Ouranologia

an Annotated Edition of a Lenten Lecture on Astronomy with Critical Introduction

Hsiang-Fu Huang

STS Occasional Papers 3

Ouranologia

an Annotated Edition of a Lenten Lecture on Astronomy with Critical Introduction

Edited and introduced by

Hsiang-Fu Huang

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Department of Science and Technology Studies

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Foreword

Historians dream of finding treasure in archives. This happened to Hsiang-Fu during research for his doctoral dissertation. He stumbled across the script for a set of public lectures on astronomy submitted in 1826 to the Lord Chamberlain's Office.

Researching public lectures in any age is frustrating work. You're lucky if a few slides or sparsely written notecards survive. Normally, we find nothing more than a printed programmes or advertisement.

Scarcity is the rule. This makes Hsiang-Fu's find so exceptional. A whole series of lecture scripts. This is gold.

Joe Cain
Professor, UCL Department of Science and Technology Studies
10 December 2014

Acknowledgements

The transcription of the *Ouranologia* was a very important part of my PhD research. This project has gone through a long journey from a transcript to an appendix of my dissertation, and now has materialised as a monograph. It was a challenging task and would not have been completed without the support of the UCL Department of Science and Technology Studies. I thank the staff of the British Library, the Victoria and Albert Museum, the Royal Astronomical Society, the ETH-Bibliothek, and the National Portrait Gallery, who assisted my archival research and permitted the use of images in this monograph. I thank Joe Cain, Simon Werrett, Frank James, Richard Bellon, and Andy Gregory, for their comments and encouragement to publish this transcript. I also thank Aileen Robinson, who first directed my attention to this manuscript at the British Library. I appreciate Tom O'Donnell proofreading my transcript. I also appreciate the reviewers of my manuscript. Finally, I am grateful to Jon Agar as the editor of this monograph.

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Preface

A manuscript *Ouranologia* (1826) is in the *Lord Chamberlain's Plays* collection at the British Library (Add MS 42875). This manuscript is a lecture syllabus on astronomy written by the playwright Samuel James Arnold (1774-1852), and delivered by the comedian George Bartley (1782-1858). Bartley's astronomical lecture was performed annually during Lent at the English Opera House (today's Lyceum Theatre) in London between 1820 and 1828. It was an extremely successful Lenten fixture during this period.

Arnold and Bartley never published their astronomical lecture. The manuscript was submitted to the Lord Chamberlain's Office and hence it was preserved in the *Lord Chamberlain's Plays*. There are many other primary sources about Bartley's lecture, including newspaper advertisements, playbills and reviews; however, none of these accounts contains a first-hand full description. The *Ouranologia* is therefore a valuable reference source for this popular Lenten spectacle.

This book consists of two parts: a critical introduction and a transcript of the lecture. The first part is an introduction to popular astronomy lectures in early nineteenth-century London. Biographical information on Arnold and Bartley is also presented. To help readers familiarise themselves with the context of Bartley's lecture, a synopsis of the syllabus is given in the first part. The second part is the transcript of the *Ouranologia*, including editorial notes and selected facsimiles from the source text.

Part I

Introduction

Hsiang-Fu Huang

Lenten Lectures on Astronomy in Theatres

Popular lectures on astronomy were a cultural phenomenon in Britain throughout the nineteenth century. Different lectures were delivered in various sites, and the speakers were not necessarily working astronomers.[1] Historians pay scant attention to these private entrepreneurs who were not among the scientific elite.[2] Many of these astronomical shows were linked with, but were not limited to, Lent and featured the transparent orrery. Private lecturers' contributions to popular astronomy remain obscure despite the widespread popularity they enjoyed at the time.

Samuel James Arnold's lecture *Ouranologia*,[3] delivered by George Bartley, was a fine example among these private popularisations of astronomy. The activities of Arnold and Bartley at the English Opera House exemplified a private venture of astronomy lecturing. As professionals in the theatre, neither man received specialised scientific training, yet they presented an astronomical lecture and enjoyed critical acclaim from audiences.

London, the metropolis and capital of Britain, possessed a vibrant marketplace for science and amusements. Many scientific institutions and specialist societies, such as the Royal Institution of Great Britain (founded in 1799) and the Royal Astronomical Society (1820), were established in the first two decades of the nineteenth century. These sites provided men of science and lay enthusiasts with a sanctuary to pursue their common interest.[4] London was not only the hub of science but also the centre of fashion, culture and entertainment. Various exhibitions, shows and spectacles were staged in the metropolis to appeal to spectators' sense and sensibility.[5] There were so many things to indulge in. Popular astronomy lectures were developed in this vibrant marketplace, and astronomy popularisers had to compete with many other entrepreneurs of science and amusements.

Bartley's lecture was not an isolated case; he had many competitors. The most significant rival was Deane Franklin Walker (1778-1865), who inherited a celebrated lecturing family business.[6] Before Bartley delivered astronomical lectures at the English Opera House, Walker performed at the same site in 1817 and 1818 (Fig. 1). Later on, during the 1820s, Walker lectured on astronomy in other West End theatres. Lent was particularly a competitive

Figure 1 "The proscenium of the English Opera House in the Strand, (Late Lyceum.) as it appeared on the Evening of the 21st March 1817, with Walker's Exhibition of the Eidouranian". E. F. Burney (artist); I. Stow (engraver); Robert Wilkinson (publisher), 11th October 1817. Credit: Victoria and Albert Museum, London. Item: S.176-1997.

season for astronomical lecturing. This Lenten 'astronomical mania' was partly due to traditional restrictions on performances during the season.[7] Dramatic performances were restricted including theatre closures on Wednesdays and Fridays and a complete ban on dramatic performances during Passion Week.[8] Such restrictions continued to exist, although declining, in the mid-nineteenth century. Major patent theatres, those that possessed a licence to perform serious 'spoken drama', such as Drury Lane and Covent Garden, particularly enforced the restrictions, while minor theatres often flouted them with impunity.[9] The ban on dramatic performances was unfavourable for actors and theatre managers, yet it was the opportunity for other entertainments. Various substitute shows flourished during the season, and astronomical lectures were a common fixture. Spectacular scenic displays, plus informative combinations of scientific instruction and religious reflections, were major justifications appealing to audiences, especially parents and juveniles.

The Author and the Lecturer

There are entries for Arnold and Bartley in the *Oxford Dictionary of National Biography* (*ODNB*).[10] However, the two figures are mostly recognised by modern historians for their theatre careers. Very little has been written about their involvement in astronomical lectures. This section provides the basic biographical information of the two protagonists. The main source in this section, if not otherwise indicated, refers to *ODNB*. I also discuss how their theatrical lives related to science.

Samuel James Arnold

Samuel James Arnold was born at Rathbone Place, London, on 5th December 1774, and he died at Walton-upon-Thames on 16th August 1852. He was the eldest son of Samuel Arnold (1740-1802), a celebrated figure in London's musical life during the last two decades of the eighteenth century. Samuel Arnold, senior, was a productive composer, who had a particular interest in oratorio. In the climax of his career, he was also appointed to several prestigious posts in musical management and conducting, such as organist of Westminster Abbey (in 1793). This influential background gave Samuel James Arnold's early career significant resources. The father and son worked in close collaboration: many music pieces in Arnold's early works were composed by his father.

In 1803 Arnold married Matilda Catherine Pye (d. 1851). She was a daughter of the poet laureate Henry James Pye (1745-1813). A portrait of Henry James Pye, now in the National Portrait Gallery, London, was painted by Arnold around 1800.[11] Later on, Arnold also collaborated with his father-in-law to write plays.

In addition to writing plays, Arnold was very actively involved in theatre management. He obtained a licence to change the old Lyceum Theatre into an English opera house (Fig. 2). He was also invited to become joint manager with J. G. Raymond of the new Drury Lane Theatre, opened in 1812. However, his management there was troubled by internal arguments and

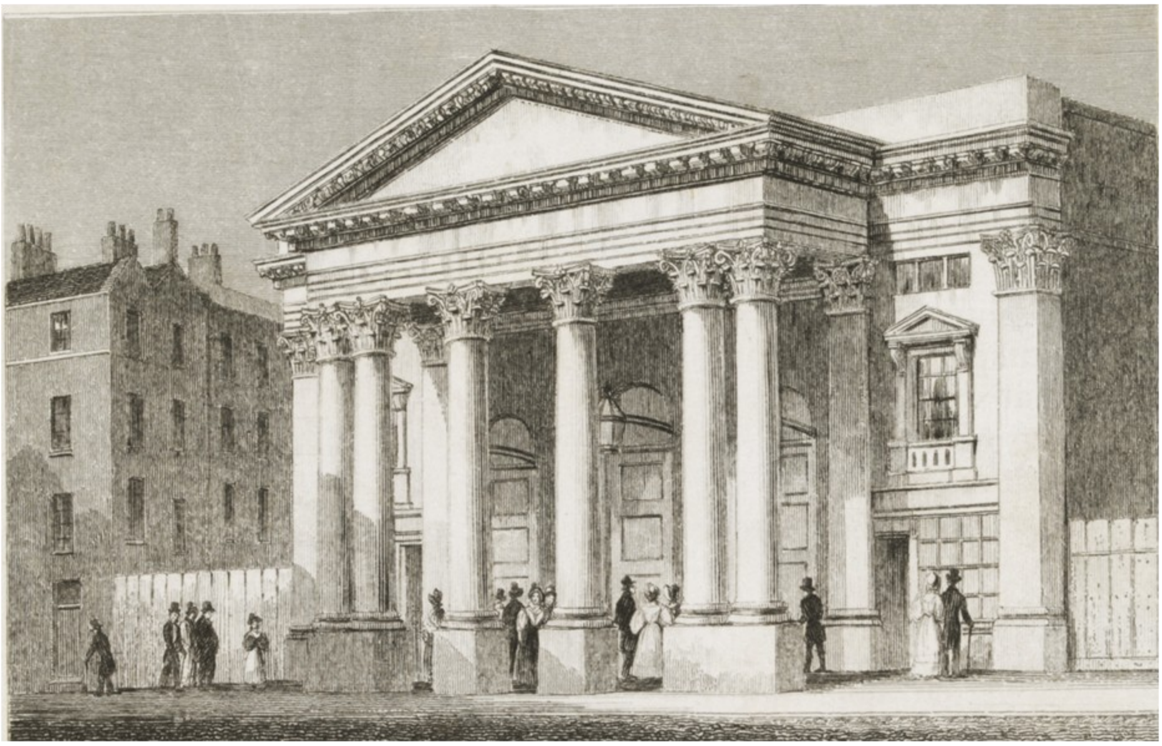


Figure 2 Exterior view of the English Opera House, probably after 1816. Arnold commissioned the architect Samuel Beazley to rebuild the old Lyceum Theatre. The new building opened in 1816 and was destroyed in a fire in 1830. Credit: Victoria and Albert Museum, London. Item: S.6126-2009.

eventually failed. Arnold resigned in 1815 and moved back to the rebuilt English Opera House, which reopened in 1816. He stayed as the proprietor and manager of the English Opera House for the next two decades.

A fire in 1830 destroyed the English Opera House. Although the theatre was rebuilt and reopened in 1834, under the name 'Theatre Royal Lyceum and the English Opera House' (commonly known as the Lyceum), Arnold never recovered from this blow. The business of the Lyceum ran at a loss. The financial difficulties caused the management much trouble. The theatre changed its manager thrice during the 1840s.

Except for his professional career in the theatre, Arnold kept a keen interest in science. He was actively involved in the activities of the Royal Institution. Arnold's name appeared in the balloting list for the committee of 'General Science, Literature, and the Arts' at the Royal Institution at least twice.[12] The *ODNB* claims Arnold was a fellow of the Royal Society, although his name does not appear in the society's *Record*.[13]

Figure 3 Portrait of George Bartley in his elderly age, Richard James Lane (artist), lithograph, 1846. Credit: National Portrait Gallery, London. Item: NPG D21693.

George Bartley

George Bartley (Fig. 3) was born in Bath in or about 1782. Bartley died at his home, 11 Woburn Square at Bloomsbury, London, on 22nd July 1858, and was buried in a family grave in the churchyard of St. Mary's, Oxford. As a son of a box-keeper at the Bath Theatre, Bartley had early opportunities of acquiring stage experience. Knowledge of his early life is limited.[14] He joined a travelling troupe, which led him to Guernsey, where he contracted his first marriage. His wife was an actress in the company and nursed him through a severe illness on the island. It is unclear when and why this marriage ended, probably due to the death of his wife.

Bartley's début in London was in December 1802, as Orlando in *As You Like It* at Drury Lane. For the next five years he was employed as an understudy, often playing a stock juvenile lover or a prologue speaker. He

Figure 4 George Bartley as Sir John Falstaff, J. Wright (engraver); Clint (painter); published in London by Simpkin and Marshall, 1821. This illustration was published when Bartley was engaging in lecturing on astronomy at the English Opera House. Credit: Victoria and Albert Museum, London. Item: S.1351-2012.

turned attention to comedy during this period. Dissatisfied with his remuneration and opportunities for promotion, Bartley left London and tried his luck in the provinces. In the succeeding seven years he performed in several towns and cities including Glasgow, Dublin, Liverpool and Manchester, with a good and gradually increasing reputation.

In 1814 Bartley married his second wife, Sarah Smith (c. 1783-1850), an acclaimed tragic actress; they had a son and a daughter. The couple made a

Figure 5 George Bartley as Sir Toby Belch, the date is unknown, probably in the mid-nineteenth century. Richard James Lane (artist); J. Mitchell (publisher). Credit: Victoria and Albert Museum, London. Item: S.4540-2009.

highly successful trip to the United States in 1818 and performed in several places including the Park Theatre at New York.

After returning from America, Bartley settled in London and accepted new stage engagements. He played at Covent Garden in winter and at the English Opera House in summer. It was also then that Bartley and Arnold started collaborating on Lenten astronomical lectures at the English Opera House. Bartley and Arnold maintained this collaboration during the 1820s.

In 1829 the Covent Garden Theatre encountered a management crisis and the business collapsed. Bartley headed a deputation of the actors to creditors and proposed a restoration of the performances. He was appointed as the stage manager of the Covent Garden Theatre and retained this post in the succeeding decade. This new engagement was perhaps the main reason Bartley ceased astronomical lecturing.

The sudden death of Bartley's only son in 1843, followed by his daughter soon afterwards and his wife in 1850, gave Bartley great grief and led to his retirement from stage. On 18th December 1852, Bartley took his farewell benefit at the Princess's Theatre, and in his address mentioned that this was exactly the fiftieth anniversary of his London début.

Bartley was particularly remembered by contemporary audiences as a celebrated comedian. He was especially successful in playing comic older men, such as Falstaff (Fig. 4) and Sir Toby Belch (Fig. 5). His oratorical skills were also highly praised. An obituary attributed his success in Lenten astronomical lectures to "his fine voice and perfect elocution".[15] An article compared Bartley to the famous actor Stephen George Kemble (1758-1822) and elocutionist Benjamin Smart (1787-1872). It claimed Bartley to be "the best prose speaker" and noted "[t]hose who question our judgment, may have their scepticism removed, by hearing this gentleman deliver his lecture on the Structure of the Earth, at the English Opera House."[16]

The Show

George Bartley lectured on astronomy at the English Opera House in Lent between 1820 and 1828. In addition to the text of the lecture submitted to the Lord Chamberlain's Office, there are also plenty of other primary sources relating to Bartley's lecture. These materials include advertisements, playbills, and reviews in periodicals and books. One example is a handbill preserved in the Royal Astronomical Society.[17] It reveals valuable information about how Bartley's lecture was carried out (Fig. 6).

