula, south-east of Melbourne, are similar to the Gunai (McCrae, 1934).

A final account that attributes aurorae to fire is from the Pitjantjatjarra people near Uluru (Ayer's Rock) in the Northern Territory. The story describes hunters breaking a taboo by cooking a sacred emu (*kalaya*). They saw smoke rise to the south, towards the land of *Tjura* (a Pitjantjatjarra word meaning 'glowing light visible at night'; Goddard, 1992: 160). This was the glow of the *Aurora Australis*, which the Pitjantjatjarra believed were poisonous flames (Harney, 1960: 74). In the story, the flames served as a portent of punishment to the hunters.

5.2 Blood and Death

The appearance of an unexpected transient event in the sky is often met with fear (e.g. Hamacher and Norris, 2010; 2011a; 2011b). The appearance of a red aurora in the southern evening skies as seen from the central-western coast of Tasmania caused astonishment and incited shouting by Aboriginal people (Anonymous, 1838). The Whadjuk people in Perth had a similar reaction on the night of 11 July 1838 when a bright auroral display was visible (Anonymous, 1838). Similar to the appearance of comets and meteors, an auroral display was an omen to the Dieri people that a person in a neighboring community had condemned someone to death (Frazer et al., 1895: 175-176). Thus, the appearance of an aurora—as with many transient phenomena—was met with great fear.

To the Dieri people, the *Aurora Australis* is called *pilliethillcha*. Whenever an auroral display is seen, it causes great fear and anxiety. The Dieri believe it is a warning from the devil (Kootchie) to keep a strict watch, as an armed party (*pinya*) is killing someone for breaking traditional laws. Aboriginal people in the camp then huddle together, when one or two step out and perform a ceremony to charm the Kootchie (Gason, 1879: 297). Fear of an aurora was developed and utilised to control behavior and social standards. Breaking traditional laws would result in a *pinya* coming to kill the lawbreakers when they least expect it.¹

The red colour of most aurorae visible from Australia was commonly associated with blood and death, as anticipated in Section 4. Auroral displays represented blood that was shed by warriors fighting a great battle or by massacre victims rising to the sky. This view was shared by Aboriginal people in the Riverine areas of New South Wales and South Australia, the Ngarigo and Wolgal people near Canberra, the Wotjobaluk people of north-western Victoria (Gibbs, 1974: 50; Howitt, 1904: 430) and the Dieri people (Gason, 1879: 297).

5.3 Spirits and Omens

Smith (1913) records accounts from two unspecified Aboriginal groups that attribute aurorae to the spirits of ancestors dancing in the sky or a portent of trouble. Aurorae served as omens of disease to the Wiimbaio near the junction of the Murray and Darling Rivers (Thomas, 1906b: 143). A bright pink aurora visible from Adelaide on 7 February 1840 (Anonymous, 1840) was believed to be the harbinger of a plague. The nearby Putpa, Wirra, and Marimeyunna clans believed aurorae were caused by sorcerers from the north and were an omen (Schurmann, 1987: 86). The Ngarrindjeri people of Point McLeay mission, South Australia, shar-

ed a similar view. A combination of rare astronomical phenomena caused fear and anxiety to the local Ngarrindjeri people in 1859. In August of that year, an aurora was visible around the time of a lunar eclipse (Anonymous, 1859; Taplin, 1859: 2 September 1859;). The Ngarrindjeri believed this signaled the arrival of dangerous spirit beings they dubbed 'wild blackfellows'. These were Aboriginal people living outside the areas of European settlements (Merlan, 1994). Like their Wiimbaio neighbors, the Ngarrindjeri considered 'wild blackfellows' to be great sorcerers with supernatural powers and were greatly feared.

6 HISTORICAL AURORAL EVENTS

Aurorae and sunspot cycles have been recorded throughout human history, particularly in eastern Asia (Keimatsu, 1970-1976; Lee et al., 2004; Matsushita, 1956; Stephenson and Willis, 1999, 2008; Willis and Davis, 2014; Willis and Stephenson, 2000, 2001; Willis et al., 2005, 2007). Since there are no written records from Australia prior to colonisation, it is difficult to connect historical aurorae in antiquity with Aboriginal traditions since the latter do not necessarily record a single point in linear time. It is probable that aurorae visible in antiquity were the basis, or re-emphasis, of auroral traditions in Australia. However, since colonisation of Australia by the British in 1788, historical records of auroral events and written accounts of Aboriginal traditions can be matched.

