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Astronomy and the Magic Lantern

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Abstract. The nineteenth century saw the introduction of the term 'populariser of science'. The development of this phrase coincided with the increasing use of the magic lantern to illustrate science lectures and astronomy was one of the first disciplines to see its widespread application. The magic lantern was invented in the sixteenth century and spread throughout Europe as a form of home or family entertainment. Examples from the eighteenth century still exist of lantern slides showing astronomical subjects. The invention of limelight illumination in the early nineteenth century resulted in the widespread use of the lantern for public lectures and, again, astronomy was one of the first and most popular subjects. Slides were produced in a wide variety of formats and showed both simple and complex astronomical concepts and phenomena. By the end of the nineteenth century astronomical lectures were seen every year by thousands of members of the general public. With the invention of the moving image and the increasing complexity of astronomy as a science, magic lantern lectures declined in popularity and by the 1930s were only generally given in academic institutions.

Origins and Development of the Magic Lantern

The magic lantern was the forerunner of today's slide projector. It is probable that the general form of the lantern was invented sometime in the sixteenth century. The recognised configuration of light source, condenser, slide and focusing lens is attributed to Christian Huygens (1629–1695). In 1663 the London optician John Reeves started to make lanterns for sale. A Frenchman, Balthasar de Monconys, recorded how he visited Reeves on the 17th May,1663. 'After we had eaten we went to Long Acre… to see Mr. Reeves who makes telescopes… But he had none ready and deferred us to another time… and also to show us how a bulls-

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eye lantern works…'.[1] De Monconys then described the lantern. In his diary for 19 August 1666, Samuel Pepys wrote '… comes by agreement Mr Reeves… bring[ing] a lanthorn, with pictures in glasse, to make strange things appear on a wall, very pretty'. A later entry says how he purchased the lantern.[2] The earliest recorded image of a magic lantern was published in 1671 in Athanasius Kaircher's 'Ars Magna Lucis et Umbrae'.[3]

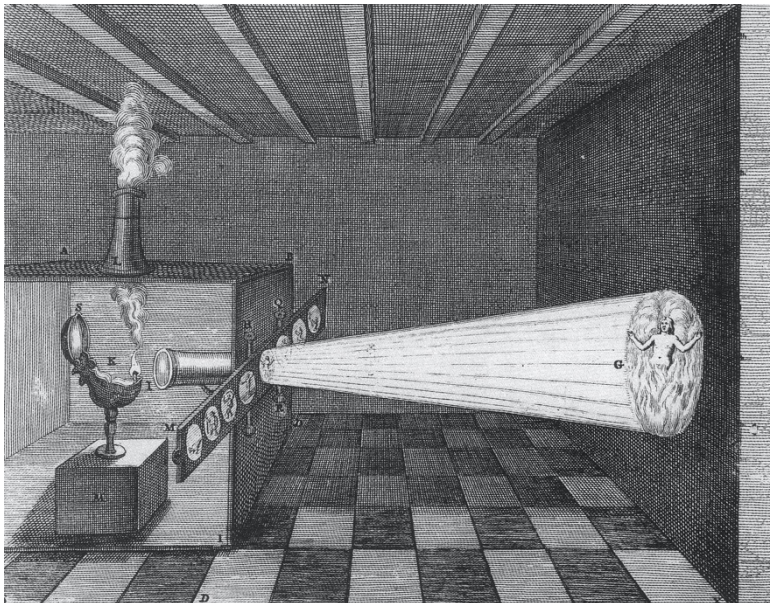

Fig 1. Illustration from Athanasius Kaircher's 'Ars Magna Lucis et Umbrae.

[1] Balthasar De Monconys, *Journal des voyages de Monsieur de Monconys, Conseiller du Roy en ses Conseils d'Estat & Privé, & Lieutenant Criminel au Siège Presidial de Lyon* (Lyon: Horace Boissat & George Remeus, 1665-66), Vol. 2, pp. 17–18, diary entry for 17 May 1663. Translation in Herman Hecht (ed. Ann Hecht), *Pre-Cinema History: An Encyclopaedia and Annotated Bibliography of the Moving Image Before 1896* (London: Bowker Saur, 1993), p. 19.

[2] Samuel Pepys, The Diary of Samuel Pepys M.A. F.R.S., edited with additions by Henry B. Wheatley (London: George Bell & Sons, 1893), entry 19 August 1666, at https://www.pepysdiary.com/diary/1666/08/.