The first thing one notices when reading the handbill is the twelve zodiac constellations and signs. These mythological figures, widely used in visual representations of constellations in astronomy, had classical roots.[18] The title encircled by the zodiacal figures shows that the lecture was performed on every Wednesday and Friday during Lent. The show was in the evening: the opening hours – "doors open at half-past 6, begin at 7" – are noted at the end of the handbill. Although this handbill does not mention how long the lecture was, a typical Lenten astronomical lecture usually took two or three hours.[19]

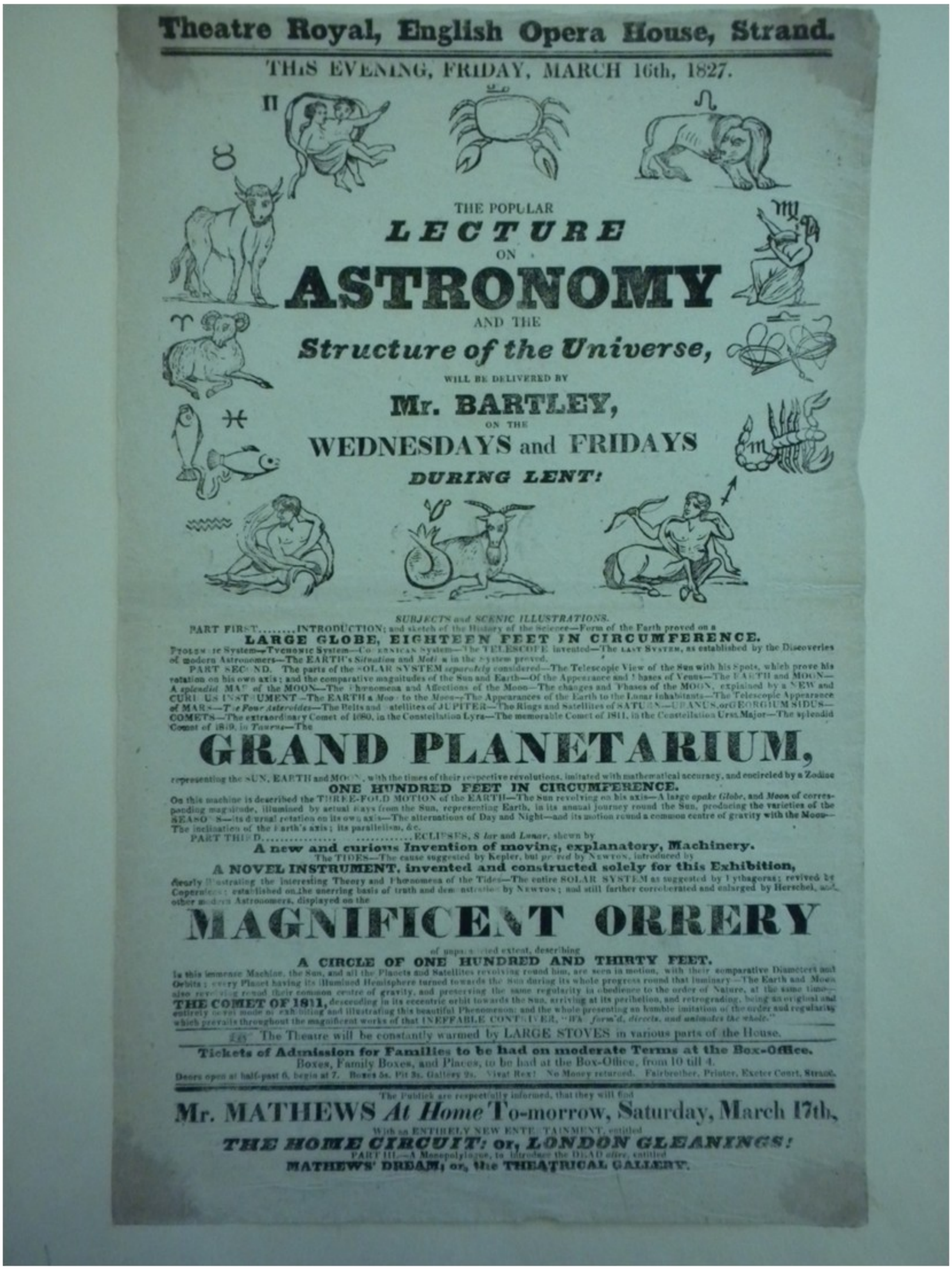


Figure 6 Playbill of George Bartley's lecture at the English Opera House during Lent 1827. Credit: Royal Astronomical Society, London, Add MS 88: 7. Image photographed by Hsiang-Fu Huang.

The charges of admission were also listed in this handbill. As usual, there were variable rates: boxes for 5 shillings; pit for 3 shillings; gallery for 2 shillings. These were the ordinary rates for admittance to a West End theatre in the early nineteenth century. This wide range of admittance charges indicates that the audience would be varied, ranging from the wealthy to the middle class. The offer of "Tickets of Admission for Families" also shows that parents and children were a particular audience targeted by the lecture.

The subjects and scenic illustrations presented in the show are also elaborated in this handbill. These contents will be discussed in detail in the next section and the transcript. Two capital lines are particularly printed in bold and hence very obvious: "GRAND PLANETARIUM" and "MAGNIFICIENT ORRERY". These were the major attractions in the show to catch the viewers' fancy.

Bartley's lecture was evidently successful. Though no records for box office or attendance are known, many accounts in contemporary periodicals and books provided critical acclaim. For example, William Kitchener (1778-1827), a writer, optical-instrument enthusiast and fellow of the Royal Society, remarked that he would "recommend [readers] to pay a visit to the OURANOLOGIA, in which is shewn the most beautiful and perfect Orrery ever exhibited," and offered the following praise: "Mr. BARTLEY well deserves the fame he has acquired, by the impressive manner in which he delivers his illustrations of these sublime subjects"[20] The popularity and influence of Bartley's lecture, was even referenced in satirical poetry. A drollery 'Love and Lunacy', written by Thomas Hood (1799-1845), mentioned Bartley's lecture. In this drollery the protagonist Lorenzo, a fictional young man who loves science, is in agony because of his girlfriend's ignorance about astronomy. Lorenzo claimed:

> Fool that I was, in my mistaken zeal!
> I should have led you—by your leave and pardon—
> To Bartley's Orrery, not Covent Garden![21]

Another account reviewing Bartley's lecture in detail was from the guidebook *London Lions for Country Cousins and Friends about Town* (1826), written by Horace Wellbeloved. It was a quality guidebook among the genre

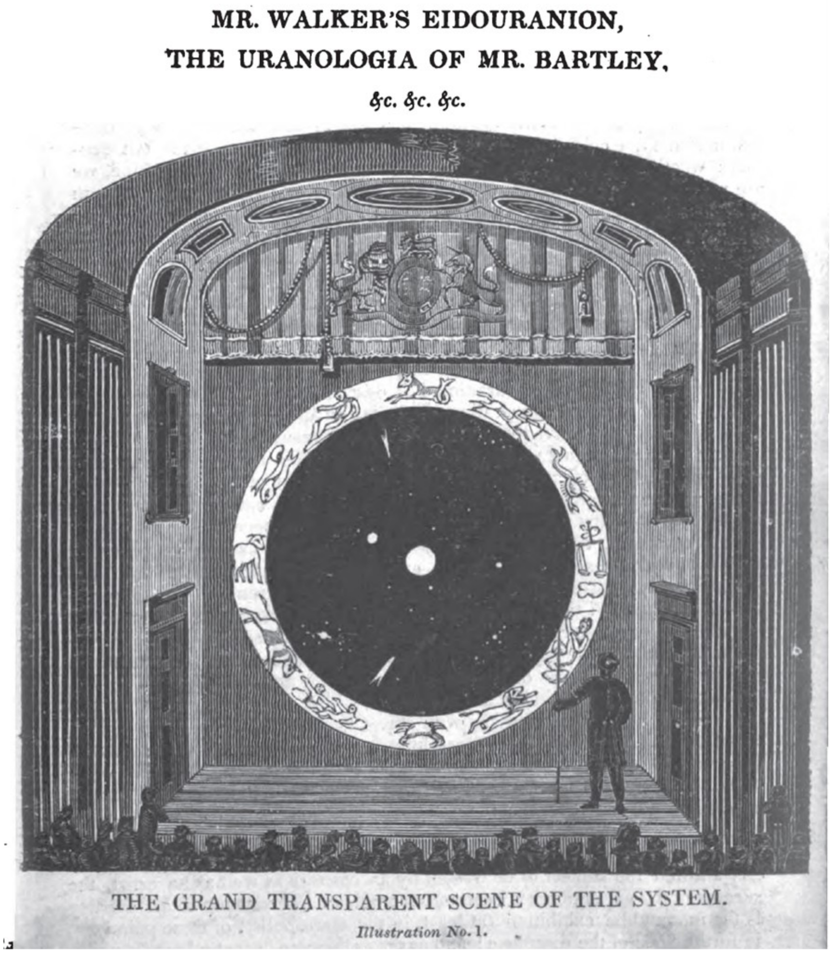


Figure 7 "The Grand Transparent Scene of the System", *London Lions for Country Cousins and Friends about Town* (1826), p. 1. Copy digitised by Google Book. The original illustration does not indicate whether this scene was from Walker's or Bartley's lecture.

introducing landmarks, sites and attractions of the metropolis. The first entry in *London Lions* is the astronomical lectures of Walker and Bartley (Fig. 7). It described Walker's and Bartley's shows: they "well deserve to rank the foremost" among "those optical exhibitions of the higher class". Wellbeloved remarked:

> Mr. Bartley is entitled to our respectable consideration on different grounds. His exhibition is a theatrical adventure, of great merit and curiosity; creditable alike to those who have undertaken, and those who embody it. Mr. Bartley delivers his lecture with great solemnity and proper feeling, has evidently a sound perception of the subject, and the importance of his task, and delivers himself of it like a

sensible man, feelingly alive to the dignity of his subject.[22]

The Text of the Lecture

The manuscript *Ouranologia* was the text of Bartley's lecture submitted to the Lord Chamberlain's Office in 1826. The reason why Arnold would submit it, however, is uncertain. Although the Lord Chamberlain held the power to examine a new drama before public performance, this censorship did not apply to Lenten amusements.[23] No other onstage astronomical lectures are known to have been submitted to the Lord Chamberlain's Office. Besides, Bartley's lecture was not a new show; it had been already delivered in the past few years. There seems no necessity for such a submission. Perhaps the submission was due to the Lord Chamberlain's personal request, since Arnold wrote in the covering letter that he was "[i]n obedience to the instructions I have received at your Lordship's office" **(f. 444)**. It is also possible that Arnold submitted the text on his own initiative to impress the Lord Chamberlain. We will never know which speculation, if either, is true until further evidence emerges.

More than a Script

The *Ouranologia* was more than a script or a common syllabus. It was neither made for the lecturer to read every line, nor simply listed the title of topics in the lecture. The manuscript was more like a copy of 'production notes' with the playwright's thoughts on what effects the audience could expect to see. It was also like an outline of the lecture written to justify what would be performed onstage. In the manuscript Arnold clearly explained his objective and the theme of the lecture. Sometimes he even explained the reasons why he adopted or not a scene in a particular part. For example, when introducing the change of lunar phases, he commented that the recurring progress "could shew on this apparatus, but as it would only reverse the succession of the same forms which have just been shewn; it might be considered as an unnecessary waste of time: particularly as the nearest Scene will shew in a different manner" **(f. 465)**.

Another example in the *Ouranologia* to show the playwright's thoughts was the scene 'Diagram of Ship' (Fig. 8). In this scene, a model vessel would appear on the top of the globe in order to demonstrate the spherical shape of the Earth. Because of the different heights spectators were seated in the auditorium, this effect might vary. Arnold had noticed such occurrence of spatial difference, thus he explained:

> A Ship will shortly appear on its [the globe's] surface, advancing towards the Audience – Those of the Spectators who are situated in the higher parts of the Theatre, will of course behold it first – As a Seaman in the foretop first discovers a Sail at Sea – Those persons in the lower parts of the Theatre will perceive it later – but I trust all of my Auditors who favor me with their attention, will find that its advances are precisely correspondent with my description; thus illustrating the Globular shape of the Earth. **(ff. 448[b]-449)**

This remark exactly shows a subtle technical detail considered by the producer, and how reliable the showmanship of the lecturer was for the performance. Arnold believed Bartley could easily distract the audience from this slight difference due to unavoidable restriction of the auditorium space. This also indicates the importance of Bartley as the lecturer. Though Arnold was the sole author of the *Ouranologia*, Bartley's role as the speaker in the programme should not be neglected.

Synopsis of the *Ouranologia*

The *Ouranologia* elaborates the subjects and scenes in Bartley's lecture. Arnold divided the lecture into three parts. The first part **(ff. 446-457)** starts with the shape of the Earth by a 'Diagram of Ship' to demonstrate the curve of its surface. It also includes different cosmological models in history: Pythagorean, Ptolemaic, Tychonic, and the "genuine one of Copernicus" **(f. 453[b])**. The stories of historic philosophers and astronomers finally lead to the achievement of Isaac Newton.

The second part **(ff. 458-476)** is an overview of the solar system, emphasising the telescopic appearances of individual planets. Comets are also an absorbing subject: three scenes of the Comets of 1680, 1811 and 1819, are included. The

Figure 8 Illustration from *The Beauty of the Heavens* (1842), p. 14, by Charles F. Blunt. The diagram of ships for explaining the shape of the Earth was a common topic in early-nineteenth century popular astronomy lectures, as this picture did. Although this illustration was not the actual scene from the *Ouranologia*, it showed the taste of what would be presented in Bartley's lecture. Credit: ETH-Bibliothek, Zürich. Item: Rar 4024.

Sun and the Moon are particularly elaborated, with many extra scenes such as the Sun's apparent magnitude to the different planets, and the orbit and phases of the Moon.

The third part **(ff. 477-493[b])** focuses on the eclipses and the tides. The causes and different types of eclipses are explained in detail; so are the tides.

Finally, the lecture concludes with the display of the extensive orrery, which contains the whole solar system and every planetary movement.

Arnold acknowledged that he drew largely on the works of the best authors, although he was never explicit about the sources of the lecture. The arrangement of subjects in the *Ouranologia* was similar to the structure of the book *Astronomy explained upon Sir Isaac Newton's Principles* (1756), written by James Ferguson (1710-1776). Ferguson was a prominent astronomy lecturer and author in the mid-eighteenth century. His *Astronomy* was reprinted many times and was also published posthumously.[24] This popular astronomy classic was still influential even over half a century after its first publication. Though Arnold did not refer specifically to Ferguson's *Astronomy*, this classic was very likely the main reference of the *Ouranologia*. In addition to Ferguson's, Arnold also quoted from other popular books such as *An Introduction to Astronomy* (1786) by John Bonnycastle (1751-1821).[25]

Legacy of Newton

Newtonian science was a significant theme in public lectures on natural philosophy in the eighteenth and early nineteenth centuries.[26] Isaac Newton enjoyed a celebrated place in the shrine of British science, as did many of his doctrines. The laws of motions, gravity, and the planetary system according to Newton's principles, were classic subjects in contemporary astronomical lectures.

The significance of Newtonian inheritance is also obvious in the *Ouranologia*. Newton was the main protagonist amongst a long line of great geniuses. Arnold's high praise reflected the prestigious status of the English national hero. "[A]ll other systems have been wholly exploded by the clear and demonstrative discoveries of our immortal Countryman Sir Isaac Newton", Arnold concluded in the first part of the lecture, "who has shewn that though ingenious Argument might suppose the course of nature to be governed by mere mechanical laws only, the works of nature would then have been incomparably inferior to what they now are both in beauty and perfection" **(f. 457)**. The phenomenon of the tides (Fig. 9), a subject best exemplifying Newtonian principles of gravitation, occupies a great part in the *Ouranologia* **(ff. 483-488[b])**.