These historical records revealed six auroral events noted by Aboriginal people. They occurred during major solar eruptions in 1838, 1840, 1851, 1859, 1869 and 1909. Each of these years coincides with a peak in the solar cycle (Figure 4). A bright auroral display on 11 July 1838 was visible from Tasmania to Perth (Anonymous, 1838) and a bright pink aurora was visible from Adelaide on 7 February 1840 (Anonymous, 1840). An aurora seen on 4 September 1851 from Hobart made sounds the local Aboriginal people described as being similar to snapping fingers. The aurora visible on 2 September 1859 from the Point McLeay mission, South Australia (Taplin, 1859: 4-7 June) coincided with the strongest geomagnetic storm ever recorded (dubbed the '1859 solar super-storm' or 'Carrington Event'). The bright aurorae witnessed by the Dieri people in 1869 (Smyth, 1878: 458) were part of the many auroral displays visible across the globe in April/May and September 1869 (Murray, 1869; Prowde et al., 1869; Tebbutt, 1870; Wintle, 1869). Major solar eruptions peaking on 25-26 September 1909 produced bright, multi-coloured aurorae visible as far north as southern Queensland (Duncan-Kemp, 1952: 44). It is worth noting that all three auroral displays occurred during the month of Sep-

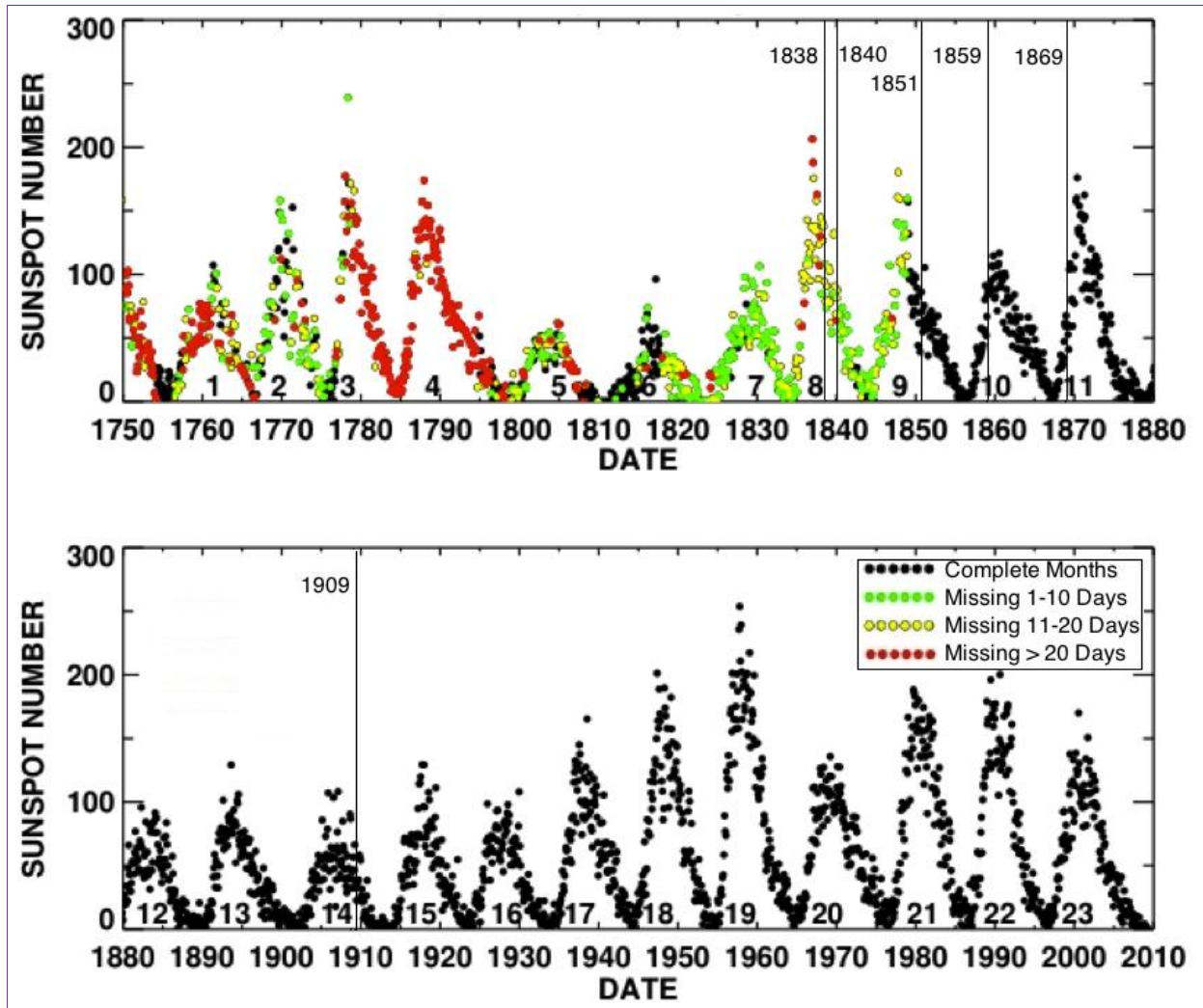


Figure 4: The number of sunspots observed between 1750 and 2010. After Hathaway (2010: Figure 2). The vertical lines show the years when historic aurorae were described in Aboriginal culture from Section 6.

tember. This accords with the general increase in geomagnetic disturbances near equinoxes (see below). Since the auroral zone only barely covers the southern edge of Australia, the discovery that historical literature only records accounts of aurorae in Aboriginal traditions during peaks in the solar cycle is to be expected.

It should be noted that a significant geomagnetic storm led to strong aurorae visible around the world on 4-5 February 1872 (Silverman, 2008). Accounts from Australia describe brilliant aurorae in Perth, Adelaide, and Melbourne on these days. While the aurorae may have been visible at more northerly latitudes (*ibid.*), no accounts were recorded from more northerly latitudes in the TROVE newspaper database. There were no recorded accounts of Aboriginal perspectives of the aurorae, although it is almost certain that Aboriginal people would have seen them in the skies.