[3] Dennis Crompton, David Henry and Stephen Herbert, *Magic Images* (London: The Magic Lantern Society of Great Britain, 1990), p. 5.

This basic lantern configuration and hand-painted images on hand-made glass represented the general form of the magic lantern until the end of the eighteenth century. Using a light source of either candle or oil burner, the image was only bright enough to allow small groups to see the show. Itinerant lanternists travelled from town to town giving public entertainments for a small fee, while middle and upper class families held shows at home for family and friends.

In the 1780s Francois-Pierre-Ami Argand developed an oil burning lamp with a covering glass cylinder which gave a much brighter light. It was quickly adopted by a Frenchman, Etienne-Gaspard Robertson, who developed a show with the lantern behind the screen, hidden from the audience. He also mounted the lantern on wheels and devised a focussing system linked to the turning of the wheels. With this device he could move the lantern towards or away from the screen, keeping the image in focus but changing its size. He specialised in what he termed 'Phantasmagoria' or ghost shows, which were very popular in revolutionary Paris. He pioneered the concept of turning all the lights out in the theatre and accompanying his show with sound effects and music. By the end of the eighteenth century he was also projecting images onto smoke, giving them a 3D effect.

Robertson eventually fell out of favour with the ruling committee in revolutionary France and embarked on a Europe wide tour, finally settling in London where he gave regular shows at the Lyceum, or English Opera House, in the Strand. At the same time a well-known family of English scientific popular lecturers, the Walkers, were giving shows on astronomy at the Lyceum and Haymarket Theatres. These shows also used a magic lantern with back projection to tell the basic story of the astronomy of the solar system, accompanied by music on the Celestina, a harpsichord type instrument that generated continuous ethereal tones. The Walkers called their presentations 'Lectures with the Eidouranion',[4] derived from the Greek for 'form of the heavens'. Other performers offered similar shows, including a 'Mr Lloyd with his Diastrodoxon', 'Offer with his Portable Eidouranion', 'Elton with his miniature portable Orrery', and 'Goodacre with his Portable Vertical Tellurian'. In the USA a Mr Greene entertained audiences with his

[4] William Walker, *An Epitome of Astronomy including an account of the Eidouranion or Transparent Orrery* (Bungay and London: C. Brightly/J. Robson and W. Clarke, 1802).

'Transparent Vertical Orrery'. Astronomical lectures at the beginning of the nineteenth century were dominated by this group of popular entertainers who provided some level of instruction in the subject within the form of a popular amusement. Typically, these entertainers charged one shilling or more for entry to the performance. It is probable that each made their own equipment.

Fig 2. Deane Walker's Eidouranion Lecture at the Royal Opera House in the Strand, 1817.[5]

[5] Robert Wilkinson and Herbert William Wilkinson, *Theatrum Illustrata*, Vol. 2 of *Londina illustrata: Graphic and historic memorials of monasteries, churches, chapels, schools, charitable foundations, palaces, halls, courts, processions, places of early amusement and modern & present theatres, in the cities and suburbs of London & Westminster* (London: R. Wilkinson, 1819–1825).

Some of the earliest known commercial astronomical lantern slides consist of 14 inch by 3 inch mahogany frames with a series of 3 inch holes.[6] The holes are covered in paper and the paper punched with a pattern of holes to represent the various constellations. The hole sizes vary to illustrate the relative magnitudes of the stars. These date from around the end of the eighteenth century.

In 1825 Lieutenant Thomas Drummond developed a form of illumination known as limelight, based on an idea suggested in 1820 by Sir David Brewster. The limelight produced an intense white light by heating a piece of lime or calcium oxide with a flame of combined oxygen and hydrogen gases. Use of this light transformed not only the magic lantern but also the theatre, allowing spotlights to be used to pick out actors on stage ('to be in the limelight'). Its introduction allowed the lantern to project over a longer distance, allowing it to be used from the back of the theatre with large audiences.

Fig 3. Limelight burner with limes and lime tongs.