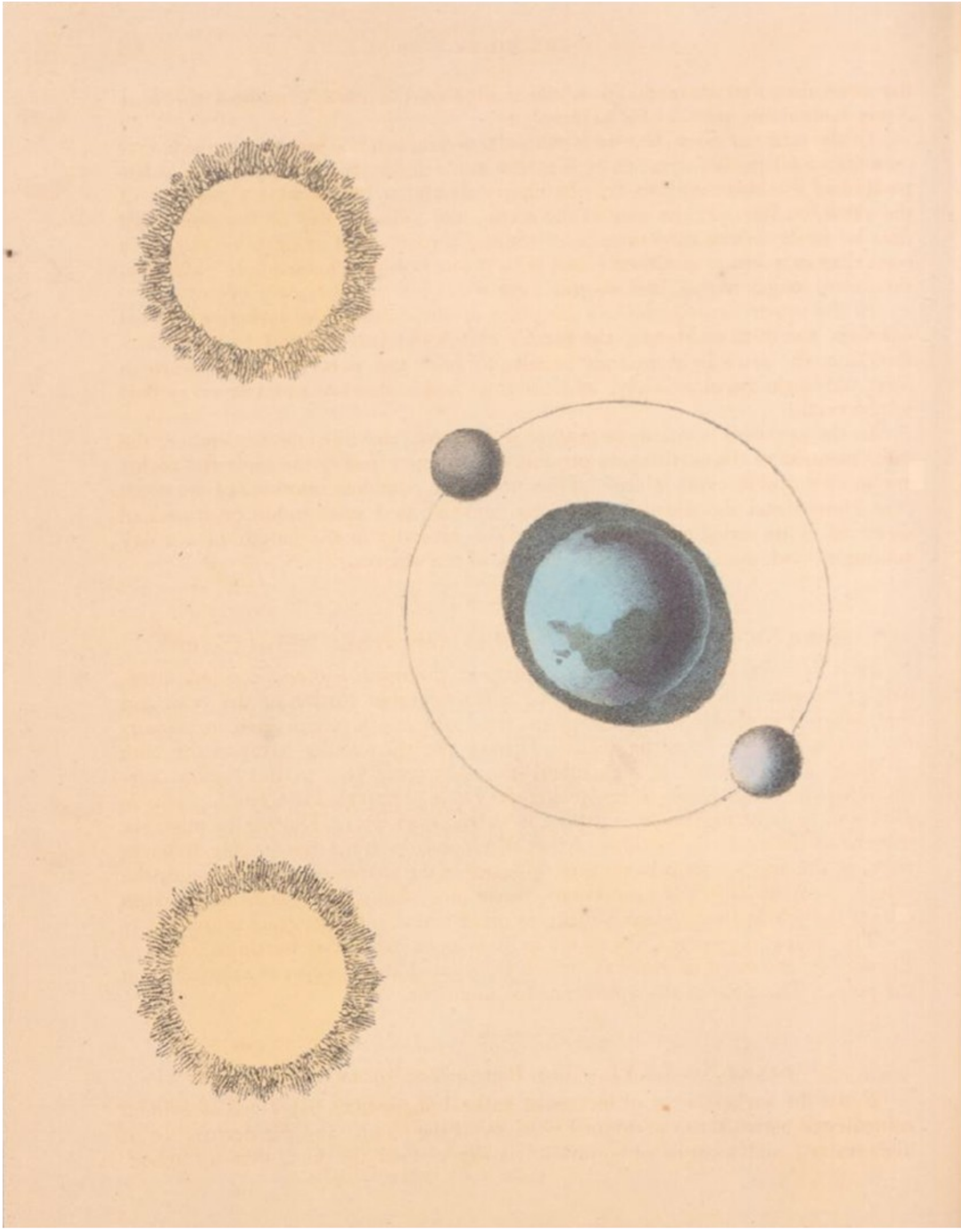


Figure 9 "The Phenomena of the Tides", illustration from *The Beauty of the Heavens* (1842), p. 83, by Charles F. Blunt. Credit: ETH-Bibliothek, Zürich. Item: Rar 4024.

Enlightenment

The progress and utility of science were celebrated by contemporaries. The dissemination of scientific knowledge indicated a path to reason. Humans benefited from advantages of science and no longer linked natural phenomena with irrational superstition. Such progressive 'enlightenment' narratives were common in popular scientific publications during this period.[27] Arnold's writing was no exception. "To Astronomy we also owe the regulation and measure of time – and all our most important discoveries in Geography and Navigation", Arnold wrote, the "dark and gloomy fears of superstition have vanished before the light of truth and reason – and the frauds practiced for Ages by designing Imposters, and Pretenders to learning in Astrology, have been exposed and ridiculed." **(f. 447)**

Natural Theology: Creation and Sublimity

The rhetoric of natural theology was prevalent among popular scientific publications in early nineteenth-century Britain. Natural theology proposed that the evidence of Creation and design was revealed in nature. Humans could discern the existance and divine wisdom of a benevolent Creator through the study of nature, God's handiwork.[28] The writings of the English clergyman William Paley (1743-1805) were especially critical to the rendition of natural theology in Britain in the early nineteenth century.[29] Later on, the *Bridgewater Treatises*, which involved many prestigious scientific authors including William Whewell and William Buckland, were a representative example of popular scientific publications explicating the doctrines of natural theology.[30]

Religious renditions of creation and design were evident in the *Ouranologia*. Arnold repeatedly reminded the audience about the advantage of astronomy: a sublime subject affording the knowledge of nature, the true system of the world, and the invariable laws by which it is governed. He claimed astronomy "has opened to us such a magnificent view of the Creation, that we are struck with astonishment at the grandeur of the spectacle, and the powers of omnipotence." **(f. 447)** When introducing the cause of the seasons, Arnold attributed such a wonderful mechanism to the benevolence of the Creator:

> This beneficent and curious provision for the existance [*sic*] and comfort of the Earth's inhabitations cannot too powerfully excite our admiration of the wisdom, or our gratitude for the goodness of the Creator. If it were not for this simple contrivance one part of the Globe would revolve constantly in the full blaze of the Sun's rays – while those regions which are situated near the poles would be

> almost, wholly, destitute of light and heat, and probably incapable of sustaining either Animal or vegetable life. – But this is not the case, for the remotest points to which the avarice or curiousity of Man has penetrated are sound to be inhabited; and doubtless that power which "tempers the wind to the shorn Lamb" – has so organized their inhabitants as to afford even in those desolate regions the Capability and means of enjoyment. **(f. 471[b])**

The narrative of these passages fitted the rhetoric of natural theology. By using astronomical knowledge, natural theologians argued that these physical facts possessed profound significance, and showed the order created by a benevolent designer. Whether Arnold intended to advocate this natural theological idea or he unintentionally followed this fashion in popular scientific publications, he was neither the first nor the last author to do so. The *Ouranologia* exactly reflected how influential such religious narratives had been in the heyday of natural theology.

Plurality of Worlds

The idea of the plurality of worlds was highly associated with debates on the existence of extraterrestrial life. Planetary systems other than the solar system – worlds outside our own world – consolidated grounds for the imagination of extraterrestrial beings, especially humanoid intelligence. Copernicus's heliocentric cosmology, along with many later astronomical discoveries, was an important factor in increasing interest in the possibility of a fully populated universe. By the mid-eighteenth century, heliocentrism had been essentially accepted by the public, and many intellectuals had adopted the idea of a plurality of inhabited worlds.[31] Scottish lecturer and minister Thomas Chalmers (1780-1847), for example, was a prominent proponent of inhabited extraterrestrial worlds. In contrast, William Whewell (1794-1866) had openly objected to Chalmers's plurality claim and engaged in fiery debates with other supporters such as David Brewster (1781-1868).[32]

This plurality concept was common in nineteenth-century British popular astronomy discourses, and was welcomed by most contemporary readers and audiences. This idea can be traced to James Ferguson, who expressed the sentiment of plurality in his *Astronomy* in the mid-eighteenth century.[33] The same sentiment also appeared in the *Ouranologia*, in which Arnold quoted Ferguson's words as the conclusion: "Thousands of thousands of Suns, multiplied without end, and ranged all around us, at immense distances from each other, attended by ten thousand times ten thousand Worlds; [...] these Worlds peopled with myriads of intelligent beings, formed for an endless progression in perfection and felicity." **(ff. 493-493[b])**

Conclusion

The *Ouranologia* provides a valuable source for historians to examine the appearance, contents, and agenda of Lenten astronomical lectures in the early nineteenth century. Samuel James Arnold, the playwright as well as the 'producer' of the lecture, elaborated the outline of the show in this manuscript submitted to the Lord Chamberlain. In addition to justifying his objectives, Arnold demonstrated his knowledge on the subject and revealed his consideration of stage effects. This manuscript was more than a script or common syllabus which merely listed topics of subjects.

George Bartley, the lecturer and a professional actor, was another key person behind this manuscript. Although Arnold did not mention Bartley's name in the text (except in the title page), one should not neglect Bartley's contribution in the performance. Bartley was the performer who realised Arnold's lecture scheme before the audiences. His showmanship and oratorical skills were critical to the success of the show. For contemporary audiences, they might associate this astronomical lecture more with Bartley than Arnold, since the former was the man in the spotlight. Advertisements and reviews also referred to Bartley rather than to Arnold.

Bartley's lectures on astronomy were a regular Lenten fixture at the English Opera House between 1820 and 1828. Although the show ran for less than a decade, it impressed critics and audiences. Nevertheless, Bartley's lecture was not the only Lenten astronomical lecture at the time. There were many competitors, such as Deane Franklin Walker, who inherited a family lecturing business. The Walkers published their lecture every year; these pamphlets are also valuable sources for studying early nineteenth-century popular astronomy lecturing.[34] The manuscript *Ouranologia* is comparable to the Walkers' printed publications.

Our understanding of Lenten astronomical shows or any itinerant lecture of this kind, however, is still limited. Many lecturers were not elite practitioners of science, and very few records of their activities have survived. Bartley and D. F. Walker were successful among these lecturers and had more visibility. Nevertheless, biographical information about their careers in astronomy lecturing is still scarce. Another unsolved mystery is the apparatus used in these astronomical lectures. The transparent orreries, and visual aids for displaying scenic transparencies, were critical apparatus moulding onstage lectures. These visual aids were often advertised by lecturers as major attractions. However, the mechanism of the transparent orrery remains unclear.[35] Neither the Walkers nor Arnold described mechanical details of their own apparatus. In the *Ouranologia*, Arnold elaborated on spectacular onstage scenes, but neglected backstage technical parts. There are no known preserved fragments of these stage machines.

Popular astronomy in the nineteenth century had a wide diversity of speakers and spaces. A lecturer who spoke of celestial phenomena could be a professional actor without a scientific background; the lecturing venue was not necessarily in a prescribed scientific site such as a specialist society. The most significant inspiration from the manuscript *Ouranologia* to modern readers is perhaps in its revelation of the the connections between astronomy and theatre. Theatrical facilities and showmanship were frequently used in popular astronomical lectures in the first half of the nineteenth century. Lent was a competitive marketplace but not an exclusive season – astronomy lecturing took place all year round in every nook and cranny of the British Isles.[36] The blend of scientific instruction, entertainment and religious narratives, all indicate a very distinct performance from what we conceive of as scientific discourses today. The *Ouranologia* is a lively specimen of these long-forgotten astronomical shows.

Notes

1. Several scholarly works have discussed public astronomy lectures in early nineteenth-century Britain. For example, Inkster (1982) and Chapman (1998), ch. 9, both emphasise the working-class popularisers of astronomy. King (1978), ch. 19, has a survey on itinerant astronomy lecturers and stresses on the playbills and orreries used by these popularisers.

2. Among the scholarship which pays attention to private or non-practitioner popularisers of science, Lightman (2007) is an excellent work but focuses on the later nineteenth century.

3. British Library, Add MS 42875, ff. 443-493b.

4. The scientific milieu of London in this period refers to Morus, Schaffer and Secord (1992). Hays (1983) provides an overview of scientific lecturing in London. For the early years of the Royal Institution, refer to Berman (1978) and James, ed. (2002). See also Desmond (1989) and Lightman (2011).

5. Altick (1978) has an extensive survey on the shows and exhibitions of London from the eighteenth century to the Great Exhibition of 1851. See also Fox, ed. (1992).

6. D. F. Walker's father Adam Walker (c. 1730-1821) and the eldest brother William Walker (c. 1766-1816) were prominent itinerant natural philosophy lecturers. The Walkers had critical contributions to the development of onstage astronomy lectures: the transparent orrery was invented by Adam Walker prior to the 1780s and they were the pioneers who moved astronomical demonstrations into theatres. For Adam Walker's biography, refer to E. I. Carlyle, 'Walker, Adam (1730/31-1821)', *rev.* Anita McConnell, *ODNB* (2004). Jan Golinski has a conference paper on Adam Walker and his invention, the Eidouranion (transparent orrery); refer to Golinski (2014). See also my dissertation, Huang (2015).

7. 'Astronomical Mania' was the title of a satirical newspaper article which reviewed the current season's crop of astronomical lectures around 1839. See Chapman (1998), p. 167.

8. For discussions of conventional Lenten restrictions on dramatic performances, see Foulkes (1997), pp. 32-34; Altick (1978), p. 364.

9. Foulkes (1997), p. 32. In the *Report from the Selected Committee on Dramatic Literature* (1832), John Payne Collier, the Lord Chamberlain's Examiner of Plays, gave evidence before the Parliament committee that many theatres continued playing on Wednesdays and Fridays during Lent; see also Jackson, ed. (1994), pp. 18-19.

10. Jessica Hinings, 'Arnold, Samuel James (1774-1852)', *ODNB* (2004); Joseph Knight and *rev.* Katharine Cockin, 'Bartley, George (1782?-1858)', *ODNB* (2004).

11. Portrait number: NPG 4253.

12. Royal Institution, Guard Book: 1, p. 87 and p. 108. These two records of the balloting list were on 29th November 1810 and 20th April 1811.

13. Hinings, *op. cit.* (10). The complete list of the Fellowship from 1660 onwards on the official website of the Royal Society does not include Arnold.

14. Two primary sources described Bartley's life in detail: 'Memoir of George Bartley', *Oxberry's Dramatic Biography and Histrionic Anecdotes*, vol. 5 (June 1826), pp. 217-231; his obituary, 'The Death of Mr. George Bartley', *The Era* (25 July 1858).

15. 'Death of Mr. George Bartley', *The Era* (25 July 1858).

16. 'Memoir of Stephen Kemble', *Oxberry's Dramatic Biography and Histrionic Anecdotes*, vol. 2 (April 1825), p. 11. Benjamin Smart was one of the most prominent authors and teachers in elocution at the time. Michael Faraday had attended Smart's private lessons. For more details of the relationship between Smart and Faraday, see Morus (1998), pp. 20-21.

17. Royal Astronomical Society, Add MS 88: 7.

18. Although these zodiac signs has astrological origin and are continually used in Western astrology, Bartley's lecture was no relation with astrology.

19. For example, Walker's Eidouranion lecture usually "begin at 7, conclude at 10"; Charles Henry Adams, another celebrated Lenten astronomy lecturer, began the show at 8 and ended at about 10. See RAS Add MS 88: 4, 8.

20. Kitchener (1824), pp. 166-167; King (1978), p. 317.

21. Thomas Hood, 'Love and Lunacy', *Comic Annual*, vol. 7 (1836), p. 79.

22. Wellbeloved (1826), p. 4.

23. For more details about the Lord Chamberlain's power of examination of theatres and dramas, see Booth (1991), pp. 145-149; Foulkes (1997), ch. 2.

24. For example, the second American edition published in Philadelphia in 1809 was edited by Robert Patterson (1743-1824). Its title page noted that it was "from the last London edition". In 1811, David Brewster (1781-1868) also edited and republished Ferguson's *Astronomy* at Edinburgh with supplementary chapters.

25. John Bonnycastle was a prolific author of scientific and mathematic textbooks. He was a teacher of mathematics, later became a professor, at the Royal Military Academy, Woolwich. For a brief biography of Bonnycastle, see Thomas Whittaker*, rev.* Adrian Rice, 'Bonnycastle, John (c. 1760-1821)', *ODNB* (2004).

26. For the development and prevalence of Newtonian science in eighteenth-century natural philosophy lecturing, see Stewart (1992); Morton and Wess (1993); Elliott (2000).

27. Eclipses, for example, are a subject regularly used in astronomy discourses to demonstrate this enlightenment, as a popular book wrote: "Before the true causes of eclipses was ascertained those phenomena were considered as supernatural, and viewed with apprehension and alarm. […] Such facts should inspire us with gratitude for the advantages we now enjoy, in a land where science is cultivated, and useful knowledge disseminated". See *The Solar System* (1799), pp. 105-106, London: The Religious Tract Society.