7 ABORIGINAL RECOGNITION OF THE 11-YEAR SOLAR CYCLE?

Aurorae are connected with the solar sunspot

cycle and are more frequent and intense during solar maxima, which occur every 11 years. Since Aboriginal people were careful observers of natural phenomena, we might expect to find a description of this cycle in Aboriginal traditions.

A survey of the literature revealed only one case of Aboriginal people recording the solar cycle in their traditions. According to Bodkin (2008: 70) the Dharawal people south of Sydney used the appearance of the aurora to announce the start of the 11-12 year Mudong weather cycle. The aurorae appear during the annual season of *Ngoonungi*. *Ngoonungi* is the period of gradual warmth, during September and October. The appearance of aurorae signalled the start of the first of the eight Mudong cycle phases: *Gadalung Burara*—the hot and dry phase. This season can last up to 20 complete lunar cycles ('20 moons') but no more (Bodkin, 2008: 72). In an interview with CNN in 2003,² Bodkin claimed that the 11-year Mudong cycle started in 2001 with the appearance of aurorae. This coincided with the peak in sunspots and the start of the last solar cycle (Figure 4). Bodkin stated that

the aurorae are seen less frequently because of increasing light pollution.

In some media interviews following the publication of her book on Dharawal seasons and climatic cycles,³ Bodkin claimed that during October aurorae were visible in the western skies as well as to the south. Historical records describe aurorae visible to the west from the Hunter Valley north of Sydney (Anonymous, 1846). It is worth noting that geomagnetic storms tend to peak in the months around the equinoxes, in particular March-April and September-October (Papitashvili et al., 2000; Stamper et al., 1999). This is when both hemispheres of the Earth are most uniformly exposed to the solar wind and its embedded interplanetary magnetic field. Accordingly, many of the aurorae identified in Aboriginal traditions were linked to auroral displays during, or around, these months, particularly September.

A higher than normal rate of observed aurorae, especially those seen from the Sydney region, could be useful for recognising the 11-year solar cycle. There has been much discussion on whether climate follows an 11-12 year cycle in phase with the solar cycle (e.g. see Haigh, 2007; Weart, 2013). Such an effect has not been established and is a topic of current research.