Almost immediately, commercial firms, particularly in London, began to produce new types of lanterns to take advantage of this increased light source. They also began to produce sets of lantern slides telling stories that could be used to entertain audiences. One of the first to mass produce slides was the firm of Carpenter and Westley in London. They made what they termed 'Copper Plate Sliders' using techniques developed in the pottery industry, to imprint the outline of images onto glass, with young female workers hand painting the colours. Their first commercially

[6] Werner Nekes, *Ich Sehe Was, Was Du Nicht Siehst* (Cologne: Steidl, 2002), p. 162.

produced set was a series of over 200 images on Natural History, showing the wide variety of animals, birds and fish found around the world. Carpenter and Westley are recognised today as slide and lantern makers of the finest quality. Their second commercially produced set of copper plate sliders was a set on astronomy, showing the major features of the solar system and constellations.

Throughout the nineteenth century the form of the lantern developed from a basic black metal body into a wide variety of styles. Handmade models of highly polished brass and mahogany became very popular in the UK. The continental manufacturers tended to work mainly with metal, although finishing the lantern in a blue metallic coating, known as Russian Iron, gave them a very attractive appearance. Lantern manufacturing also developed in the USA although it was the middle of the nineteenth century before large scale commercial production began. The use of a lantern with two or even three lenses and light sources became popular by the middle of the nineteenth Century, allowing images to be superimposed and phased in/out of each other, creating spectacular effects.

The limelight burner had inherent dangers from burning a mixture of oxygen and hydrogen, and many newspaper reports of accidents and explosions were recorded. Various alternatives were developed including substituting the hydrogen gas with ether or acetylene. However, both these methods had attendant dangers. In the 1870s carbon arc burners began to be introduced and the limelight burner phased out. Eventually, as the electric light improved it replaced the carbon arc. Throughout the history of the magic lantern, paraffin and oil burners were in use, particularly for home lanterns.

Lantern Slides

As the design of lanterns developed, so did the form of lantern slides. From its origins until the 1880s all slides followed the basic design of glass with hand painted images. By 1850 most images were printed in outline and the colouring applied by hand. Mahogany frames were used to give strength. From 1850 onwards the use of photography became more widespread, but where colour images were produced it was still by hand painting. Early slides were generally 10 to 14 inches long by 3 inches high and consisted of either one long piece of mahogany framed glass with three or four images painted on or three or four round openings with individual circular panes of glass each with a painted image. From the late 1840s the trend was to produce single mahogany slides with one

3 inch diameter image. This 7 inch wide by 4 inch high format became the standard until the 1880s. From the 1890s onwards photographic slides became the most common and in the UK a size of 3.25 inches square became the standard. In the USA and continental Europe the standard size for photographic slides was 4 inches wide by 3.25 inches high.

Many manufacturers attempted to create new 'standard' sizes and astronomy lantern slides can be found in many different types. The most famous lantern theatre in London was the Royal Polytechnic in Regent Street, which had a huge custom built lantern and specially made slides that measured at least 10 inches square. The larger the slide, the higher the quality of image that could be produced. Regardless of shape or size, most astronomical slide sets follow the same basic story and it is possible that the general form of narrative had a common origin. Certainly all slide sets I have seen follow the generic information written about by William Walker.[7] However, given the level of astronomical knowledge at the time and the fact that all the slides appear to have been targeted at laymen audiences, then the range of astronomical subjects would have been naturally quite limited.

From the beginning of commercial production, slides were produced in sets and normally came with a narrative or 'reading'. Many companies hired out lanterns, slides and all the necessary associated equipment. It would be possible to send a telegram to a supplier, ordering whatever slides and equipment were required from their catalogue and have them delivered by the railway company to the hall were the lecture was to take place. After the lecture the railway company would collect them and return everything to the supplier, with an invoice arriving a couple of days later. There are many stories of the disasters that could occur when the lecturer failed to prepare properly and relied on the printed reading to provide all the necessary knowledge. However, the availability of this relative low cost material allowed many people to provide astronomical lectures without significant capital outlay. A recent 'straw poll' indicated that today, examples of astronomical mechanical slides are in the hands of several hundred UK collectors, indicating a probable scale of production (and hence demand) through the nineteenth century of at least a few thousand sets.

[7] Walker, *An Epitome of Astronomy*.