28. Bowler and Morus (2005), pp. 350-354. For further discussions on the significance of natural theology in nineteenth-century Britain, see Brooke (1991), ch. 6; Brooke and Cantor (1998), chs. 5-6; Knight (2007), ch. 2.

29. The full title of Paley's book is *Natural Theology or Evidences of the Existence and Attributes of the Deity*, which was first published in 1802.

30. The production, readership and influence of the *Bridgewater Treatises*, refer to Topham (1992; 1998).

31. Crowe (2001), p. 211. Many scholarly works are on the background and history of extraterrestrial life debates covering different eras, which includes Dick (1982) and Crowe (1986; 2001). Ruse, ed. (2001) has a concise introduction on the plurality of worlds debate, focusing on the context involving William Whewell. See also Guthke (2003), in which he emphasises secular philosophical concerns rather than theological contexts.

32. Chalmers's sermons at Glasgow and his book *A Series of Discourses on Christian Revelation,*

Viewed in Connection with the Modern Astronomy (1817) best exemplified his idea on the plurality of worlds. Whewell anonymously published a tract *Of The Plurality of Worlds* (1853) to refute Chalmers. See Ruse, ed. (2001).

33. Crowe (2001), p. 220. For an example of plurality narratives in Ferguson's works, see Ferguson (1756), p. 6.

34. The Walkers' lecture syllabus *An Account of the Eidouranion* (also entitled *An Epitome of Astronomy* in later editions) was published annually since about 1782 and reached the thirty-first edition in 1824. See also King (1978), p. 311.

35. For example, King (1978) argues a 'mechanical' transparent orrery, which was a geared machine consisting of pinions, wheels and cords. In contrast, Bird (2005) argues the transparent orrery was an optical device which incorporated phantasmagoria techniques. See King (1978), p. 310; Bird (2005), pp. 90-91.

36. For more details of popular astronomy lectures in early nineteenth-century Britain, see Huang (2015).

Part II

Transcription of the *Ouranologia*

Editorial Notes

The source manuscript of the *Ouranologia* is held by the Manuscript Collections, British Library, located in the *Lord Chamberlain's Plays*, vol. XI (January 1826), reference number Add MS 42875, ff. 443-493b. The *Lord Chamberlain's Plays* is a series of plays submitted to the Lord Chamberlain's Office, from 1824 to 1968, when that office held the power to censor performances. For further information about the current status of the collection, refer to the British Library's official guide.†

The inscriptional history for the documents incorporated into the *Lord Chamberlain's Plays* is not clear. The source text contains a covering letter from Samuel James Arnold to the Lord Chamberlain's Office, plus a detailed syllabus of the lecture. The lecture syllabus is divided into three parts; it was written on both sides of the folio in black ink. The original hand-writing is mostly clean and tidy, and contains few corrections. Two separate sets of pagination appear together in the source text. One set is the folio numbers archived by the British Library; the other, the page numbers noted in the text, is not continued between each part of the lecture. The latter is probably original pagination.

The present edition was transcribed by Hsiang-Fu Huang. The transcription has been verified by proofreading against digital scanned images of each page. The proofreader was Tom O'Donnell.

For convenience of reading here, line breaks in the original text are not preserved, except at page breaks and quotations from poems or psalms. Paragraph breaks follow the original. Spelling, grammar, and stylistic consistency remain as in the original. Symbols of corrections and underlining within the source text are also preserved as in the original. Except for the above conventions, all editorial interpolations are annotated by Huang. Editorial interventions are indicated by [ ] brackets. Annotations are indicated by Roman numerals in [ ] brackets.

The two sets of pagination in the original text are provided in this transcription. To avoid confusion, they are presented in separate places. The British Library folio numbers are marked in the outer margins of the text; a folio number indicates the present folio starts from this line. The presumably original text page numbers are indicated by [ ] brackets within the text. In summary, pagination follows these formats:

f. x Folio x in the source text (recto).

[b] The verso of a folio.

[**x**|**y**] Page transition in the source text, from page x to page y.

[**x**|**y***] Page transition in the source text, from page x to page y, occurs within a word. To preserve clarity, the transitional word is preserved in page x.

Samples of Facsimiles

Figures 10 to 12 show the scanned images of the title page, the covering letter from Arnold to the Lord Chamberlain's Office, and the first page of the lecture, respectively. The transcript starts following the samples of facsimiles.

† 'The Manuscript Collections Reader Guide 3: The Play Collections', British Library. http://www.bl.uk/reshelp/pdfs/readerguide3.pdf (accessed 1 September 2015)

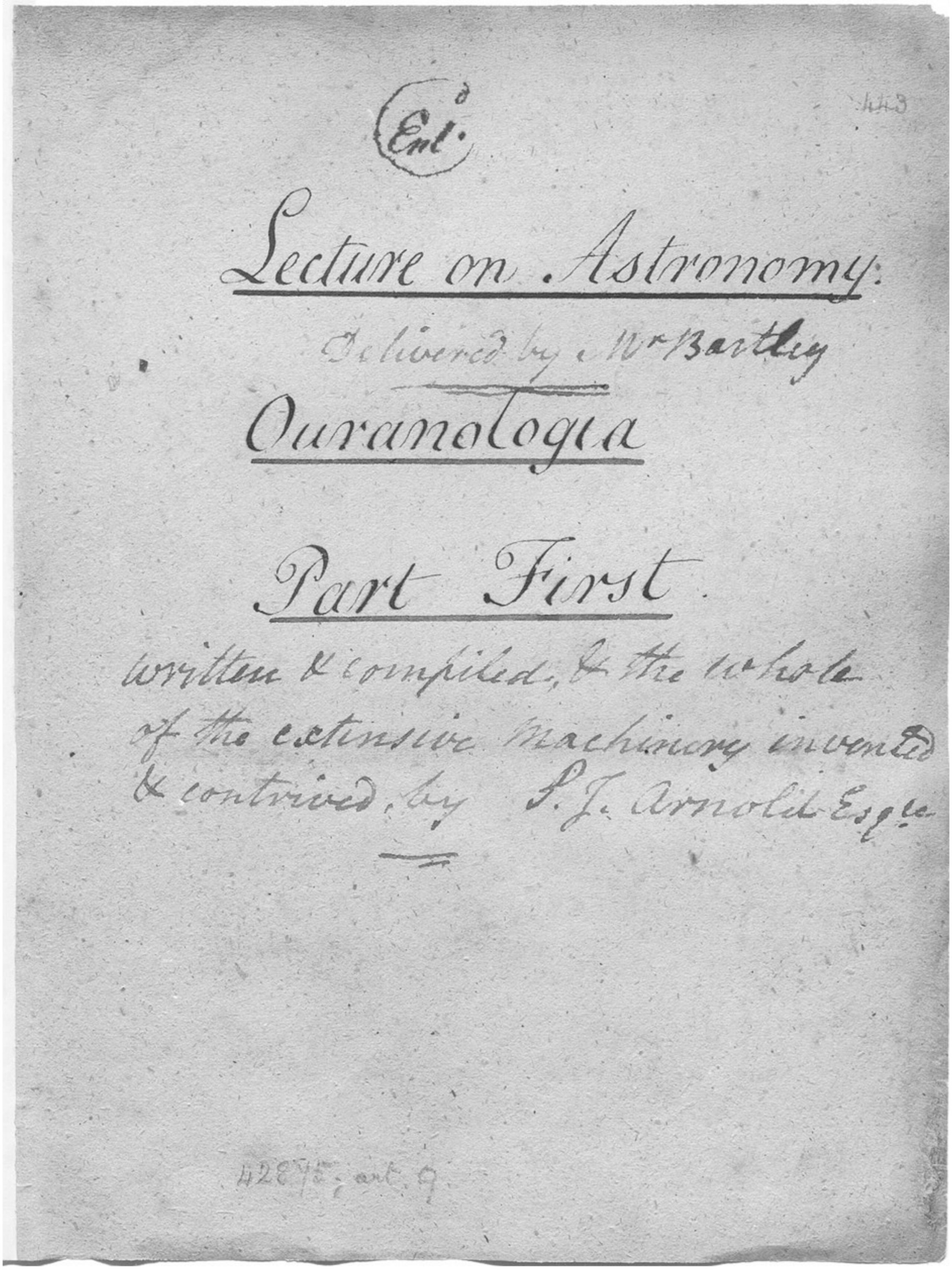
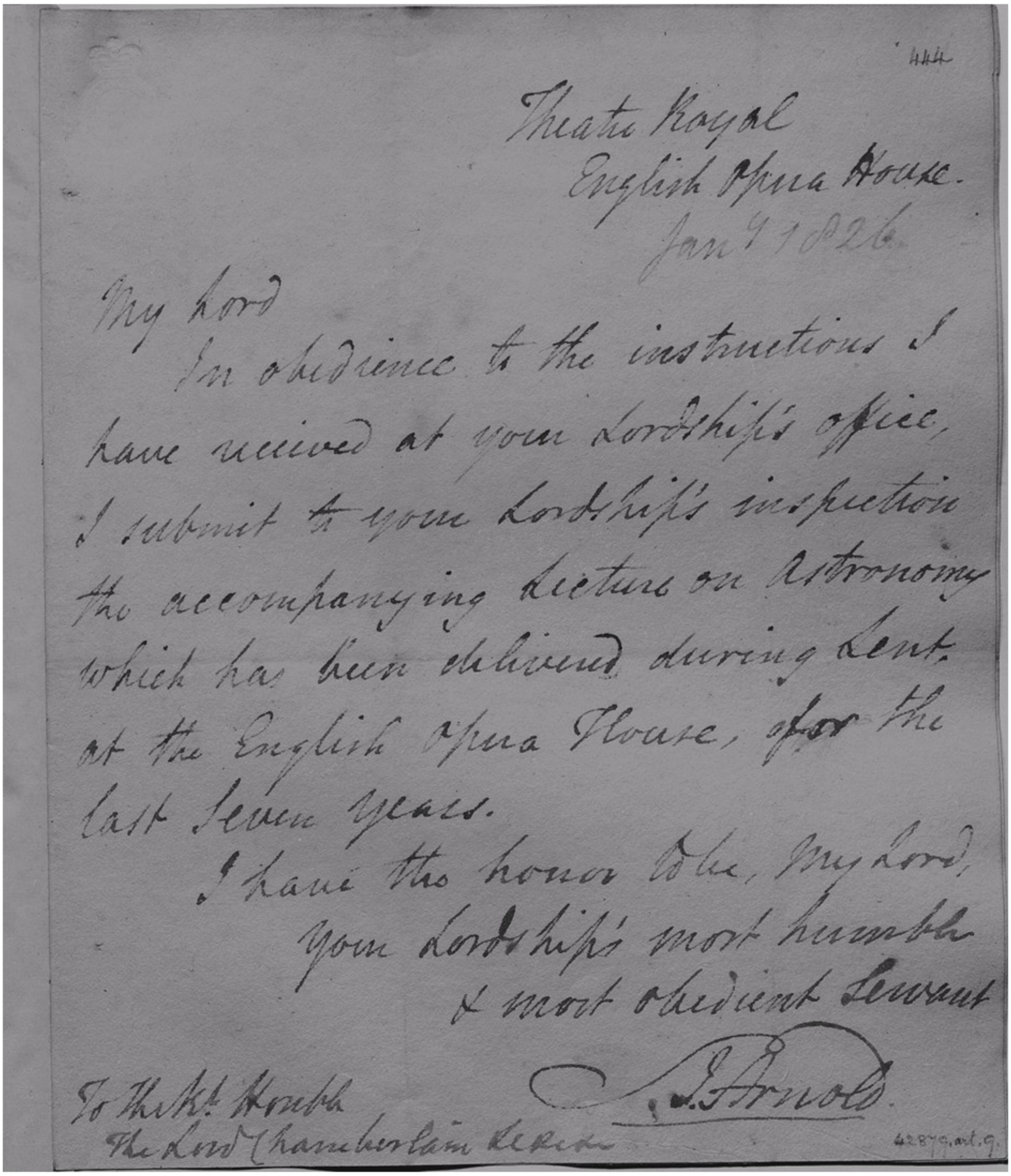


Figure 10 The title page of the *Ouranologia*. Credit: British Library, Add MS 42875, f. 443.



444

Theatre Royal
English Opera House.
Jan 9 1826

My Lord

In obedience to the instructions I have received at your Lordship's office, I submit to your Lordship's inspection the accompanying Lecture on Astronomy which has been delivered during Lent, at the English Opera House, for the last Seven years.

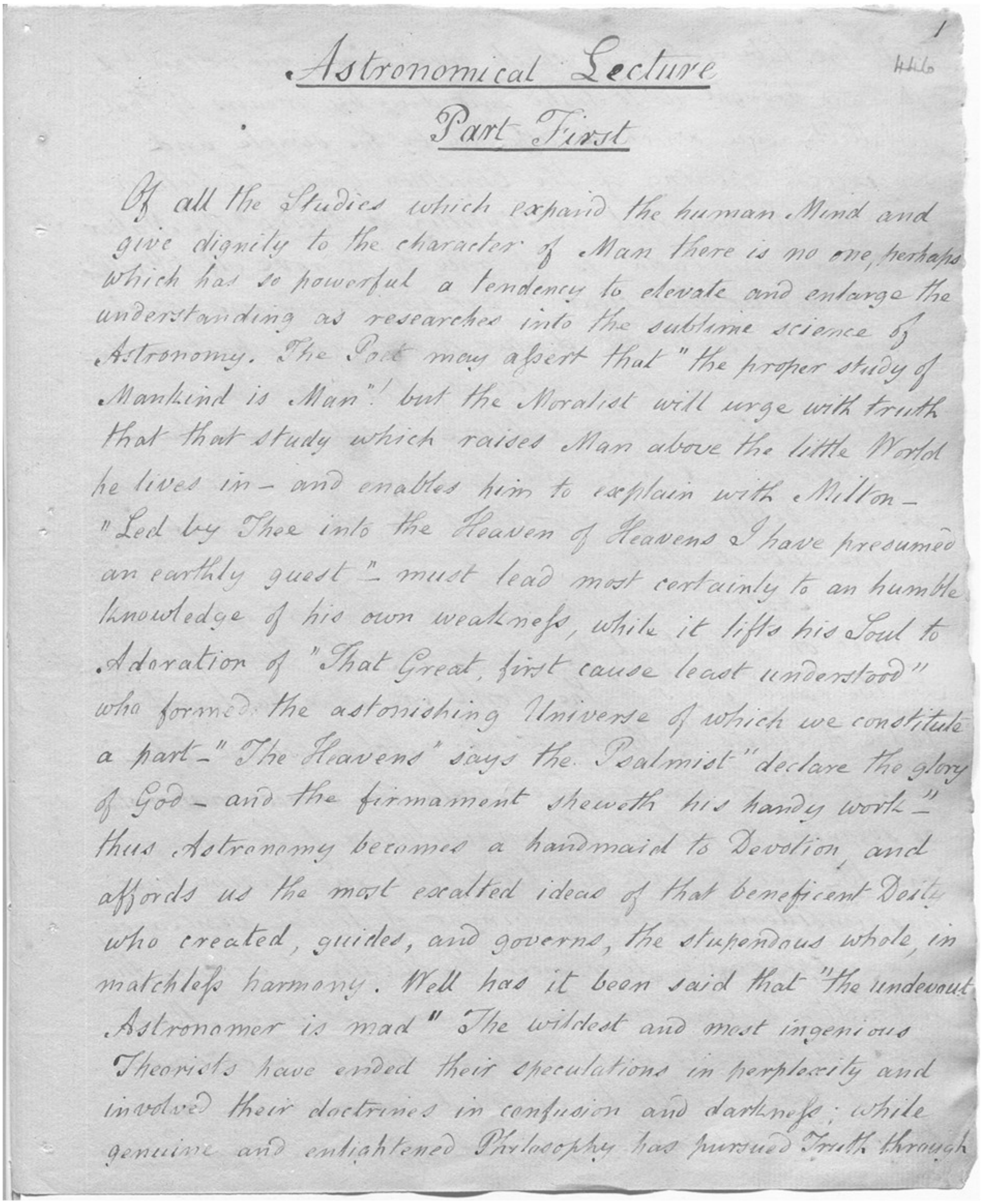
I have the honor to be, My Lord,
Your Lordship's most humble
& most obedient Servant

S. J. Arnold

To the Rt. Honble
The Lord Chamberlain &c &c

42879.art.9.