8 REPRESENTATIONS OF AURORAE IN ROCK ART

Clear representations of aurorae in Australian rock art have not been reported in the literature. Plausible, but unconfirmed, representations of aurorae in Australian rock art are reported from a group of researchers led by Anthony Peratt (Peratt, 2003; Peratt et al., 2007; Van Der Sluijs and Peratt, 2010). Peratt and his colleagues claim that in antiquity, intense solar activity directed a significant amount of plasma energy towards the Earth, interacting with the Earth's magnetic field and causing brilliant aurorae that would have been seen worldwide. Based on the visible shapes derived from computer simulations of these proposed auroral events, Peratt and his colleagues then compared the auroral shapes to rock art motifs from around the world. The team noted several motifs that are evident in rock art around the world and suggest that they depict this auroral display (Figure 5). The interested reader is directed to the papers of Peratt and colleagues for an in-depth explanation and analysis of this work. At this stage there is no clear evidence that any rock art motifs in Australia represent these auroral displays or that the artistic motifs described by Peratt and colleagues represent these proposed auroral events. Without oral traditions or ethno-historical evidence to explain the meaning of art-

istic forms, these motifs are open to interpretation.

It is worth noting that auroral displays are affected by increases and decreases in the Earth's magnetic field. The magnetic poles reverse on long timescales (450,000 years on average), with the magnetic field decreasing significantly before reversing. This could result in significant auroral displays. The last geomagnetic reversal occurred 780,000 years BP, but recent evidence indicates that an excursion occurred approximately 41,000 years BP (Nowaczyk et al., 2012). This is within the period of human habitation of Australia, although we urge caution in stretching these claims too far.

9 VIEWS OF AURORAE IN OTHER CULTURES

Aurorae are included in the oral traditions and mythology of numerous cultures across the world (see Akasofu, 1979; Holzworth, 1974; Stothers, 1979). To the Inuit of the Hudson Strait in the far north of Quebec, Canada, aurorae represented the torches of spirits who were leading the souls of the recently-deceased to paradise (Holzworth, 1974). The Inuit of the Coronation Gulf in eastern Nunavut, Canada, perceived aurorae as a manifestation of the spirits that brought good weather (Weyer, 1969: 243). In Point Barrow, Alaska, aurorae were greatly feared and the people armed themselves for protection (ibid.). Associations with death, spirits or battles were found among the people of Scotland (Mackenzie, 1935: 222), Siberia (MacCulloch, 1964: 398), Finland (ibid.), and Estonia (ibid.).

The Maori of New Zealand call aurorae *Tahunui-a-rangi*, which roughly translates as 'great glowing sky' (Reed, 1999:194-195; cf. Moorfield, 2011). Descriptions of aurorae in Maori traditions are numerous. For example, a Maori man from Wanganui on the south-western coast of the North Island was interviewed in 1869 and explained that when their ancestors migrated to New Zealand, one *waka* (canoe) continued sailing south towards the horizon where aurorae were seen, settling a land in the far south (Best, 1955: 71). The Maori see aurorae as a reflection of the fires cast by these ancestors, which signal their presence. Another story describes aurorae as *Maru*, the name of a Maori war-deity (Craig, 1989: 160). According to Kingsley-Smith (1967), "... anyone going on the war-path and seeing an aurora would not continue on his way, for such conduct would have been considered suicidal."

10 CONCLUDING REMARKS

Accounts and descriptions of aurorae are found in the oral traditions of Aboriginal Australians