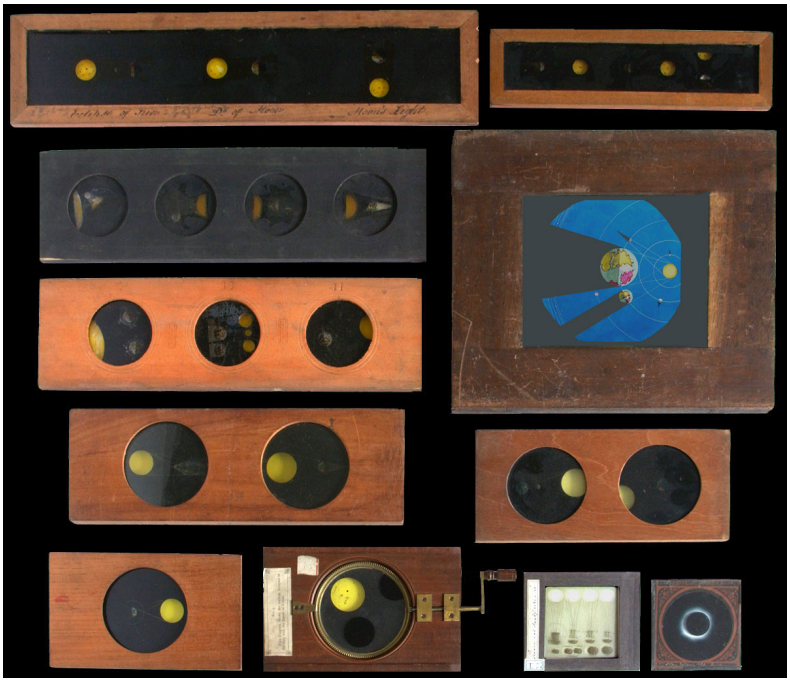

Fig 4. A selection of astronomy lantern slide formats showing eclipses.

The two main manufacturers of astronomy slides through the nineteenth century were Carpenter and Westley and Newton & Co. Both produced a full set of astronomy slides with readings. The Carpenter and Westley set consisted of thirty slides and the Newton & Co set thirty-eight slides. Newton & Co included some geology slides in their series. In addition, both companies produced a set of ten mechanical slides that worked by turning a handle on the side which caused one or more glass image discs to rotate. When turned within the lantern such effects as the earth rotating around the sun or the earth rotating on its axis could be shown. The effect on screen would be remarkably similar to that obtained by Walker and his Eidouranion. Additional slides consisted of two plates of glass which could slide past each other. By painting the sun on one disk and a black circular image on the other, it was possible to slide the plates within the lantern, one in front of the other, and simulate an eclipse of the sun.

Fig. 5. Astronomy slide sets by Newton & Co (circa 1850).

Both manufacturers followed the same general story in their slide sets. Since the images were first developed in the 1840s then the lectures contained no references to spectroscopy, astrophysics or photography. Indeed they provide basic information on the solar system and celestial mechanics with some coverage of the constellations and their mythical associations.

A Typical Astronomy Lantern Lecture

The slide set typically started with a discussion of the figure of the earth. A flavour of the style of the reading can be gained from the text to accompany this first slide:

> Had the surface of the ocean been a level or plain as represented in this diagram, a vessel proceeding out to sea, if viewed from the land would merely appear to increase or diminish in magnitude, according to her distance from the observer, but the whole of her figure would be visible as far as the power of the eye or the telescope could reach. This, however, is not the case when the progress of the ship is minutely observed; for as the vessel recedes her hull first disappears, then her rigging, and last of all her top mast – as though she were sinking into the water. And also, a vessel in approaching an observer would seem to rise out of the water as she advanced towards him. These are appearances which could not take place if the surface of the water were a level or plain. But they arise from its rotundity.

Fig 6. First slide to show the 'Figure of the Earth'.

The second slide would be a mechanical slide. It showed a fixed earth with a ship on a second glass disc attached to a lever handle. Raising and lowering the handle would show the ship disappearing and appearing over the horizon. Again the two observers are illustrated and the shape of the earth (or its rotundity) could be explained.

Fig 7. Second slide to show the 'Rotundity of the Earth'.

The next few slides would show the different theories on the model of the solar system. The first model was normally the Pythagorean system with the 'Hearth of the Universe' or 'Throne of Zeus' at the centre of a finite, spherical solar system with the stars fixed on an outer sphere. It includes the 'counter earth' to account for why we could never see the Throne of Zeus or 'Look God in the Face'. The next slide would then move onto the Ptolemaic geocentric model, followed by the Tycho Brahe heliocentric/geocentric combined model. Finally, the Copernican heliocentric model would be shown. The narrative describes this as the 'Copernican or Newton model', explaining that although Copernicus proposed the model, Newton and his mathematics proved it to be correct. This, I believe, is an example of Victorian Britain not wanting to acknowledge European precedence for the proposal of a heliocentric solar system.