Figure 11 Covering letter, Samuel James Arnold to the Lord Chamberlain's Office, 9th January 1826. Credit: British Library, Add MS 42875, f. 444.



1

446

Astronomical Lecture

Part First

Of all the Studies which expand the human Mind and give dignity to the character of Man there is no one, perhaps which has so powerful a tendency to elevate and enlarge the understanding as researches into the sublime science of Astronomy. The Poet may assert that "the proper study of Mankind is Man"! but the Moralist will urge with truth that that study which raises Man above the little World he lives in – and enables him to explain with Milton – "Led by Thee into the Heaven of Heavens I have presumed an earthly guest" – must lead most certainly to an humble knowledge of his own weakness, while it lifts his Soul to Adoration of "That Great, first cause least understood" who formed the astonishing Universe of which we constitute a part – "The Heavens" says the Psalmist "declare the glory of God – and the firmament sheweth his handy work" – thus Astronomy becomes a handmaid to Devotion, and affords us the most exalted ideas of that beneficent Deity who created, guides, and governs, the stupendous whole, in matchless harmony. Well has it been said that "the undevout Astronomer is mad" The wildest and most ingenious Theorists have ended their speculations in perplexity and involved their doctrines in confusion and darkness; while genuine and enlightened Philosophy has pursued Truth through

Figure 12 The first page of the first part of the lecture text. British Library, Add MS 42875, f. 446.

Lecture on Astronomy. **f. 443**

Delivered by M[r] Bartley

Ouranologia

Part First

Written & compiled, & the whole
of the extensive machinery invented
& contrived, by S.J. Arnold Esq. &c

Theatre Royal **f. 444**
English Opera House
Jan 9 1826

My lord

In obedience to the instructions I have received at your Lordship's office, I submit to your Lordship's inspection the accompanying Lecture on Astronomy which has been delivered during Lent, at the English Opera House, afar the last seven years.

I have this honor to be, my Lord,
your Lordship's most humble
& most obedient Servant

S. J. Arnold

To The Kt. Hon.ble
The Lord Chamberlain's [unknown words]

f. 446

Astronomical Lecture

Part First

Of all the studies which expand the human Mind and give dignity to the character of Man there is no one, perhaps which has so powerful a tendency to elevate and enlarge the understanding as researches into the sublime science of Astronomy. The Poet may assert that "the proper study of Mankind is Man"! [i] but the Moralist will urge with truth that that study which raised man above the little World he lives in – and enables him to explain with Milton – "Led by Thee into the Heaven of Heavens I have presumed an earthly guest" [ii] – must lead most certainly to an humble knowledge of his own weakness, which it lifts his Soul to Adoration of "That Great, first cause least understood" [iii] who formed the astonishing Universe of which we constitute a part – "The Heavens" says the Psalmist "declare the glory of God – and the firmament sheweth his handy worth –" [iv] thus Astronomy becomes a handmaid to Devotion, and affords us the most exalted ideas of that beneficent Deity who created, guides, and governs, the stupendous whole, in matchless harmony. Well has it been said that "the undevout Astronomer is mad" [v] The wildest and most ingenious Theorists have ended their speculations in perplexity and involve their doctrines in confusion and darkness; while genuine and enlightened Philosophy has pursued Truth through [**1**|**2**]

[b] [cont.] all the labyrinths in which mere fancy had entangled it, and brought it to light and day by means of that infallible clue which is afforded by the simple and majestick opening of the Christian Creed – To believe in one all powerful and intelligent Being "The Maker of Heaven and Earth" is at once to remove all difficulties and to render that clear to our understandings which before appeared to our darker reason incomprehensible. I trust we may stand excused, if, in opening even a popular Lecture on so sublime a subject we have thus assumed a tone and language of a serious cast, as best belitting [*sic*] the dignity of the science which is to be the subject of it.

Astronomy has conferred the most essential benefits on Mankind by expanding the understanding". In the early Ages of the World, ere men had learnt to judge of effects by their Causes, a total Eclipse of the Sun or Moon was regarded with the almost consternation, as seeming to portend the annihilation of the universe; and the Comet with his fiery tail and blazing hair, was considered as the harbinger of divine vengeance; whose appearance denounced the Death of Princes, the destruction of Empires, famine and pestilence. But these Opinions, as distressing as they were erroneous, are, at length, entirely exploded; and we are now taught, by Astronomers, to look upon Comets and Eclipses [**2**|**3**]

[cont.] with tranquility and Composure." **f. 447**

To Astronomy we also owe the regulation and measure of time – and all our most important discoveries in Geography and Navigation. The dark and gloomy fears of superstition have vanished before the light of truth and reason – and the frauds practiced for Ages by designing Imposters, and Pretenders to learning in Astrology, have been exposed and ridiculed. "Such are the advantages which society have derived from the cultivation of this science; but there is yet another, which, though less evident to the world in general, is nevertheless inestimable in the Eyes of a Philosopher. This is the knowledge which it affords us of nature; of the true system of the World; and the invariable laws by which it is governed. Astronomy has opened to us such a magnificent view of the Creation, that we are struck with astonishment at the grandeur of the spectacle, and the powers of Omnipotence. By looking abroad into the universe, we exalt our ideas of the supreme intelligence, and extend the narrow sphere of human conceptions; the faculties are strengthened and improved; the understanding is enlarged; and the Mind in the contemplation of so many glorious objects, finds itself drawn to that Being who informs, directs, and animates the whole." [**3**|**4**]

[b] I shall now proceed to explain in what we trust will be found an easy and familiar manner, the most striking Phænomena of the subject we wish to illustrate.

So many excellent works having been written on this subject it can hardly be expected that any striking novelty either in language or arrangement should be attempted – known and admitted Truths allow of no decorations from Fancy; and flights of imagination would be strangely wasted on a Theme so vast, that the clearest intellect becomes bewildered in the contemplation of its immensity. so stupendous indeed is the Theme that the human Mind shrinks into conscious insignificance when attempting to push inquiry, or thoughts beyond certain limits into the boundless regions of eternity and space.

To confine ourselves therefore to what is known, and now proved beyond the chance of future doubt, will be our bounden duty – In so doing we shall draw largely on the works of the best Authors who have written on the subject, because nothing can be added to that which is already complete and full; and to vary language which expresses its object with perspicuity and precision, merely for the sake of variety, might [**4**|**5**]

f. 448 [cont.] more probably involve failure than elicit improvement.

The grand improvement <u>we</u> hope to accomplish is in the mode of illustrating by explanatory Scenery produced on Optical principles those doctrines which never can be so well conveyed to the understanding as thro' such a medium.

"As the Earth we inhabit is constantly subject to our observation, and is that with which we are the best acquainted, a description of its form and magnitude naturally first excites our Curiosity and attention.

This vast body was long considered as a large circular plane spreading out on all sides to an infinite distance: and the Heavens, above it, in which the Sun, Moon and Stars appear to move daily from East to West, (that is, in the same way as the hands of a

Watch move) were imagined to be at no great distance from it, and to have been created solely for the use and ornament of our Earth. But it is now well known to Mathematicians and Philosophers, that the Earth is of a round or spherical figure, nearly resembling that of a Globe.

The truth of this doctrine, without having recourse to scientific principles, will appear sufficiently evident from the voyages of those celebrated Navigators Magellan, Sir Francis Drake, Lord Anson, Cook [vi], &c. who all set out, at different times, to sail round the [**5**|**6**]

[cont.] World; and, by steering their course continually westward, arrived, at length, at the shore they departed from; which could never have happended, had the Earth been of any other than a spherical or globular figure. **[b]**

This form is also obvious, from the circular appearance of the Sea itself, and the circumstances which attend large objects when seen at a distance on its surface. Thus, when a Ship leaves the shore, we first lose sight of the hull, or body of the Vessel; afterwards of the rigging ; and at last discern only the top of the Mast; which is evidently owing to the convexity of the water between the Eye and the object; or otherwise, the largest and most conspicuous part would have been visible the longest, as is manifest from experience. The same remark holds good in the case of a ship approaching the shore. The top of the Mast is first to be discerned, afterwards the rigging and sails, and lastly the hull of the Vessel. This doctrine I shall now illustrate by experiment.

Scene 1st Diagram & Ship

This Globe has been prepared for the purpose – A Ship will shortly appear on its surface, advancing towards the Audience – Those of the Spectators who [**6**|**7**]

[cont.] are situated in the higher parts of the Theatre, will of course **f. 449** behold it first – As a Seaman in the foretop first discovers a Sail at Sea – Those persons in the lower parts of the Theatre will perceive it later – but I trust ~~each~~ all of my Auditors who favor me with their attention, will find that its advances are precisely correspondent with my description; thus illustrating the Globular shape of the Earth.

The Vessel is now in motion – it is probably visible to a part of the Audience – as it approaches it will meet the observation of others – while its appearance encreases [*sic*] to those who first perceived it – as it advances the whole of the Auditory will behold it; – and now – having reached its destination. I flatter myself the illustration has been sufficiently evident.

"Another proof &c. ——— [**7**|**8**]

[b] "Another proof, which is of no less force than either of the former, is taken from the shadow of the Earth, when the face of the Moon, in the time of a lunar Eclipse. For as the Moon has no light but what it receives from the Sun, and the Earth being, at this time, interposed between them, the Moon must either wholly, or in part, become obscure. And since in every Eclipse of this kind, which is not total, the dark part always appears to be bounded by a circular line, the Earth itself, for that reason, must be spherical; because it is evident, that none but a spherical body can, in all situations, cast a circular shadow. Nor are the little unevenesses on the Earth's surface, arising from Hills and Valleys, any material objection to its being considered as a round body; since the highest Mountains we are acquainted with, bear a less proportion to the whole bulk of the Earth, than the small risings on the Coat of an Orange bear to that fruit; or a grain of Sand, to an artificial globe of a foot in diameter. And accordingly we find, that these trifling protuberances occasion no irregularities in the shadow of the Earth, during the time of a lunar Eclipse; but that the circumference of it always appears to be even and regular, as if cast by a body perfectly globular."

"A number of other proofs might be given to the same [**8**|**9**] [cont.] purpose, but these are the most popular, and such as I apprehend must entirely convince every impartial enquirer, whose object is truth; It will not be amiss in this place to offer a summary description "of the different opinions of Philosophers, concerning the situation of the heavenly Bodies, or the place which they possess in the universe; and we collect from several testimonies, that the true doctrine of the planetary motions was known in the world from the most early ages, and taught by some of the greatest and wisest men of antiquity. That admirable Philosopher Pythagoras, who flourished near five hundred years before the Christian Era, was undoubtedly acquainted with this doctrine. We accordingly find that many of his followers had just notions of the planetary system; and not only taught that the Earth moved daily on its own axis, and revolved annually round the Sun, but gave such an account of the Comets as is agreeable to modern discoveries. They also taught that every Star was a world, having each of them something corresponding to our Earth, such as air and water; and that the Moon, in particular, was inhabited by larger and more beautiful Animals than those of our [**9**|**10**] **f. 450**

[cont.] Globe. **[b]**

At this period however, great as might be the merit of Theory, little could be ascribed to Discovery; the telescope, which has since opened so vast and splendid a field of observation in the Heavens, was then unknown – any attempt therefore at arrangement respecting a System impervious to the unassisted Eye must have been necessarily involved in error in many essential points – Be this as it may, the real merit of the first suggestion of the now proved and acknowledged system can be fairly traced no farther backward than to Pythagoras, who therefore must be considered as the first promulgator if not the discoverer of the true System which is now admitted by every civilized country on the Globe.

"This System, however, was so extremely opposite to the prejudices of sense and opinion, that it never made any great progress in the ancient world. The Philosophers of antiquity (despairing of being able to overcome ignorance by reason.) set themselves to adapt the one to the other, and to form a reconciliation between them.

The most celebrated of those who undertook to establish an hypothesis of this kind, and to defend it [**10**|**11**]

f. 451 [cont.] with a show of reason and argument, was Ptolemy, an Egyptian Philosopher, who lived in the time of the Emperor Adrian [vii], about an hundred and thirty year after the Christian Era." and in order that we may the better explain the gradual advances of this Science, we will here with your permission present to you a representation of his system called the Ptolemaic.

Scene Ptolemaic System

"He supposed with the vulgar, who measure every thing by their own conceptions, that the Earth was fixed immoveably in the centre of the universe; and that the Moon, Mercury, Venus, the Sun, Mars, Jupiter and Saturn, revolve round it in the order they are here pointed out. Above those was the firmament of the fixed stars beyond this, he imagined were crystalline orbs, the primum mobile, and last of all, the coelum empyrium, or heaven of heavens. All these vast orbs he imagined to move round the Earth once in twenty-four hours, and also in certain stated or periodical times, agreeable to their annual changes and appearances. Every Star he supposed to be fixed in a solid transparent sphere, like crystal; and to account for their different motions, he was obliged to conceive a number of circles called [**11**|**12**]

[b] [cont.] eccentrics and epicycles, which crossed and intersected each other in various directions. And if any new motion was discovered, a new heaven of crystal was formed to account for it. So that, as Fontenelle [viii] observes, heavens of crystal cost him nothing, and he multiplied them without end, to answer every purpose.

This absurd system is referred to by Milton, in the 8th book of his Paradise Lost, where, speaking of the dreams of visionary Philosophers, concerning the nature and motion of the heavenly bodies, he says,

__________________ "Or if they list to try
Conjecture, he his fabric of the Heavens
Has left to their disputes, perhaps to move
His laughter at their quaint opinions wide
Hereafter, when they come to model heaven
And calculate the Stars, how they will wield
The mighty frame, how build, unbuild, contrive
To save appearances, how gird the sphere
With centrie and eccentrie scribbled o'er,
Cycle and epicycle, orb in orb" [ix]

But independently of those considerations, this rude system was soon found incapable of standing the test of observation and experiment; and, notwithstanding the opposition of blind and zealous bigots, it has long [**12**|**13**]

[cont.] been rejected by all mathematicians and true Philosophers. **f. 452**
The planets, Mercury and Venus, are now well known not to include the Earth in their orbits; and the Comets move through the Heavens in all manner of directions, so that they must infallibly have met with continual obstructions, and would, long ere this, have broken all those crystal spheres to pieces, and rendered them totally unlit for the purposes for which they were designed.

The contradictions and perplexities attending the Ptolemaic hypothesis, were indeed so numerous and evident, that it was impossible they should ever be reconciled upon that supposition. But notwithstanding this, mankind were not easily induced to give up their darling prejudices, and embrace the truth, however beautiful the form in which she presented herself to them. Many early habits must be corrected, and vulgar prepossessions eradicated from the mind, before we can be brought to reckon the Earth as a planet, and to consider this prodigious Globe, which, of all things in nature, appears to be the most fixed and stable, to be carried round the Heavens with the rapidity of fifty eight thousand miles an hour.

To humour these prejudices, by keeping the [**13**|**14**]

[b] [cont.] Earth still fixed in the centre, but at the same time to remove some of the most palpable absurdities attending that doctrine, was the design of Tycho Brahe, who attempted to establish a new system, and to account for the celestial motions by a more plausible hypothesis. This noble Dane, who flourished in the latter end-of the sixteenth century, had furnished himself with an excellent collection of mathematical instruments, and by that means, had made himself too well acquainted with the motions of the heavenly bodies, to imagine their centre to be any where else than in the Sun. He was struck with the Beauty, simplicity and harmony of the Pythagorean system, which Copernicus had lately revived; but out of respect for some passages of scripture, which <u>seemed</u> to contradict this doctrine, he set himself about to reconcile his learning with his faith; and in his system (which I now show you)

<u>Scene – Tychonic System</u>

You will perceive, in order that the Earth might remain quiescent, he supposed the Sun, with all the Planets, to be carried about it it [*sic*] in the space of a Year; whilst these, by their proper motions, revolved round the Sun in their several periods. "In this new system of Tycho's, there is some ingenuity, though but little conformity [**14**|**15***]

f. 453 [cont.] to truth and observation[.] For having rejected the diurnal rotation of the Earth on its axis, he was obliged to retain the most absurd part of the Ptolemaic hypothesis, by supposing that the whole universe, to its farthest visible limits, was carried by the primum mobile about the axis of the Earth continuably every day. But in this, however, he was abandoned by some of his followers, who chose rather to save this immense labour to the spheres, by ascribing a diurnal motion to the Earth; on which account they were distinguished by the name of Semi-Tychonics.