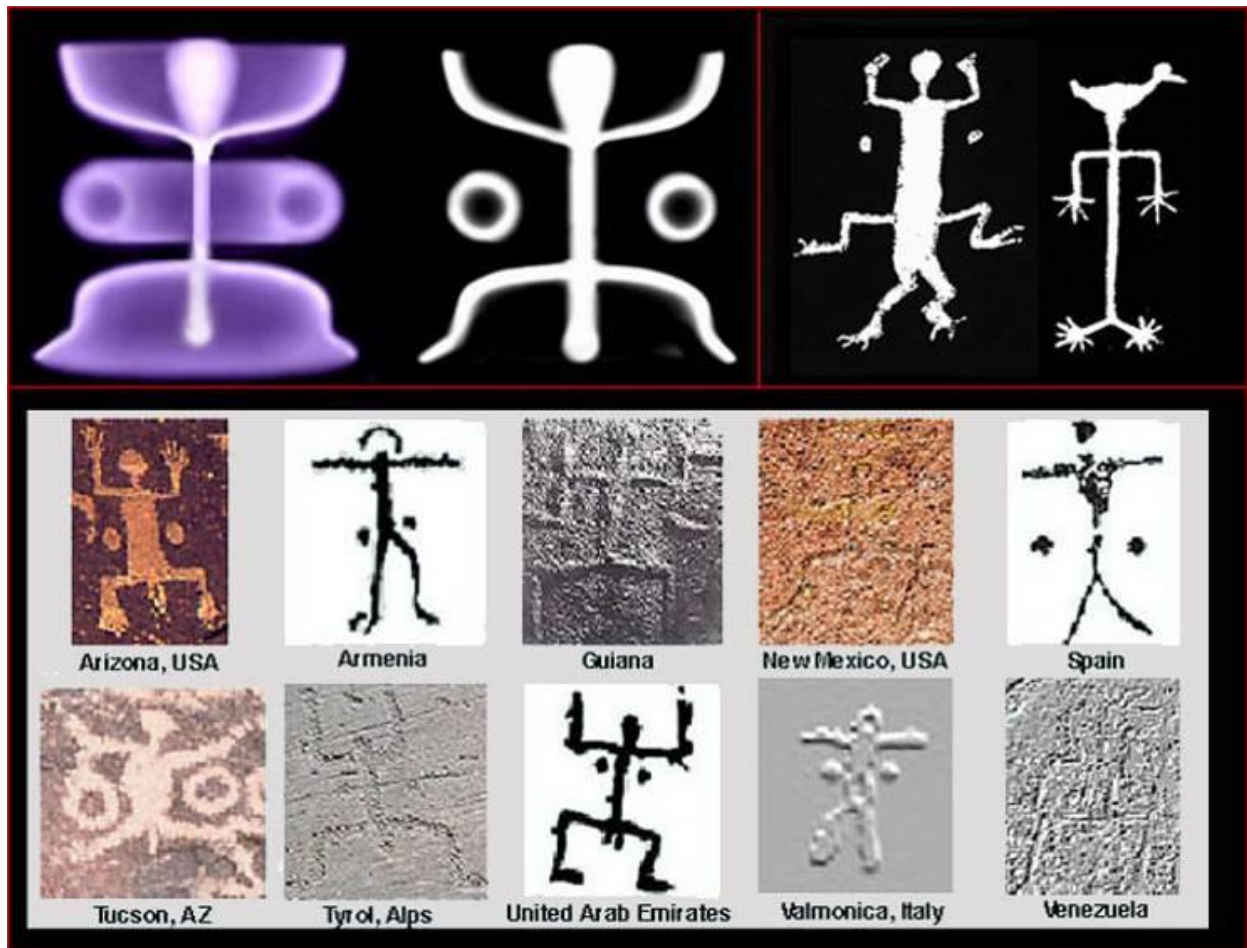


Figure 5: A computer simulation of one of the shapes caused by the proposed high-intensity auroral display (top left), an interpretation of what it may have looked like (top middle), and various rock art motifs that Peratt and his colleagues believe may represent this phenomenon (top right, bottom). Similar motifs are found in Australia (e.g. McCarthy 1976), although any connection to the proposed auroral display is speculative (after Peratt, 2003).

across the southern half of the continent. Significant solar eruptions caused auroral displays that were visible as far north as southern Queensland, but no examples are recorded from areas north of the Tropic of Capricorn. As predicted in Section 4, most Aboriginal accounts describe aurorae in negative terms and associate them with blood, death, fire or evil spirits. Aurorae are also associated with a southerly direction. This is due largely to their generally reddish appearance on the southern horizon. A comparison of cultural interpretations of aurorae from other parts of the world, particularly New Zealand, showed a similar association.

Aurorae play an important role in the oral traditions of Aboriginal Australians. Aurora traditions provide us with a more complete understanding of Aboriginal sky knowledge and cultural astronomy. Aboriginal views of the phenomenon are similar to those of the Maori of New Zealand and other cultural groups across the world.

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12 NOTES

1. An account of retribution from a sky deity for careless behavior is reported by Berndt (1947). A Wiradjuri man (central New South Wales) claimed that when someone is careless, Kurikuta would come down from the sky, turning the night into day. Berndt suggests this is a reference to an aurora. Kurikuta, an emu, was the wife of the sky deity *Baiame*. She had a quartz body and when she came down from the sky, she was seen as a brilliant flash of light that made a great thunderous sound (Berndt, 1947: 28). Given her association with a brilliant flash of light accompanied by the sound, it is probably a reference to lightning or possibly a fireball/airburst (bright/exploding meteor) as opposed to an aurora. Quartz was believed

to be a material manifestation of celestial deities that were brought to Earth by meteors (Hamacher and Norris, 2010).

2. <http://edition.cnn.com/2003/TECH/science/03/18/offbeat.weather.aborigines.reut/>
3. <http://www.murrindindiclimatenetwork.org.au/24/Fran-Bodkin/>

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