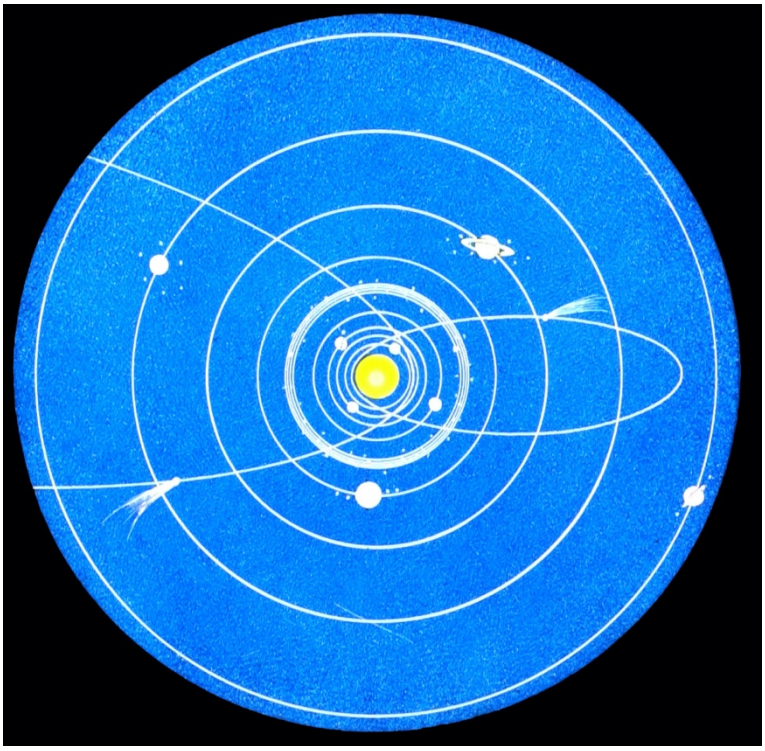

Fig 8. The Copernican or Newton Model of the Solar System.

The movement of the earth around the sun and the sun's annual progress through the constellations of the zodiac, the movement of the moon around the earth and the earth's rotation on its axis are then explained. There is also a slide showing the size of the earth's shadow to demonstrate the relative sizes of the sun and earth. Rackwork mechanical slides would demonstrate these phenomena with on screen motion.

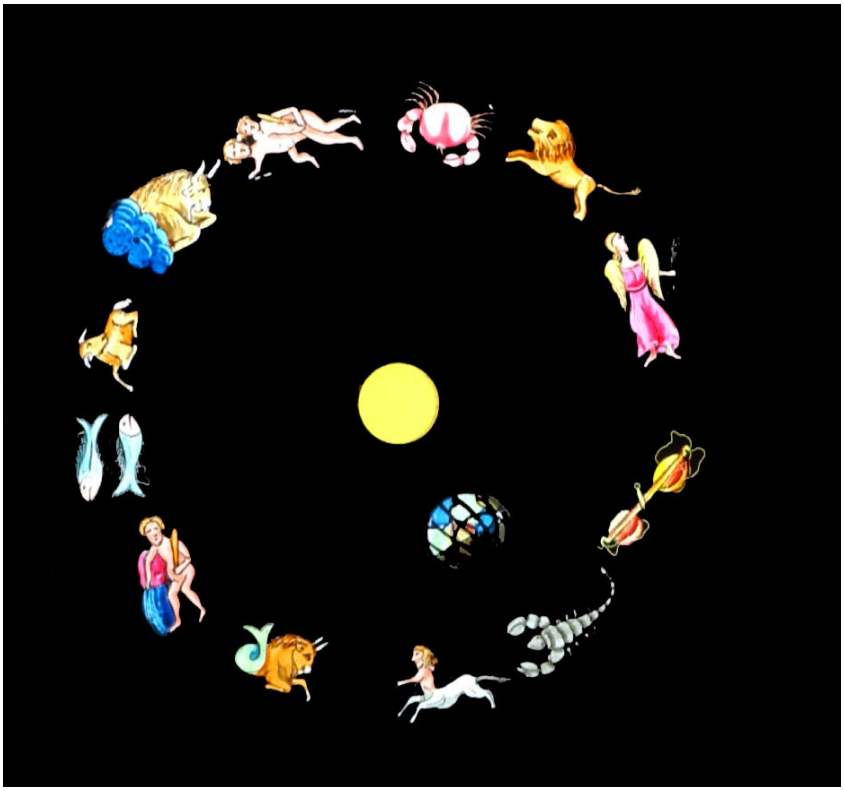

Fig 9. The Earth's annual motion around the sun, showing the sun moving through the constellations of the zodiac. By turning a handle on the side of this slide, the earth appears to rotate around the sun.