It was about the middle of the sixteenth century that Copernicus, a bold and original genius, adopted the Pythagorean, or true system of the universe, and published it to the world with new and demonstrative arguments in its favour seized with a darling enthusiasm, he laid his hands on the cycles and crystal orbs of Ptolemy, and dashed them to pieces. And, with the same noble phrensy, he took the unwieldy earth and sent her far from the centre of the systems both of Ptolemy & Tycho Brahe to move round the Sun with the rest of the Planets; so that of all the celestial equipage, with which she had been formerly dignified, there only remained [**15**|**16**]

[cont.] the Moon to attend and accompany her on her Journey. We remove this ideal system – to prepare for the introduction of the genuine one of Copernicus[.] **[b]**

Scene
Copernican – System

You will here see the Sun in the Centre, and the Planets revolving round him in their proper orbits, but without their satilytes; for it was torwards the end of the same century, and about the beginning of the next that those great men Galileo and Kepler particularly distinguished themselves in the defence of this doctrine; and by means of the Telescope, which was the invention of that time, made many new and surprising discoveries in the heavens. By applying this Instrument to the planets, Galileo first observed, that the phases of the Moon; and thence inferred that she revolved round the Sun as a centre. He also proved the revolution of the

Sun on its axis, from the motion of his Spots; and by that means rendered the diurnal rotation of the earth more credible. The four satellites which attend Jupiter, in his revolution about the Sun, represented, likewise, in miniature, a just [**16**|**17**]

f. 454 [cont.] image of the great solar system, and rendered it more easy to conceive how the Moon might attend the Earth, as a satellite, in <u>her</u> <u>annual</u> revolution. In short, by his discovering hills and cavities in the Moon, and spots in the Sun, he proved, clearly, that there was not so great a difference between celestial and sublunary bodies as Philosophers had vainly imagined.

From these discoveries, Astronomy began to assume a new form, and most of the celestial phænomena were soon accounted for, according to their real or physical causes. Des Cartes [*sic*], Gassendus [x], Cassini, and Newton, employed themselves, with the utmost diligence, in improving and perfecting this science: and the last of these great men, in particular, has established the Copernican System upon such an everlasting basis of mathematical demonstration, as can never be shaken, but must last as long as the present frame of nature continues in existence.

<u>Scene</u>
<u>Copernican or Newtonian System</u>

And now, before I proceed to describe this part of the universe which Astronomers have called the "Visible World", or Solar System – it will be proper [**17**|**18**]

[b] [cont.] to state that by the universe we are to understand the whole frame of nature, as extended throughout infinite space. And, by the Solar System, is meant that <u>portion</u> of the universe only, which comprehends our Sun, planets, Satellites and Comets. Of which system, though contrary to what was formerly supposed, by these ancient as well as by many modern Astronomers, the Sun is now well known to be placed in the centre and to have eleven primary planets moving round him, each in its own path or orbit."

"The names of these planets, according to their distance from the centre or middle point of the Sun, are Mercury, Venus, the Earth, Mars, Vesta, Juno, Pallas, Ceres, Jupiter, Saturn, and Uranus, or the Georgium Sidus; the latter of which was discovered in the year 1781, and Vesta, Juno, Pallas, and Ceres, since the commencement of the present century [xi]; among which it is to be observed, that the two first, Mercury and Venus, having their orbits within that of the Earth." or, in other words, revolving in smaller circles round the Sun "are called inferior planets, and the others, which revolve beyond it, are called superior planets.

Now if we can form a notion of the manner [**18**|**19**]

f. 455

[cont.] in which our Earth moves, we shall easily conceive the motions of all the rest of the planets, and by that means obtain a complete idea of the order and œconomy [*sic*] of the whole system. For which purpose, nothing more is necessary than to consider the common appearances of the Heavens, which are constantly presented to our view, and attend to the consequences that follow from such observations. For since it well known that the Sun and Stars appear to move daily from East to West, and to return nearly to the same places in the Heavens again in twenty four hours, it follows that they must really move, as they appear to do, or else that we ourselves must be moved, and attribute our motion to them; it being a self evident principle, that, if two things change their situation with respect to each other, one of them, at least must be moved. But if this change be owing to the revolution of the Stars, we must suppose them to be endowed with a motion so amazingly rapid, as to exceed all conception. Since it is known, by calculations founded on the surest observations, that their distances from us are so immense, and the orbits in which they revolve so prodigiously great, that the nearest of them would move at least [**19**|**20**] a hundred thousand Miles in a minute. Now as nature never does that in a complicated and laborious manner which may be done in a more simple and easy one, it is certainly more agreeable to reason, as well as to the power and wisdom of the Creator, that these effects should be produced, by the motion of the Earth; especially as such a motion will best account for all the celestial appearances, and, at the same time, preserve that beautiful simplicity and harmony, which is found to prevail in every other part of the creation.

This argument will also appear still more forcible, if we compare the vast bulk of the celestial bodies with the bulk of our Earth. For it is well known to Astronomers, that the Sun in bulk is above a million of times bigger than the Earth; and consequently, judging from analogy, it follows that many of the Stars are at least of an equal magnitude. It is much more probable, therefore, that the Earth revolves round its axis, with an easy natural rotation, once in twenty-four hours, than that those vast bodies should be carried from one place to another, with such incredible velocities. [**20**|**21**]

f. 456 The absurdity of supposing the Earth a sedentary and immoveable body is sufficiently exposed in the sublime speech of Adam to the Angel Raphael when he is inquiring the nature of the celestial motions:

How nature, wise and frugal, could commit
When I behold this goodly frame; this World
Of heav'n and earth consisting, and compute
Their magnitudes; this earth, a spot, a grain
An atom, with the firmament compar'd
And all her number'd stars, that seem to roll
Spaces incomprehensible (for such
Their distance argues, and their swift return
Diurnal) merely to officiate light
Round this ~~spacious~~ earth, this punctual spot
One day and night; in all their vast survey

Useless besides; reasoning I oft admire
How nature, wise and frugal, could commit
such disproportions. – [xii]

Nor is it any objection to this rotation of the Earth, that we are unable to perceive it. For as the motion of a Ship at Sea, when the sails swiftly over the smooth surface of the water, is almost, if not wholly imperceptible to the passengers and company on abroad; much more so must it be with such a large body as the Earth, that has no impediments or obstacles of any kind [**21**|**22**]

[cont.] in its way, to disturb its motion. A Balloon, turning upon its axis, as it floats through the atmosphere, affords an apposite representation of the Earth, in its annual progress round the Sun: **[b]**

"That spinning steeps,
On her soft axle, as she paces even,
And bears us swift with the smooth air along." [xiii]

This motion of the Earth round its axis, which, from the instances already given, has been rendered sufficiently evident, is called its diurnal, or daily motion; and is that which occasions the regular return of day and night, and all the celestial appearances before mentioned. But there is also <u>another</u> motion of the Earth, called its <u>annual</u>, or <u>yearly</u> motion, which occasions the various vicissitudes of the <u>Seasons</u>, Summer, Winter,
Spring, and Autumn."

But as a particular description of this Scene will be necessary, and least we should extend this part of the Lecture to a length which might exhaust your attention, I shall, with your permission reserve till towards the close of the Evening, the <u>minute</u> detail of the particulars; which will be given on the extensive apparatus prepared for that purpose.
Enough, in this place to observe; that all other [**22**|**23**]

[cont.] systems have been wholly exploded by the clear and de- **f. 457** monstrative discoveries of our immortal Countryman Sir Isaac Newton; who has shewn that though ingenious Argument might suppose the course of nature to be governed by mere mechanical laws only, the works of nature would then have been incomparably inferior to what they now are both in beauty and perfection, and consequently far less worthy of its ineffable Contriver,

"Whose mighty hand,
For ever busy, wheels the silent spheres;
Works in the secret deep; shoots, streaming thence,
The fair profusion that o'erspreads the spring;
Flings from the Sun direct the flaming day;
Feeds every creature; hurls the tempest forth:
And, as on Earth this grateful change revolves
With transport touches all the springs of Life. [xiv]

End of Part First

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Ouranologia

Part Second

Part Second f. 459

Telescopic Appearances of the Planets

Having given a general idea of the figure and motion of the Earth, before we proceed to a more minute explanation it may not be amiss to turn our attention in a similar detached manner to the rest of the planets, and I shall accordingly take them in the order in which they revolve round the Sun.

The comparative distances and periods of revolution will be reserved for the grand Scene I have before alluded to but a particular notice of each may be properly taken in this place. It is to be observed, that the Planets are all opake spherical bodies, like our Earth, that have no proper light of their own, but shine by means of the borrowed light which they receive from the Sun – and therefore only that side of them which is turned towards him, can receive the benefit of his light, whilst the opposite side, which the borrowed rays cannot reach, remains in obscurity; till, by the rotation of the planet on its axis, that part is also turned towards the [**1**|**2**]

[cont.] Sun; and thus, the alternations of day and night, are produced on the surface of those Worlds, as they are on ours. But before I speak of the planets, it will be proper to offer a few remarks on the phænomena and affections of that immense Globe, from which they all derive the blessings of light and heat; that glorious Sun; upon whose influence, the very existence of the Worlds that revolve around him may be said to depend. – And although to attempt a representation of this brilliant and stupendous Mass, must **[b]** be inevitably attended with <u>failure</u> – it <u>may</u> be well (for the purpose of illustration) to offer <u>something</u> <u>like</u> a view of his telescopic appearance to the <u>Eye</u> of the <u>spectators</u>. We shall do this particularly with a view to show the comparative magnitudes of the Sun and Earth, from whence a more clear notion will be obtained of the enormous bulk of this Magnificent Star.

<u>Scene – Sun and Earth.</u>

We will suppose then that this resembles the Sun – a great stretch of complasance [*sic*] I confess is necessary on this occasion – but in point of fact such as are here represented, are the appearances of Spots [**2**|**3**]

f. 460 [cont.] which are noticed on his surface, when viewed through a powerful Telescope, assisted by a smoked Glass; without which his intense brightness would defy inspection. In this part you will perhaps be able to discover a small speck, which is placed there in order to represent the comparative size of the Globe we inhabit – and this is really correct, for if you will suppose an artificial Sun – nine feet in diameter, the Earth will be pretty accurately represented as a Globe of only one inch –

The Sun was generally considered by the Antients as a Globe of pure fire, but from a ~~nunl~~ number of dark spots, which, by means of a Telescope may be seen on different parts of his surface, it appears that this opinion was ill founded. These spots consist, in general, of a nucleus, or central part, much darker than the rest, and seems to be surrounded by a mist or smoke.

About the time that they were first discovered by Galileo, forty or fifty of them might be frequently seen on the Sun at a time, but at present we can [**3**|**4**]

[b] [cont.] seldom observe more than thirty; and there have been periods of seven or eight years, in which none could be seen.

The general opinion concerning the Solar spots is, that they are occasioned by the smoke and opake matter thrown out by volcanos or burning mountains of immense magnitude; and that when the eruption is nearly ended, and the smoke dissipated, the fierce flames are exposed; and appear like faculæ, or luminous spots. the motion of the spots appears to be from East to West, and as they are observed to move quicker, when they are near the central regions than when they are near the limb; it follows that the Sun must be a spherical body; and, that he revolves on his axis, in a contrary direction; or, from West to East. – The time in which he performs this revolution, is twenty five days, and about 6 Hours; and from the line of the motion of the Spots, which is sometimes straight, but oftener crooked or elliptical, it is discovered that his axis is not perpendicular to the plane of the ecliptic, but [**4**|**5**]

[cont.] inclined to it, so as to make an Angle with the perpendicular of about seven degrees and a half[.] **f. 461**

The Sun's apparent magnitude to the different Planets

It will naturally be conceived that owing to the greater proximity of some of the Planets to the Sun, and the distance of others, the appearance and magnitude of that immense body must fluctuate according to those distances. To the inhabitants of Mercury (who is situated so closely in his neighbourhood) he must indeed appear of a most stupendous bulk, and of inconceivable brightness, but as the other planets gradually recede from him, his bulk and brightness will be sensibly diminished. I shall now exhibit this fact by a transparent Scene which represents his comparative magnitudes to all his attendants.

Scene

It is here shewn from actual calculation that to this planet which represents Mercury the Sun will appear of this enormous bulk. To Venus of these dimensions. To the Earth as here shewn. To [**5**|**6**]

[b] [cont.] Mars of this Diameter – To Jupiter of this – To Saturn of this diminished size, and to the Georgium Sidus he will seem only a very large and brilliant Star.

What provision the bountiful hand of nature may have made for the light and warmth of these remote planets is beyond human reason to conjecture; but from the contrivance which we discover in <u>all</u> that is <u>within</u> the reach of our senses for the happiness of his creatures; no rational doubt can exist that the Deity has afforded to the whole of his creation an equal distribution of the blessings we enjoy.

Of the Planet Mercury, which is the nearest to the Sun, we can say but little – His proximity to that luminous body renders <u>observation</u> upon him extremely difficult and rare – but we shall introduce to your notice the next Planet, Venus, whose greater distance from the source of light has enabled Astronomers to make accurate observations on her nature and Appearances –

<u>Scene – Phases of Venus</u> [**6**|**7**]

f. 462 This transparency represents the Phases of this planet as well as her appearance at full; and it will be observed that she bears a striking resemblance in her changes to our Moon – It is certain that wherever the Sun may be placed, the orbit of Venus surrounds and encloses him within herself, and therefore Venus, while she describes this orbit must really move round the Sun. For this planet is observed to be sometimes above, or beyond the Sun; and sometimes below him; or between the Sun and us: and the same argument holds good in regard to Mercury. This is clearly ascertained by the appearances of these phases which are proofs that she [word correction] encircles the Sun in an orbit <u>smaller</u> than that of our Earth, or these phænomena would <u>never</u> <u>appear</u> to us any more than they do in the <u>superior</u> <u>planets</u>, which describe larger orbits round the Sun than the Globe we inhabit. – Venus also is found to be diversified with spots.

Mountains and Valleys have been discovered in this planet, by means of good instruments; [**7**|**8**]

[cont.] and from the <u>motion</u> of her spots it is determined, that she revolves round her axis from West to East in the space of about twenty-three hours. **[b]**

As our Earth is the next in distance from the Solar regions – we now naturally proceed to a consideration of its placid & useful attendant the Moon –

Of all the discoveries which have been made by means of the Telescope, those relating to the Moon are the most curious & interesting. This planet being much nearer to us than any of the rest, is the first that offers herself to our inspection, and is the best adapted for examination.

<u>Scene – The Moon</u>

By viewing her with the <u>naked</u> <u>eye</u> we discern a number of spots, which the imagination naturally supposes to be Seas, Continents, and the like; and on a more accurate inspection, with a <u>telescope</u>, the hypothesis of planetary worlds receives additional confirmation. Vast cavities and asperities are observed upon various parts of her surface, exactly resembling valleys and Mountains; and every other appearance seems to indicate, that she is [**8**|**9**]

[cont.] a body of the same nature with our Earth. We can scarcely hope to make optical instruments sufficiently perfect to render animals visible at such a distance; but Herschel, sometime ago discovered a manifest volcano in the Moon; and if improvements are pursued, we may, perhaps, receive indubitable proofs of her being an inhabited World. **f. 463**

Galileo, when he first saw this planet through his Telescope, was struck with the singularity of her Appearance; and being free from the prejudices of the Schools, soon discovered a striking similarity between her and the Earth. This is what Milton finely alludes to when he describes the Shield of Satan, in the first book of his Paradise Lost.

