

## Dirty Fires: Cosmic Pollution and the Solar Storm of 1859

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On 1 September 1859 the first solar flare ever observed from earth was witnessed separately by Richard Carrington, an established astronomer, and Richard Hodgson, an amateur scientist, both of whom had been observing sunspots when they found themselves witnesses to an entirely different event. The resulting solar storm, which lasted from 28 August to 2 September, remains perhaps the most significant space weather event observed by humans.<sup>1</sup> During this week, unusual phenomena began occurring across the globe. On both 28 August and 2 September an extraordinary display of the aurora borealis appeared across the northern and southern hemispheres, a red glow in the sky so bright that 'at about one o'clock ordinary print could be read by the light'.<sup>2</sup> The sky was so red and intensely lit that it prompted some witnesses to worry that a disastrous fire might have erupted in a nearby neighbourhood. On the same evenings, communications systems failed across America and Europe as telegraph machines were overwhelmed by electrical surges. In Paris, sparks reportedly flew from the equipment, and in Philadelphia, a telegraph manager wrote that 'streams of fire' appeared around the machines as operators desperately worked to save them.<sup>3</sup> In Washington DC, one telegraph operator was badly shocked by a spark of electricity which hit him in the forehead (though he recovered quickly).

Ideas about the sun were transforming rapidly during the mid-nineteenth century. Many Victorian conceptualizations of the sun fell into two categories: either fears about its fate and how it would affect the earth's future, or parallels between it and the earth that projected earthly concerns onto the sun's surface. Earlier in the nineteenth century, stellar

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<sup>1</sup> Though no observatories directly witnessed the solar flare, the Kew Observatory in England, headed by Balfour Stewart, observed such strong magnetic disturbances at the time of the flare that its machinery could not accurately record the peaks of activity, which ultimately had to be estimated. See E. W. Cliver, 'The 1859 Space Weather Event: Then and Now', *Advances in Space Research*, 38 (2006), 119–29 (p. 123).

<sup>2</sup> 'The Auroral Display in Boston', *New York Times*, 3 September 1859, p. 4.

<sup>3</sup> 'Observations Made at Pittsburgh, Pa., Communicated by E. W. Culgan, Telegraph Manager', *American Journal of Science and Arts*, 2nd ser., 29 (1860), p. 97.

astronomy was viewed as a largely speculative area of enquiry. In his *Cours de philosophie positive* (1830–42), Auguste Comte argued that astronomers should not pursue the study of stellar astronomy because little would ever be known of the chemical composition of the stars.<sup>4</sup> In the mid-nineteenth century, however, Victorian astronomers took an increasing interest in the workings of the sun's surface, partially encouraged by the observations of sunspots by figures like Samuel Heinrich Schwabe and Carrington, as well as by observations of solar prominences (sometimes referred to as 'protuberances') made visible during solar eclipses in 1836, 1842, 1851, and 1860. It was during the 1851 eclipse that astronomers made the connection that prominences were a solar rather than lunar feature (Cliver, p. 121). In 1859 Robert Bunsen and Gustav Kirchhoff discovered that chemical elements produce unique spectra, enabling Victorian scientists to begin studying not simply the movement of stellar bodies, but also their chemical composition.<sup>5</sup> Though the sun was often associated with purity, heavenly light, and warmth, developments in thermodynamics led to increasing anxieties about a solar decline or 'heat death', fears that found representation in the images of the cooling sun of H. G. Wells's *The Time Machine* (1895), or the entropic chaos of Richard Jefferies's *After London* (1885).

The Victorians also conceived of the sun in industrial terms. As Allen MacDuffie and Barri Gold have persuasively demonstrated, the sun was often thought of as a kind of engine, or as connected to the workings of engines. MacDuffie notes that 'in its popular metaphorical elaborations, thermodynamics also drew upon the imagery of industrial machinery to describe the operations of the universe'.<sup>6</sup> He points to Balfour Stewart and Peter Guthrie Tait's 1875 *The Unseen Universe*, in which they write:

The visible universe may with perfect truth be compared to a vast heat-engine [...]. The sun is the furnace or source of high-temperature heat of our system [...] and the energy which is essential to our existence is derived from the heat which the sun radiates.<sup>7</sup>

Gold points out that the sun was perceived as a wasteful source of energy, arguing that 'added to the increasing conviction that [it] was limited as a

<sup>4</sup> Michael J. Crowe, *Modern Theories of the Universe from Herschel to Hubble* (New York: Dover, 1994), pp. 146–48.