Slides would follow showing the surface of the sun and its sunspots, the sun with total and partial eclipses, causes of the phases of moon and examples of its appearance at each phase plus a slide showing lunar eclipses. The major surface features on the moon were quite accurately detailed. Slides would illustrate the major planets. Descriptions of the phases of Venus would be followed by a rackwork slide showing the

causes of direct and retrograde motion of the planets. Slides of comets would show the orbit of Biela's comet, the Great Comet of 1680 and an eccentric motion rackwork slide of a comet showing the tail growing and receding as it orbited close to the sun. Biela's comet was popular as during its brief life in the 1830s it had an orbit within the orbit of Saturn and made several passes in quick succession around the sun before breaking up. The Great Comet of 1680 inspired Edmund Halley to investigate comets and the next comet of 1682 became known as Halley's comet.

There is then a series of mathematical slides discussing the causes of twilight, the earth's elliptical orbit around the sun and the causes of stellar parallax. It's surprising to see a lecture start with the proposition that the earth is round and 20 slides later be showing the concept of elliptical orbits and gravitational attraction.

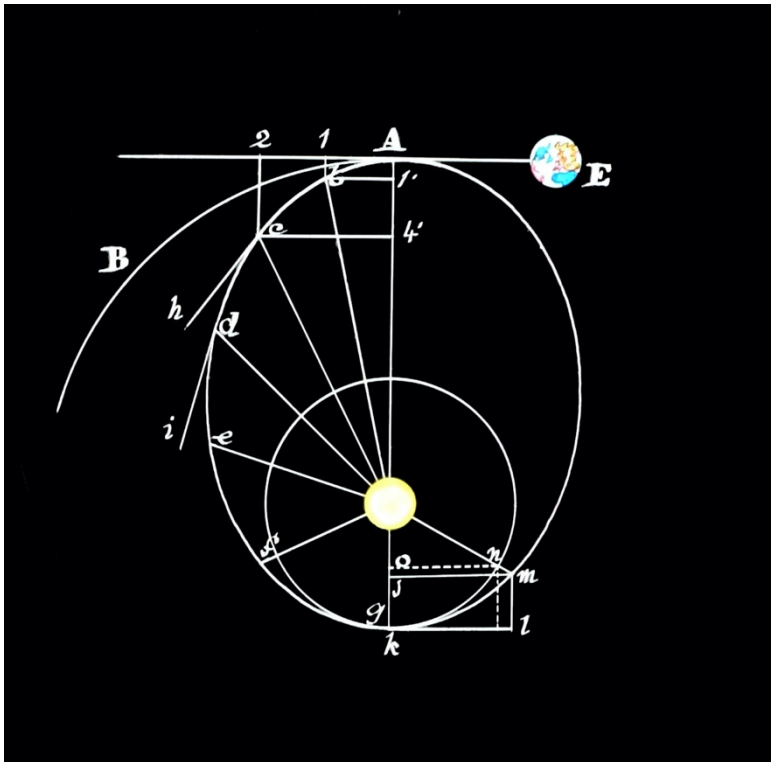

Fig 10. Slide showing the elliptical orbit of the Earth.

There follows a series of slides showing a sample of the major constellations. All sets contained the Great Bear and Orion but whole slide sets of the major constellations were available. Carpenter and Westley also produced constellation slides with two glass plates. One glass would show the major stars and the second the mythical constellation figure. By sliding the two plates apart/together it was possible to see just the stars or the stars with their attendant figure.

The final slide recommended by both Carpenter and Westley and Newton & Co was an Orrery slide showing the movement of the planets around the sun. The slide consisted of a series of geared wheels, one for each planet, turned by a threaded handle. The gearing allowed the planets to rotate at a simulation of their respective rotational periods. The slide was updated sometime after 1846 to add the recently discovered planet Neptune.