______________ "The broad circumference
Hung on his Shoulders like the Moon; whose orb
Through optic glass the Tuscan artist views,
At Evening; from the Top of Fesole;
Or in Valdarno: to descry, <u>new Lands</u>,
<u>Rivers</u> or <u>Mountains</u> in her spotty globe". [xv]

Several Astronomers have given us tolerably exact Maps of the Moon, with figure of every spot, as it appears through the best telescopes, distinguishing each of them by a proper name " – This which we now display is copied from a very accurate and faithful Map, laid down [**9**|**10**]

[b] [cont.] from actual observations by D[r] Kitchener, and executed under his immediate superintendence and direction. [xvi]

"That the spots in the Moon, which are taken for Mountains and Valleys, are in reality such, is evident from their shadows. For in all situations of the Moon, the <u>elevated</u> parts are constantly found to cast a triangular shadow, in a direction <u>opposite</u> to that of the Sun; and, on the contrary, the <u>cavities</u> are always <u>dark</u> on the side <u>next</u> the Sun, and <u>illuminated</u> on the opposite one; which is exactly conformable to what we observe of Hills and Valleys on the Earth.

These appearances of the Moon are explained by Astronomers, as caused by the varieties of her surface. The brightest parts being supposed to be eminences of Mountains, in several places heightened by Volcanos. – The darker spots, shadows of those Mountainous regions, and the broad dark places, Seas and Lakes, which conformably to the known properties of Water, reflect a very small portion of Light. All Bodies reflect, light in the proportion of their Density.

In looking at the Moon through a Telescope, we constantly observe the same face; from which it is evident that she turns only once round upon her axis in the time of every periodical revolution; so that the [**10**|**11**]

[cont.] inhabitants of the Moon have but one day and night in the course of a month. **f. 464**

One of the most remarkable phænomena attending the Moon, is the continual change of figure to which she is subject. Sometimes she appears perfectly full, or circular, at other times only half or a quarter illuminated, changing through a great variety of shapes. And as these changes are always the same at the same elongation from the Sun, they prove that she receives her light from that Luminary: for the Moon being enlightened on that side only which faces the Sun, a greater or less quantity of that enlightened part will be visible, according as it is turned towards us, or from us; and her figure will consequently appear to vary through the whole of her revolution."

By the assistance of a new moving apparatus we shall be enabled to show all the varieties of form which the Moon periodically undergoes from this, her appearance at the full, to her disappearance at the change: presenting with minute accuracy her various forms during her Wane. You will be enabled to observe in this progress – her Gibbous or Oval shape, her form when she is in her last quarter, and only half of her enlighten'd side is visible: and her appearance on her arrival at her last Octant; When her visible enlighten'd part assumes the form of a Crescent. [**11**|**12**]

Commence the movement of the Scene. **[b]**

A part of her Limb becomes obscured, and she begins to shew the Gibbous or Oval form, which is apparent when she reaches her third Octant, where she arrives about 3 days and a half after the full. And we have here displayed her ragged edges which clearly demonstrate the mountainous construction of her surface:

this edge which fringes the dark side of the Moon is uneven, and broken in upon, by luminous points. There are unquestionably occasioned by the mountains which catch the rays of the Sun before he illumines the valleys below. Every one [*sic*] must have observed a similar effect on our own Globe at the rising and setting of the Sun: and this effect continues during all the changes of form which the Moon undergoes. She further decreases as her enlightened part becomes more withdrawn from the Earth: We now perceive only one half of her enlightened side, precisely as she appears when she reaches the last quarter: and this Scene possesses the advantage of shewing every possible gradation of form, to which the Moon is subject with the minutest accuracy; and even more clearly than can be discerned by the most assiduous astronomer, because, some of these varieties occur, both when the Moon is below the horizon, and when she is above it during our day [**12**|**13**]

f. 465 [cont.] light; at each of which periods. no observations can be made. A still greater part of her enlightened side is turned from us, as she approaches her last octant, when she becomes horned as she now appears, and this Crescent form gradually diminishes until we lose the whole of the enlightened part of the Moon and she arrives at the Change. After which, the New Moon goes through precisely the same gradations of form on the increase, which have here been shewn on her decrease, until she again arrives at her full or circular appearance: Which progress we could shew on this apparatus, but as it would only reverse the succession of the same forms which have just been shewn; it might be considered as an unnecessary waste of time: particularly as the nearest Scene will show in a different manner, not only all these varieties of the Moon in her orbit, but also her relative situation to the Earth during her Monthly revolution.

Scene Moon's orbit and Phases.

We will suppose the Sun to be placed so as to enlighten this; the Earth in the centre, the former surrounding it describing the orbit and Phases of the Moon. Then when the Moon is here, in conjunction with the Sun, her dark side being turned towards the [**13**|**14**]

[cont.] Earth, she will disappear as represented in this circle, and is now called the New Moon. When she comes to her first octant at this place, or has gone through one eighth of her orbit, a quarter of her enlightened hemisphere will be turned towards the Earth, and she will then appear horned as in this place. **[b]**

When she appears here, or has gone thro' a quarter of her orbit, she shews us one half of her enlightened hemisphere, and is then said to be a quarter old. At the next point she is in her second octant and by shewing us more of her enlightened hemisphere she appears Gibbous, as here described. – At this place her whole enlightened side is turned towards the Earth, and now she appears round, and is said to be at her full – In her third Octant part of her dark side being turned towards the Earth she again appears gibbous and is on the decrease: – When she arrives to this point we see just one half of her enlightened side, at which time she appears still farther decreased; When she comes to her fourth octant we only see a quarter of her enlightened hemisphere, which occasions her to appear horned; and here again having now completed her course, [**14**|**15**]

[cont.] she again disappears, and becomes a new Moon as before. **f. 466**

Precisely similar appearances must our Earth present to the Lunar inhabitants; with this difference, that the enlighten'd face of our Globe must appear thirteen times larger to them than the Moon does to us. It may not perhaps be consider'd a waste of time to shew the curious appearance our Earth must exhibit.

Scene
Europe – Asia and New Holland.

We have here the great continent of Europe, Asia, and Africa; and new Holland. The Eastern Ocean, and Indian Sea. The Ethiopic Ocean, and branching from the Western or Atlantick ocean, the mediterranian Sea, and hence it may be easily conceived how vast and glorious an object to the inhabitants of the lunar regions a Moon of such dimensions must appear. I now come to a brief description of the Planet Mars, the next beyond our Earth – The face of Mars, unlike that of Venus, is always found to be round and full, as his superior situation required; excepting at the time of the quadratures, [**15**|**16**]

[b] [cont.] when a small part of the unenlightened hemisphere being turned towards us, his disc appears, like the Moon about three days after the full.

Scene – Mars.

This planet is also diversified with spots like the Moon, by which his diurnal revolution is ascertained in the direction from West to East; and from his ruddy and obscure appearance, as well as from other circumstances, it is concluded that his atmosphere is nearly of the same density with that of the Earth. Herschel has observed that two circles surrounding the poles of this planet, are very white and luminous, which he considers as probably owing to great quantities of Snow lying there without melting."

The next objects of attention in our system, are the four newly discovered Planets, Vesta, Juno, Pallas and Ceres but they are by far too small to admit of such accurate observations to be made upon them as is necessary for ascertaining any particular spots, or other phænomena, which might be observed upon their discs. [**16**|**17**]

Scene Jupiter

f. 467

The Telescopic appearance of Jupiter, affords a vast field for the curious enquirer. This Planet is surrounded by several faint stripes called belts or bands, which are parallel to the plane of his orbit, and consequently to each other. They are not regular or constant in their appearance: for sometimes only two are to be seen, and sometimes four or five; When their number is most considerable, one or more <u>dark</u> <u>spots</u> are frequently formed <u>between</u> the belts, which increase till the whole is united into one large dusky band. This planet is also diversified with a number of large Spots, which are the brightest part of his surface; but, like the belts, they are subject to various mutations, both in their figure and periods. It has been conjectured that these belts are Seas, and that the variations observed, both in them and the spots, are occasioned by tides, which are differently affected according to the positions of his Moons. The four Satellites of Jupiter were first observed by Galileo, the 7th of January 1610, soon after the invention of the Telescope, but the belts were not discovered till [**17**|**18**]

[cont.] near twenty years afterwards. **[b]**

The next planet which claims our notice, is Saturn, he is at too great a distance for <u>us</u>, to distinguish (without powerful instruments) those varieties, which <u>have</u> <u>been</u> observed upon his surface, and therefore, it is but lately that the time of his diurnal rotation has been determined.

Scene – Saturn.

It is now ascertained that this diurnal revolution is performed in ten hours, sixteen minutes and nineteen seconds. With a good Telescope, we also discover on the disc of Saturn, the faint appearance of belts, resembling those of Jupiter, and which are probably of a similar nature. The magnificient Ring, which encircles the body of this planet, is inclined to the plane of the ecliptic in an angle of about thirty degrees; in consequence of which its apparent figure is continually varying[.]

This Ring has the appearance of a large flat circle, turned edgewise towards the Body of the planet, <u>without</u> <u>touching</u> it; its distance from Saturn being nearly equal to its breadth, [**18**|**19**]

f. 468 [cont.] which is about thirty thousand Miles. It was first discovered by Huygens, and for a considerable time was supposed to be a single undivided body. The great improvements which have been made in the construction of Telescope enable Astronomers to distinguish two rings very easily. By means of spots that have been observed on the surface of these rings, Sir W^{m} Herschell [*sic*] discovered, that they revolve about an axis, which is perpendicular to their plane, in ten hours, sixteen minutes and nineteen seconds; being the same time in which the planet itself performs his diurnal rotation; Besides this ring, that serves as a sort of perpetual Moon to enlighten the inhabitants of Saturn, he has the advantage of seven Satellites. Two of these Satellites are here described within the ring, in which situation they have been seen – these revolve about <u>him</u> in the same manner as our Moon revolves about the Earth; and thus furnishing his dreary regions with that constant supply of light, which his remote situation, with respect to the Sun, seems to render so peculiarly necessary.

The next, and highest planet in our system, [**19**|**20**]

[b] [cont.] which has yet been discovered, is called Uranus, or the Georgium Sidus – the honor of this discovery belongs to the late Sir William Herschell [*sic*], And if the immense distance of "<u>Saturn</u>" from the Sun, render any observations upon <u>him</u> extremely difficult and uncertain, without the aid of the most powerful instruments; much more will these difficulties be increased with regard to Uranus which revolves at nearly double the distance of Saturn; and therefore, none of those varieties can be discovered on the Disc which are observed in the less remote planets; consequently, nothing can with certainty be known of the duration of its diurnal motion. However, Sir W^{m} Herschell [*sic*] ascertained with his Forty feet Reflector, that it has six Satellites revolving about it, and it is probable, judging from analogy, that it is attended by a still greater number; but which, on account of his immense distance from us, are beyond the reach of telescopic observation.

Comets

The Planets are not the only moving bodies visible in the Heavens. There are others which appear [**20**|**21**]

[cont.] at uncertain intervals and with a very different aspect from the planets. These are very numerous, and no fewer than 450 are supposed to belong to our solar system. They are called Comets. And some Comets have appeared, which were as well designed, and as round as planets: but in general they have a luminous matter diffused around them, or projecting out from them, which to appearance very much resembles the Aurora Borealis. Comets come in a direct line towards the Sun, as if they were going to fall into his body; and after having disappeared for some time in consequence of their proximity to that luminary, they fly off again on the other side as fast as they came, projecting a tail much greater and brighter in their recess from him than when they advanced towards him; but, getting daily at a farther distance from us in the Heavens, they continually lose a part of their splendour, and at last totally disappear. Their apparent Magnitude is very different; sometimes they appear only of the bigness of a fixed Star of the second Magnitude [**21**|**22**] **f. 469**

[cont.] at other times they equal the diameter of Venus, and sometimes even of the Sun or Moon. These bodies will also sometimes lose their splendour suddenly, while their apparent bulk remains unaltered. With respect to their apparent motions, they have all the inequalities of the planets; sometimes seeming to go forwards, **[b]** sometimes backwards, and sometimes to be stationary.

The Comets, viewed through a Telescope, have generally very different appearances from any of the planets. The nucleus, or Body of a Comet, seems much more dim. Sturmius tells us, that observing the extraordinary Comet of 1680 with a telescope, it appeared like a Coal dimly glowing; or a rude mass of matter illuminated with a dusky fumid light, less sensible at the extremes than in the middle; and not at all like a star, which appears with a round disc and a vivid light." [xvii]

This most extraordinary Comet I shall now show you as it was seen by Newton and laid down from actual observation when it was in that part of the Heavens in which the Constellation Lyra is situated, and which is also here represented[.] [**22**|**23**]

f. 470 <u>Scene, Comet of 1680</u>

This Comet was remarkable for its near approach to the Sun; so near, that in its peribelion [*sic*] it was not above a sixth part of the diameter of that luminary from the surface thereof. The tail like that of other Comets, increased in length and brightness as it came nearer and pass'd towards the Sun; and became shorter & fainter as it went farther from <u>him</u> and from the <u>Earth</u>, till that and the Comet were too far off to be any longer visible.

The Comet of 1811 is doubtless in the Recollection of most of my hearers – The representation of it which I shall now produce is a faithful Copy of its appearance in the Constellation Ursa Major.

<u>Scene – Comet 1811</u>

This Comet was first noticed in France in the Arctic Sky in the Month of March. He traversed our system from South to North and was first seen in this Island in August. Early in September it arrived at its perehelion [*sic*] at which period it was about 100 Millions of Miles from the Sun. The <u>tail</u> of this Comet, (soon after it began its retrogradation) [**23**|**24**]

[cont.] was about 30 Millions of Miles in length. It approached within little more than 100 Millions of Miles of the Earth, and totally disappeared in January 1812. **[b]**

As we are upon the subject of Comets, we will with your permission give a representation of the Comet of 1819 as it presented itself to the Telescope in the Constellation Taurus.

<u>Scene – Comet 1819</u>

The progress of this Comet was similar to others, therefore it is exhibited only to gratify those who had not an Opportunity of ascertaining its Telescopic Appearance. And now having shewn the most accurate representations of the Planets and the most interesting objects of the Solar System, we will with all speed present to your view the different <u>revolutions</u> of the Earth and Moon on the extensive Planetarium prepared for that purpose. –

<u>Planetarium</u>

In this apparatus we endeavour to convey an idea of the Sun situated in the centre of the System with the Earth and Moon performing their Annual [**24**|**25**]

[cont.] diurnal and monthly revolutions. **f. 471**

Previous to putting it in motion, it will be proper to offer a few remarks upon each of the objects individually. I will commence with the Sun, which will be represented as revolving on his Axis in twenty five of our days, and about six hours. The Sun's day therefore (if we may use the expression) is of that length – and this fact has been accurately ascertain'd by means of the motion of the spots on his surface. –

The rotation of the Earth on its Axis, is performed in twenty four hours, forming our day and night, according as we are advanced towards the Sun or withdrawn from his rays. The motion in its ~~annual revolution~~ orbit (being the path it describes during its annual revolution round the Sun) is completed in 365 days and 6 hours forming our Year – You will clearly perceive that The Axis of the Earth is not perpendicular, but that it inclines 23 degrees and a half, <u>from</u> a perpendicular to the plane of its orbit, and by that Axis keeping always parallel to itself during the Earth's annual revolution round the [**25**|**26**]

[b] [cont.] Sun, the northern and southern hemispheres alternately receive the benefit of the Sun's light and heat, producing all the phenomena of the Seasons.

This beneficent and curious provision for the existance [*sic*] and comfort of the Earth's inhabitations cannot too powerfully excite our admiration of the wisdom, or our gratitude for the goodness of the Creator. If it were not for this simple contrivance one part of the Globe would revolve constantly in the full blaze of the Sun's rays – while those regions which are situated near the poles would be almost, wholly, destitute of light and heat, and probably incapable of sustaining either Animal or vegetable life. – But this is not the case, for the remotest points to which the avarice or curiousity of Man has penetrated are found to be inhabited; and doubtless that power which "tempers the wind to the shorn Lamb" – has <u>so</u> <u>organized</u> their inhabitants as to afford even in those desolate regions the Capability and means of enjoyment.