<sup>5</sup> John B. Hearnshaw, *The Analysis of Starlight: Two Centuries of Astronomical Spectroscopy*, 2nd edn (Cambridge: Cambridge University Press, 1990), pp. 28–29.

<sup>6</sup> Allen MacDuffie, *Victorian Literature, Energy, and the Ecological Imagination*, Cambridge Studies in Nineteenth-Century Literature and Culture, 93 (Cambridge: Cambridge University Press, 2014), p. 83.

<sup>7</sup> Balfour Stewart and Peter Guthrie Tait, *The Unseen Universe; or, Physical Speculations on a Future State*, 3rd edn (New York: Macmillan, 1875), p. 84.

power supply was the realization that most of the sun's energy would be waste'. She continues: 'How little of the sun's heat and light (late Victorians calculated anxiously) would be intercepted for use on earth; how much would dissipate uselessly into space!'.<sup>8</sup> The same language of waste that applied to engines was also applied to the sun. In 1868 Balfour Stewart and Norman Lockyer noted that 'the sun's energy is spent in producing the wood or coal, and the energy of the wood or coal is spent (far from economically, it is to be regretted) in warming our houses and in driving our engines'.<sup>9</sup> Their language draws together the organic and the industrial (a point to which I will return) and envisions the burning of the sun, the burning of coal, and the driving of engines as continuous and implicitly related processes.

I argue that the sun was also conceived of as a form of potential pollution. For casual observers on earth, the 1859 storm represented not simply an electromagnetic disruption, but a kind of cosmic contamination, an influx of material that altered day-to-day experience. The 1850s were already a time in which concerns about air pollution were increasing in England; the 1853 Palmerston Act focused on the issue of smoke abatement, while the 'Great Stink' during the summer of 1858 had Londoners thinking about contamination, sewage, and foul air. While industrial pollution had clear man-made origins that celestial contamination lacked, ideas about pollution had an effect in shaping the way that Victorians experienced cosmic events. For the Victorians, both cosmic and industrial activity produced matter — organic or man-made — that could not be controlled. Responses to the 1859 storm highlight the intersection of ideas about pollution and celestial events, an intersection which additionally shaped later understandings of solar flares. In the 1870s figures like the English astronomer Richard Proctor and the French astronomical artist Étienne Trouvelot each drew together ideas about stellar activity with images of smoke and contamination.

Those describing the 1859 aurora compared it to 'strange fires' in the sky, an ominous 'blood red' presence which suggested that forces from space had the capacity to contaminate the earth's atmosphere.<sup>10</sup> In the 1850s astronomers still debated whether the origins of the aurora borealis were

<sup>8</sup> Barri J. Gold, *ThermoPoetics: Energy in Victorian Literature and Science* (Cambridge, MA: MIT Press, 2010), pp. 45–46.

<sup>9</sup> Balfour Stewart and J. Norman Lockyer, 'The Sun as a Type of the Material Universe, Part II', *Macmillan's Magazine*, August 1868, pp. 319–27 (p. 322).

<sup>10</sup> *Cincinnati Daily Commercial*, 1 September 1859, quoted in James L. Green and others, 'Eyewitness Reports of the Great Auroral Storm of 1859', *Advances in Space Research*, 38 (2006), 145–54 (p. 149); *New York Herald*, 29 August 1859, quoted in Green and others, p. 146.

earthly or cosmic.<sup>11</sup> Witnesses nevertheless linked the aurora with anxieties about not only cosmic interference, but pollution as well, imagining the aurora as a contaminating fire. For the Victorians, solar prominences and solar storms brought attention to the unnerving power of the sun, a presence that provided the means for life on earth, but that also threatened to disrupt daily life, not by becoming too faint or too weak in an eventual heat death, but rather by sending powerful jets of energy towards the earth that would flood and overwhelm human technological systems. The Victorian reaction to the solar storm of 1859 was to envision the aurora borealis both as a display of heavenly beauty and as a source of unexplained cosmic pollution. Newspapers reporting on the 28 August and 2 September auroral displays emphasized the mixed reactions that observers felt in the presence of a night sky that was simultaneously beautiful and frightening. One reporter described the scene as a ‘ghastly splendor’, while another wrote: ‘Nothing could exceed the grandeur and beauty of the sight; the effect was almost bewildering, and was witnessed with mingled feelings of awe and delight by thousands.’<sup>12</sup> Similarly, in San Francisco an observer noted, ‘Half-past eleven. The appearance now is positively awful. The red glare is over houses, streets, and fields, and the most dreadful of conflagrations could not cast a deeper hue abroad.’<sup>13</sup> This ‘most dreadful of conflagrations’, far from being a source of warmth or comfort, had become a source of pollution that could not be controlled or contained.