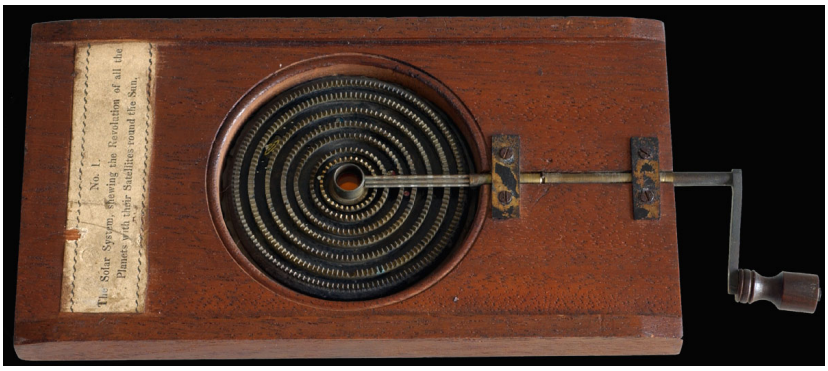

Fig 11. Mechanical slide showing the movements of the major planets around the sun.

Many other slides were produced by the major manufacturers and could be added to the lecture. Carpenter and Westley produced mechanical slides showing the rotation of the major constellations around the north celestial pole and the south celestial pole. A mechanical slide to demonstrate the causes of the tides was available. Slides were produced showing the major satellites of Jupiter orbiting the planet. Several types of mechanical slides were developed to show the sudden appearance of the corona during a total solar eclipse, including complex mechanisms with diaphragms to allow the corona to appear instantaneously. I recently had the opportunity to examine a mechanical slide designed to show shooting stars. A slide of the stars in the sky would be shown on screen

with this slide being superimposed - a rare example of an astronomy slide for use with a double lens (biunial) lantern. There were also mechanical slides of aurora showing shimmering lighting effects. Other slides showed atmospheric effects such as mock suns (sundogs) and the effect of looming – the appearance above the horizon of a distant object that would normally be hidden below it, caused by unusually large terrestrial refraction, usually due to a thermal inversion. Several slides of nebulae were available, nearly all based on drawings from Lord Rosse's telescope at Birr in Ireland.

The Impact of Photography

In the 1850s the new science of photography was applied to astronomy. Almost immediately, glass photographic plates were made up into lantern slides. It appears that for some time the difficulty and expense of producing photographic lantern slides meant that they were only produced in limited numbers. However, by the 1870s photographic astronomy slides were being produced in commercial quantities. As the science of spectroscopy and astrophysics developed, the ability to communicate these concepts with photographic images developed rapidly. By the 1880s photographic slides had largely replaced the hand painted images and the quality of photographic images allowed the slide size to shrink to 3.25 inches square. Hand colouring was used where required but astronomical slides were generally only produced in black and white. In their catalogue for the 1889-1890 season, the London firm of York & Co were offering a 300 slide set on astronomy, comprising 75 slides on The Sun, 115 slides on the Solar System, 70 slides on the Sidereal System and 40 slides on Instruments. Individual examples of these slides are very common today.

From the 1880s onwards the commercial availability of high quality black and white images made it easy for professional astronomers to acquire slides and use them in their lecturing. At the same time, astronomy was becoming too specialised a subject for most self-taught lecturers to maintain their expertise and the academics became the prevalent lecturers to the general public. Major events such as the Transit of Venus in 1874 brought astronomy to public attention.

The Academic Lecturers

One of the foremost popular lecturers at the end of the nineteenth century was Sir Robert Ball, Lowndean Professor of Astronomy at Cambridge.

He carefully balanced his professional duties with his public lecture tours and as well as several appearances at the Royal Institution, he made three lecture tours of Canada and American. An Edinburgh journalist wrote in 1905, 'there is no important town in England, Scotland, Ireland or Wales and no important scientific institution in the country where Sir Robert Ball has not lectured and in most cases lectured often. At a very moderate estimate over one million people have heard him lecture'.[8] Even allowing for exaggeration, in 1905, this was at the height of his fame and he continued lecturing for a further five years. Almost without exception Sir Robert lectured with a lantern. In one of his notebooks he wrote a brief reminder to himself 'beware when lecturing in Manchester. They get bored after 75 minutes'.

