Northern Lights in Labrador, Canada after massive Sun Eruption
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Editorial

There was a smart chap called Einstein,
Whose theories curved way out of line,
He claimed light is bent,
No one knew what he meant,
But now we all think he's divine.

Yes, I know, don't give up the day job! Anyway, pick a word from the first line of the limerick. Now count the number of letters it contains and progress that number of words. For example, 'Einstein' contains eight letters and maps onto 'He'. Repeat this process to the end of the limerick and I guarantee ... [drum roll] … that you will end up on the word 'divine'. This exercise seems to demonstrate the convergence of a Markov chain, though we can do better than that. Wherever you started, you selected the word 'light' en route and this is my theme for this issue of *Mathematics Today*. The United Nations has declared 2015 to be the International Year of Light and Light-based Technologies (IYL), and with very good reason. This year celebrates several anniversaries of events that changed our perceptions of light significantly.

Perhaps the first major investigations were conducted a millennium ago by Arabic scholar Ibn al-Haytham, who published the *'Book of optics'* in seven volumes around 1015. Prior to this, ancient Greeks held differing opinions to explain the nature of vision. Mathematicians Euclid (c. 300 BC), who published the book *'Optics'*, and Ptolemy (c. 150 AD) supported the *extramission theory* of light, where vision is created by light rays emanating from the eyes. Conversely, philosopher Aristotle (c. 350 BC) and physician Galen (c. 150 AD) supported the *intromission theory*, where vision is created by light entering the eyes from an object. Al-Haytham's treatise formulated reasoned experimental arguments in support of intromission theory, which established a fundamental basis for our subsequent understanding of light and vision.

Jumping ahead to the 17th century, a different bifurcation of beliefs arose. Isaac Newton presented the findings of his research into optics and supported the *corpuscular theory* that regarded light as a stream of tiny, high speed, rectilinear particles. In contrast, Christiaan Huygens supported the *wave theory* and developed the corresponding mathematics to account for reflection and refraction. However, the next important anniversary to be celebrated in 2015 is a bicentenary. In 1815, Augustin-Jean Fresnel presented his seminal findings on the aberration of light to the French Academy of Sciences. He is perhaps better known for designing lenses with large apertures and short focal lengths, such as those used in lighthouses.

Next we celebrate the sesquicentenary of a truly major event. In 1865, James Clerk Maxwell published the paper *'Dynamical theory of the electromagnetic field'* in *Philosophical Transactions* of the Royal Society. This effectively defined the theory of electromagnetism, including light waves that travel in free space at the constant velocity $c = 3 \times 10^8$ m/s, and earned him a place as one of the greatest scientists ever. Maxwell's discoveries opened up avenues of research with invisible electromagnetic waves, including ultraviolet light, x-rays and gamma rays (shorter wavelengths) and infrared light and radio waves (longer wavelengths).

2015 is the centenary of another remarkable event. In 1915, Albert Einstein published *'The field equations of gravitation'*, which forms the basis of his *general theory of relativity* and which links light with gravity in the field of cosmology. This paper has led to major new research areas including the search for black holes and gravitational lensing. Indeed, January's issue of *National Geographic* magazine contained an interesting article on the rather expensive hunt for dark matter. Shortly afterwards, David Hilbert published his *'Foundations of physics'*, which presents an axiomatic derivation of the field equations. To celebrate Einstein's achievements, we are currently planning a special issue of *Mathematics Today* for this autumn. This will include articles on *'The origins of general relativity'* by Chris Linton and *'A century of general relativity'* by Malcolm MacCallum, both of which are bound to be most enlightening.

Shortly after recently deceased Charles Townes shared the Nobel Prize in Physics with Nikolay Basov and Aleksandr Prokhorov for inventing the laser, our final anniversary is a semicentenary and corresponds to two major contributions to the advancement of our understanding and development of light, which both occurred in 1965 and which will also be discussed in our special issue. The first relates to the discovery of cosmic microwave background

radiation by Arno Penzias and Robert Woodrow Wilson, who were subsequently awarded the Nobel Prize in Physics for their achievement that provided evidence to support the *big bang theory*. The second relates to Charles Kao's remarkable developments concerning the transmission of light in fibres for optical communications. These have revolutionised our capacity for transmitting data over long distances at high rates.

Light is truly special. Its many manifestations are so common place to many of us that perhaps we do not always give it the credit it deserves. Laboratory demonstrations of Young's fringes, Newton's rings, polarisation and Faraday cages never cease to amaze, though nature is the real champion of light. Clear days offer beautiful sunrises and sunsets, scenic shadows and striking patterns, while cloudy days present colourful clothing and umbrellas, and reflections from raindrops and puddles. But there are many amazing sights to those of us who are fortunate enough to experience them: stars, bioluminescence, lightening, rainbows, mirages, northern (southern) lights, fireworks, floodlights, soap bubbles and so on.

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On occasional school visits, I find that shining a torch against a wall is a simple way to display the conic sections. However, one of my more remarkable experiences involving light was a Brocken spectre with full glory while hiking in the Lake District with a friend. This is when a low winter sun projects a large shadowy image of the observer onto dense mist, often surrounded by glowing multicoloured annuli: truly amazing. Then again, my grandparents claimed that ball lightening once passed right through their living room, in through a closed window and out through a solid wall!

Light is very important in our everyday lives. It is used to scan goods at supermarket checkouts, to play CDs, DVDs and BDs, and for medical diagnosis and surgical treatment. Moreover, light assists with robotic operations and is important for communications, security and safety. Energy production, architecture, transport and engineering also make use of light, as do manufacturing, quality control, chemical analysis and biological studies. Applications continue to advance with increasing use of light-emitting diodes to resolve the problems of energy waste and light pollution. Other recent opportunities in scientific research involving light include heliospheric imaging to detect coronal mass ejections, the development of invisibility cloaks for military use and the manufacture of smart clothing mostly for the fun of it. Indeed, light offers us much pleasure in terms of leisure and recreation.

The Institute of Physics is a founding partner for IYL and the UK patron is His Royal Highness the Duke of York. If you are interested in finding out more or attending any of the many celebratory events taking place this year, visit www.light2015.org for further information. There are festivals, lectures, seminars, discussions, master classes, training courses, interactive exhibitions, demonstrations and street parties all around the UK, and indeed the world, at a variety of levels to suit everybody. This is a rare opportunity not to be missed.

However, as many readers know, 2015 is a notable year for another reason. Congratulations to the London Mathematical Society (LMS) on its 150th anniversary, which is a very fine achievement. The LMS is also hosting many celebratory and public events around the UK this year and details may be found on its website. The IMA and the LMS work closely together, along with the RSS, EMS and ORS, within the Council for the Mathematical Sciences as an authoritative and objective body that represents mathematical sciences in the UK. We wish the LMS every success with its anniversary activities.

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Optical phenomenon, known as a Brocken Spectre or Mountain Spectre, Haleakala National Park, Maui, Hawaii.