This pollution not only transformed the night sky, but demonstrated the power to penetrate, and even destroy, communications systems. Like industrial pollution, the contaminating forces of the aurora borealis affected both the natural world and the built environment. These cosmic displays were not simply ominous signs; they had the physical power to

<sup>11</sup> In 1733 Jean-Jacques d’Ortous de Mairan argued that the sun played a major role in the appearance of the aurora. However, nineteenth-century scientists argued for a variety of possible causes, including atmospheric, electrical, and magnetic sources. See Denison Olmsted, *On the Recent Secular Period of the Aurora Borealis* ([Washington DC]: Smithsonian Institution, 1856), p. 41. Both Carrington and Hodgson were cautious about linking the 1859 flare with the auroral displays. See Richard Christopher Carrington, *Observations of the Spots on the Sun, from November 9 1853, to March 24 1861 Made at Redhill* (London: Williams and Norgate, 1863). Balfour Stewart, however, told the Royal Society in 1861 that the recordings of magnetic activity coinciding with the solar flare suggested that ‘our luminary [the sun] was taken in the act’. See Balfour Stewart, ‘On the Great Magnetic Disturbance Which Extended from August 28 to September 7, 1859, as Recorded by Photography at the Kew Observatory’, *Philosophical Transactions of the Royal Society of London*, 151 (1861), p. 428; See also Cliver, p. 123; and Stuart Clark, *The Sun Kings: The Unexpected Tragedy of Richard Carrington and the Tale of How Modern Astronomy Began* (Princeton: Princeton University Press, 2007), p. 82.

<sup>12</sup> *Cincinnati Daily Commercial*, 29 August 1859, quoted in Green and others, p. 146; *San Francisco Herald*, 5 September 1859, quoted in Green and others, p. 149.

<sup>13</sup> *San Francisco Herald*, 5 September 1859, quoted in Green and others, p. 149.

disrupt human systems. Telegraph operators understood that a link existed between appearances of the aurora and problems with telegraph machinery, although official connections between the aurora and electromagnetic fields would not be made until 1905 (Cliver, p. 124). The visible displays of fire in the atmosphere above also translated into fires, shocks, and electrical surges within the telegraph machines; as equipment failed, an excess of electricity became a form of pollution. The displays of cosmic energy indicated not an entropic universe running out of power, but a universe capable of directing too much energy into the earth's atmosphere.

In thinking of the aurora as a form of contaminating fire, the Victorians imagined the earth at war with surrounding cosmic forces, forces that they could not fully understand or command. For observers on earth, the aurora offered a vision of a destructive and terrifying power capable of invading the planet without warning, a 'terrible bombardment', as one writer noted:

Vivid arrows of light [...] would again shoot higher and higher, until they covered the whole sky. This continued to grow darker, first to scarlet, then to crimson, and finally to the blood red like appearance of an immense conflagration. The whole sky appeared mottled-red, the arrows of fire shooting up from the north, like a terrible bombardment, of which we could see all and hear none, while the stars of greater magnitude shone through like sentry lights.<sup>14</sup>

The earth is imagined in a state of war with the surrounding universe, defended only by the 'stars of greater magnitude', which appear calm and reassuring in comparison to the tumult of the sky. In the same vein, observers regularly linked the aurora with blood, with another eyewitness noting the 'blood red appearance' of the heavens.<sup>15</sup> In the struggle between the earth and the surrounding universe, the human world is clearly unable to defend against penetrating rays from space.