As well as arranging his own lecture tours, Ball lectured widely for an organisation called the Gilchrist Trust. They sponsored lecture tours by eminent professionals on scientific subjects across the country. Intended for ordinary working people to attend, one of their stipulations was that at least 800 seats had to be available priced at one penny each. Ball's first lecture was in Rochdale in 1880. He lectured in Goole in 1890 and the local paper report recorded that the lantern was operated by Mr James Garbutt and that the lecture had an audience of 1000 with many turned away. Ball himself recorded in his biography that he appreciated the skill of Garbutt as a lanternist and used him whenever the lantern management and slide manipulation was critical. The Gilchrist Trust lectures were occasionally covered in the *Illustrated London News*. Apparently, ticket touts were frequently involved with tickets to Ball's lectures. In January 1882 he lectured for the Gilchrist Trust on successive nights in Banbury, Northampton, Chesterfield, Gainsborough, Selby, Dundee, Perth, Brechin, Montrose and finally Kirkcaldy. North East Scotland in late January would have been somewhat of a challenge. Ball claimed he had given Gilchrist Trust lantern lectures in over 200 different places in Lancashire and Yorkshire alone. He recorded that more than 500 people attended his talk in Chipping Norton, where the total population was less than 4000.

By the end of the nineteenth century, the increase in leisure time, desire for self-improvement, and the rise of local Literary, Philosophical and Scientific Societies made attending astronomy lectures a very popular public pastime. Many well respected astronomers gave public lectures. However, Ball was one of the last great astronomy academic popularisers

[8] Hugh McGregor, *Famous Astronomers* (Edinburgh, 1913), p. 99.

who specialised in lecturing. The technical advances in astronomy in the early twentieth century lead to such high levels of specialisation that few professional people became famous for their public lecturing on the subject. Lantern manufacturing began to decline and by the 1920s astronomy slides were mainly produced for use in academic institutions or by astronomical societies. Later slide sets assume a reasonable level of prior knowledge from the audience.

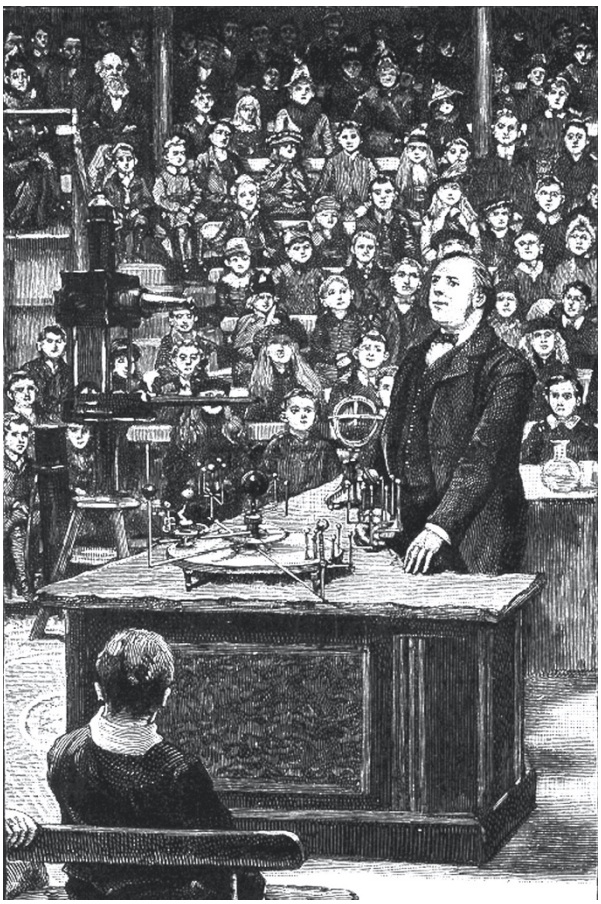

Fig 12. Sir Robert Ball lecturing at the Royal Institution in 1889.[9]

[9] Ball, Sir Robert, *Starland*, London 1889, frontispiece.

Conclusions

Public lectures on astronomy were very popular in nineteenth century Britain. The Magic Lantern was widely used to illustrate these lectures and this popularity was due, in part, to the availability of magic lantern slide sets. Relatively complex concepts in astronomy (celestial mechanics) were frequently presented. The surviving number of astronomy lantern slides indicates that sets were sold in their thousands throughout the century. There was a shift from popular lecturers (entertainers) to academics (educators) through the century and developments in magic lantern technology assisted this process. However, their popularity declined in the early twentieth century as the science became specialised and other forms of entertainment gained in popularity. The price of lectures declined as the academic lecturer became prevalent and lectures became more popular.