The aurora, then, was not seen simply as a luminous, if unnerving, display. It was read as a signal that humans were not the only ones capable of polluting their environment — the cosmos could also be polluted by powers beyond their control. As the nineteenth century progressed, astronomers began to link solar activity with auroras,<sup>16</sup> and to imagine solar prominences themselves in terms of pollution. In 1871 Richard Proctor noted that solar flares could 'resemble smoke from chimneys or from the

<sup>14</sup> *Washington Daily National Intelligencer*, 2 September 1859, quoted in Green and others, p. 146.

<sup>15</sup> *New York Herald*, 29 August 1859, quoted in Green and others, p. 146.

<sup>16</sup> Richard A. Proctor, *The Sun: Ruler, Fire, Light, and Life of the Planetary System* (London: Longmans, Green; New York: Scribner, Welford, 1871), pp. 370–73.

craters of volcanoes' (p. 263). His comment not only highlights the way that industrial and natural sources of pollution intersected, but also the way that solar activity was framed in terms of industrial contaminants. Similarly, in 1873 Étienne Trouvelot produced illustrations of solar prominences that were reminiscent of industrial smoke, visually linking solar fires with contamination. While witnesses of the 1859 solar storm described that event as a kind of contaminating fire, by the 1870s individuals like Proctor and Trouvelot had begun to make the connection between solar fires and industrial pollution more explicit.

Trouvelot, a Frenchman who spent the majority of his adult life in the United States, is best remembered as the man who unintentionally introduced the gypsy moth to the US. In the 1870s, after this unfortunate occurrence, he moved on from entomology to a new-found interest in astronomy after he had had the opportunity to observe a number of auroras. The detail and precision of Trouvelot's illustrations led to a job at the Harvard College Observatory in 1872, and in 1875 he was invited to use the refractor at the United States Naval Observatory to produce further depictions of solar and celestial objects. Over the course of his career Trouvelot produced thousands of sketches of astronomical phenomena, and in 1876 his works were displayed at the United States Centennial Exhibition in Philadelphia. A selection of his work titled *The Trouvelot Astronomical Drawings Manual*, which included an image of a solar prominence dated 5 May 1873 (*Fig. 1*), was published in 1882. Trouvelot described the work as a collection of plates 'which were intended to represent the celestial phenomena as they appear to a trained eye'.<sup>17</sup>

Much like the eyewitness accounts of the 1859 solar storm, Trouvelot's image highlights the otherworldly and disquieting qualities of solar prominences. The illustration blends the organic with the industrial: the flares depicted look simultaneously like factory smoke rising from the sun's surface, and yet also like a kind of solar tentacle — a tendril reaching out towards the earth. In his *Astronomical Drawings Manual*, Trouvelot describes some prominences as 'immense fiery bundles' while stating that 'others resemble trees, or animal forms, in a very striking manner' (p. 19). Though he does not explicitly link the prominences with industrial pollution, his images and descriptions draw together the threads of the industrial and organic that I have highlighted — the image calls to mind not only trees and tentacles, but also contaminating smoke. The flickering and flame-like quality of the image makes the prominence seem almost alive, suggesting the power of the sun's flames to reach across the cosmos and impact life on earth in ways both necessary and unnerving. Such imagery encouraged Victorian viewers to think of the connections between the sun

<sup>17</sup> E. L. Trouvelot, *The Trouvelot Astronomical Drawings Manual* (New York: Charles Scribner's Sons, 1882), p. v.





*Fig. 1: E. L. Trouvelot, Solar Protuberances. Observed on May 5, 1873 at 9h, 40m. A.M. (1873). Science, Industry and Business Library: General Collection, The New York Public Library Digital Collections. <<http://digitalcollections.nypl.org/items/510d47dd-e6c8-a3d9-e040-e00a18064a99>>.*

and the earth. These bodies were separated by millions of miles, and yet the strange ejections from the sun's surface could directly shape day-to-day experiences. More importantly, Trouvelot imagines the sun's activity as a kind of organic pollution capable of transforming the night skies on earth and permeating the built environment.

Responses to the 1859 solar storm envisioned outer space as a place filled with potentially disruptive and contaminating forces that humans had little ability to defend against, and which underscored the frailty of the built environment in the face of celestial events. By the 1870s, both Trouvelot and Proctor depicted the sun in terms of industrial imagery, highlighting not only the intersections of the categories of the natural and the man-made, but also increasingly complex ways of imagining the relationship between the earth and its sun.