This Phenomenon of the Seasons will be evidently demonstrated presently, as the Earth travels over its annual road. [**26**|**27**]

f. 472 I have now described two of the Earth's revolutions, its diurnal and its annual; but it has a third – namely – its monthly revolution with the Moon round a common centre of gravity. All these various motions will be distinctly visible on this apparatus. – And I venture particularly to call your attention to the fact – that both the Earth and Moon, will, during their course round the Sun receive their light (and we may consequently suppose their heat) from the object which is here placed to represent that luminary, at this moment the Sun would appear to the inhabitants of this Earth to be situated in that Constellation or sign of the Zodiac which is called Aries (the Ram) which sign the Sun appears to enter about the 20th March, the commencement of our Spring – it is now therefore the vernal Equinox and when the Earth is thus situated, you will observe that one half of the Globe (divided as it were from pole to pole) is completely enlighten'd by the rays of the Sun – at this period of the Year the length of the days and nights are equal all over the Earth. – it is therefore called the Equinox. – Precisely similar circumstances will occur by [**27**|**28**]

[cont.] and bye, when the Earth has made one half of its annual journey and arrives at the Autumnal Equinox, of which we shall speak at the proper time. **[b]**

We will now commence the revolutions of these bodies and while they are revolving round their centre of attraction the Sun, and during their progress I will explain to those who may not be previously acquainted with the subject, what is meant by the twelve Signs of the Zodiac, which are here represented. –

The ancient Astronomers in order to distinguish the various parts of the Heavens formed certain sets of Stars into Constellations; and in order to impress their localities on the recollection and to communicate a description of them in an easy and intelligible manner, gave to these Constellations the names of certain Animals, Persons, or things, accordingly as the fancy suggested them, and as we occasionally conceive forms in a good Winter Fire.

These constellations so fancied and designated they afterwards divided into three sets – Those of the Northern Hemisphere – Those of the Southern [**28**|**29**]

[cont.] and those of the Zodiac. **f. 473**

The Zodiac of which we are now to speak, is a Zone or girdle of about Eighteen degrees ~~round~~ broad, in the centre of which is the Ecliptic or that path in the Heavens in which the Sun appears to move, and which is so called because eclipses usually take place when the Moon is either crossing or nearly approaching to, this apparent road of the Sun. – In this circle of the Heavens, the Orbits of all the Planets belonging to our system are included; and is so called because the names of the signs are taken from Animals and other living Creatures – Zodiac being a Greek word signifying such a collection.

Through all these various signs of the Zodiac the Sun was observed to appear to move annually. – but in fact the Sun as relates to them is stationary it is the Motion of the Earth which produces this effect; for when the Earth is here – we see the Sun in the Constellation opposite to us – and we say the Sun is in the Constellation, Gemini, the Twins and as the Earth travel still further on, the Sun still appears to shift his place as relates to that Constellation. [**29**|**30**]

[b] [Page number is incorrectly written as page 20 in the original text.]

The constellation in the right side of the Scene is called Aries the Ram, and this is the form which the fancy of the Antients has given to it. the next is Taurus the Bull – Gemini the Twins – Cancer the Crab – Leo the Lion – Virgo the Virgin – Libra the Balance – Scorpio the Scorpion – Sagittarius the Archer – Capricornus the Goat – Aquarius the Waterbearer – and Pisces the Fishes. –

The Earth having pass'd thus far on its journey, has been the Sun appear to move from Aries through the signs of Taurus – and Gemini: and now to the Inhabitants of this Globe he would appear to be gradually entering Cancer the Crab. It is therefore our Summer Solstice: and you will I trust observe, that the Southern parts of the Earth are no longer within the Sun's rays. – The Earth's Axis having kept parallel to the plane of it's orbit, it is now the North pole which is illuminated: and therefore, we, the inhabitants of this Country (which is situated so far to the North of the Equator) enjoy our Summer season, our longest days and shortest

Nights. –

It will next be observed that a great deal of meaning was attached to these different Charaters [*sic*] of [**30**|**31**]

[cont.] the Zodiac – For as the Earth performs its annually Journey round the Heavens, and the Sun appears progressively to enter these signs, they will all be bound in some degree indicative of the Seasons, nearly correspondent [*sic*] with the Twelve Months of our Year. – **f. 474**

Beginning at Aries the Ram – and proceeding round the circle to Virgo the Virgin – These first six are called the Northern Signs – proceeding on from Libra the Balance to Pisces the Fishes – These lower six are called the Southern signs. The first mentioned being our Summer, and the last our Winter signs.

The Ram – The Bull – and the Twins.
were selected as characteristic of Spring –
The Crab – The Lion – and the Virgin.
as emblimatical [*sic*] of Summer.
The Balance – The Scorpion – and the Archer
as descriptive of Autumn – and
The Goat – The Waterbearer – and the Fishes
as illustrative of Winter. –

The Earth <u>has</u> <u>now</u> <u>completed</u> one half of its annual journey – it has pass'd from Libra the Balance, and will shortly enter Aries the Ram – and the Sun has consequently [**31**|**32**]

[cont.] appeared to the Inhabitants of that Globe to travel from Aries through Taurus, Gemini, Cancer, Leo, Virgo, and is now seen by the inhabitants of that Globe it would appear to be entering in Libra the Balance. At this time then it is the Autumnal Equinox, or the 21st Sept^r. – and as the Earth proceeds you will again perceive the days and nights are equal all over the Globe: from Pole to Pole. **[b]**

For the better illustration of this subject. It may be proper in this place to direct your attention to the Mechanism of this Planetarium. You may have noticed that the Sun revolves on his Axis, which is clearly distinguishable from the Spots on his surface – but it may not have been noticed that the number of his revolutions are strictly conformable to truth and nature. He turns on his Axis once, in precisely the same time that the Earth revolves on it's Axis, twenty five times and one quarter – And thus performs in the course of our Year, 14 revolutions and one third. –

This Globe which is here placed to represent the Earth, you will also perceive not only preserves it's parallelism, of which I have already spoken, but actually performs the precise number of revolutions on the axis, which the earth we inhabit performs (namely 365 and [**32**|**33**]

f. 475 [cont.] one quarter) in the course of its annual journey round the Sun.

It will also be seen that it revolves round it's common centre of gravity with the Moon at the same time that all the the [*sic*] other complicated motions are produced, and conformably to the exact periods in which they are performed in Nature. –

The Moon too must claim some part of your attention – she performs twelve revolutions and one third during her journey round the Earth, and with the Earth round the Sun. – the Earth performs 30 revolutions while she completes one.

The Earth is now arrived to that point of it's annual journey when it's inhabitants will see the Sun appearing in Capricorn the Goat – You will perceive that it is now the Southern regions which receive in turn the genial blessings of the Sun's light and warmth – It is therefore our Winter – the rays of the Sun pass obliquely upon us, and that for a very short duration our nights are now the longest, and our days the shortest, and we are arrived at the 21st December. From this time the sun begins to appear ascending: and the inhabitants of our climate again to look forward with Cheerfulness to lengthning [*sic*] days, and the Animating

Scenes [**33**|**34**]

[cont.] of reviving nature and parturient spring. – **[b]**

I have already noticed that the Earth revolves 365 times and one quarter during its annual journey – now, as we reckon only 365 days in our Year, it will be clear that we lose in every year 6 hours – or one quarter of a day: and in order to avoid the confusion which this error formerly created, and which was rectified some years ago by the alteration of the Style, we have now ev'ry fourth Year an extra day added namely the 29th February; which is called the Bissextile or Leap Year. – Thus compensation is made for the loss on the three proceeding years of 6 hours each, and the redeem'd 6 hours on the fourth, make together the 24 hours, or one day; which would otherwise have been missing in our calculation of the Year. –

Thus the Earth has completed its ~~Animal~~ annual journey round the Sun, and I trust we have shewn satisfactorily, the obvious causes of the succession of the Seasons, the alternations of day and night, and their respective duration during the different periods of the Year.

And these gradations have been established by the bountiful hand of Nature, to heighten our pleasures and our comforts by variety. – The Scene is perpetually [**34**|**35**]

[cont.] changing, but the order of things is immutable and eternal [.] **f. 476**

Look nature through, tis revolution all,
All change, no death: day follows night; & night
The dying day: Stars rise, and set, and rise;
Earth takes th' example: See the summer gay
With her green chaplet, and ambrosial flowr's,
Droops into pallid Autumn; Winter gray
Ho'rid with frost, and turbulent with storm
Blows Autumn and her golden fruits away
Then melts into the Spring; soft Spring with breath

Favonian, from warm chambers of the South
Recals the first: all, to reflourish fades
As in a wheel all sinks to reascend." [xviii]

Our next subject will be to explain some of the Phenomena attendant on the Earth, especially the Solar and Lunar Eclipses, and the Tides – and these with your permission we shall receive for a new Scene at the opening of the next part.

<u>End of Part Second.</u>

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Part Third

Part Third f. 478

I now proceed to a description of the interesting subject of Eclipses.

Of all the phænomena of the Heavens, there are none that engage the attention of Mankind more than Eclipses of the Sun and Moon, and to those who are unacquainted with Astronomical principles, nothing appears more extraordinary than the accuracy with which they can be predicted. To enter into a popular explanation of all the principles of this doctrine would be almost impossible; – I shall therefore only attempt to give a general idea of the subject, and to shew without the embarrassment of calculations, the foundation upon which it depends.

In the first place then, it is to be observed that all opake or dark bodies, when they are exposed to the light of the Sun, cast a shadow behind them in an opposite direction, and as the Earth is a body of this kind, whose shadow extends over a large sphere, and to a great distance, it is plain that the Moon, in passing through this space, must be deprived of her light, or suffer an Eclipse. The Sun being larger than the Earth, the Earth's shadow is conical, and ends in a [**1**|**2**]

[cont.] point. The figure of the Moon's shadow is also that of a Cone; indeed this must be invariably the case when ever [*sic*] the body which emits the light, is larger than the body which receives it – as this simple experiment will sufficiently prove. The central light of this Theatre is so much larger than this small Globe that you will perceive as I withdraw it from this spot the shadow will gradually decrease and at last end in a point – This shadow of the **[b]**

Moon then when it falls upon any part of the Earth, the inhabitants of that part will be involved in darkness, and the Sun will seem to them to be eclipsed as so long as the shadow covers them. But as the Moon is much less than the Earth, and as its shadow can extend over but a small portion of the Earth's surface, there will be <u>total</u> darkness, only in that space where the shadow falls; and in the circumjacent places, the inhabitants will see a greater or less part of the Sun's Disc obscured, according as they are nearer to or farther from the Shadow: so that Eclipses of the Sun are always confined to particular places; but those of the Moon may be observed from every part of the Earth, when she is above the horizon at the time the Eclipse happens.

From what has been said, it is plain that there [**2**|**3**]

f. 479 [cont.] can be no lunar eclipse but at the time of full Moon, or when she is opposite to the Sun; and that an Eclipse of the Sun can never happen but at the time of a new Moon, or when she is in conjunction with that luminary: for it is only at those times that the Earth and Moon are in a straight line with the Sun, or that the shadow of the one can fall upon the other. And since there is a new and full Moon every Month, it may be naturally enough imagined that there should be two Eclipses in a Month, one of the Sun, and the other of the Moon: but this is far from being the case; for there are but few Eclipses in comparison to the number of new and full Moons. If, indeed, the plane of the Moon's orbit were coincident with that of the Earth's, the Moon would then pass through the middle of the Earth's shadow, and be eclipsed at every full: and, in like manner, the Moon's shadow, falling upon some part of the Earth, would occasion an Eclipse of the Sun at every change. But one half of the Moon's orbit being elevated about five degrees and a third above the plane of the Ecliptic, and the other half as much depressed below it, the Moon can never come in the same plane with the Earth, but when she is in the nodes, or one of the two points where the orbits intersect each [**3**|**4**] [cont.] other. And, therefore, as the Moon may make a number of revolutions round the Earth, before a new or full Moon takes place in one of those points, it is plain that there may be no Eclipse, either of the Sun or Moon, in the space of several Months. **[b]**

When the Nodes, or two points of intersection, are in a right line with the centre of the Sun, at the time of a new Moon, the Moon's shadow will fall upon the Earth, and occasions a Solar Eclipse; and if they have the same situation at the time of a full moon, the Earth's shadow will fall upon the Moon, and occasion a Lunar Eclipse. But when the Sun and Moon are more than seventeen degrees from either of the Nodes at the time of conjunction, the Moon is then generally too high or too low in her orbit for any part of her shadow to fall upon the Earth. And when the Sun is more than twelve degrees from either of the Nodes, at the time of opposition, the moon is commonly too high or too low in her orbit to go through any part of the Earth's shadow; so that in both these cases there will be no Eclipse.

It will now be necessary to give you some account of the different kind of Eclipses, and the causes which produce them. And here nothing more is requisite to be observed, than that every variety of [**4**|**5**]

[cont.] this kind that can take place, (either with respect to the Sun or Moon) is owing to the elliptical figure of their orbits, and the position they are in at the time the Eclipse happens. **f. 480**

When the Moon changes at her least distance from the Earth, and is within the proper limits of the Node, she will appear large enough to cover the whole Solar Disc; and those inhabitants of the Earth where her shadow falls, will have the Sun entirely hid from their sight. – But when the Moon changes at her greatest distance from the Earth, and is near enough to the Node, her diameter will subtend a less angle than the Sun's, and, on that account, her dark shadow must terminate in a point before it reaches the Earth, and to the inhabitants of that part of our Earth over which the dark shadow hangs, the Sun's edge will appear like a luminous Ring, all round the body of the Moon.

For the better illustration of the subject, we have prepared a moving optical apparatus – and four descriptive Scenes will now be shewn in succession. The first will describe the progress of a Total Solar Eclipse: – the second will represent an annular Eclipse. and, the third will shew the progress of a partial Solar Eclipse. The Fourth will be spoken of previous to its appearance. [**5**|**6**]

[b] This is to represent the Disc of the Sun previous to the commencement of the obscuration; which will now proceed, and produce (I trust) an accurate idea of the progress of that rare and interesting Spectacle[.]

Total Eclipse

It is worthy of particular remark, that as the Moon's apparent diameter when largest, exceeds the Sun's when least, by only about a minute and a half of a degree, the total darkness, in the greatest Eclipse of the Sun that can happen at any time and place, will continue no longer than whilst the Moon goes through a Minute and a half of her orbit from the Sun; which she describes in a little more than three minutes of time. But when the change happens within seventeen degrees of the Node, and the Moon is at her mean distance from the Earth, the point of her shadow will just reach the Earth, and the darkness, on the small spot where it falls, can be only of a moment's continuance. A total Eclipse of the Sun is a very curious Spectacle. Clavius who observed the one which happended on the 21st of August 1560 at Coimbra in Portugal [xix], observes, that the obscurity was greater, or at least more striking and sensible than that of the Night. It was so dark for some time, that he could scarcely see his hand; [**6**|**7**]

f. 481 [cont.] some of the largest Stars made their appearance for about a minute or two, and the Birds were so terrified that they fell to the ground. These Eclipses however happen but seldom at any particular place.

Annular Eclipses are much less common. The last remarkable one of this kind being that of the 1st April 1764 which was seen at Rennes, Calais, and Pello in Lapland.

Scene – Annular Eclipse

This is an exact portrait of an Annular Eclipse. Which curious and beautiful appearance is thus produced. When the Moon changes at her greatest distance from the Earth, and is still near enough to the Node, her diameter will subtend a less angle than the Sun's, and on that account, her dark shadow must terminate in a point before it reaches the Earth; and at that place over which it hangs, the Sun's edge will appear like this luminous ring all round the body of the Moon.

We now proceed to the third Scene the progress of a partial Eclipse of the Sun – and the one selected will represent the Eclipse which happened in [The folio is damaged here. It seems no words are lost] September 1820 which doubtless most of my Auditors beheld. [**7**|**8**]

Scene, Partial Solar Eclipse **[b]**

We are again to consider this the Disc of the Sun, and the obscuration commences. Astronomers, in order to calculate accurately the extent of Eclipses; divide the Sun's Disc into twelve equal parts or digits – in the Eclipse here shewn ten of those digits were obscured; – the greatest obscuration being on at this moment – after which, the Moon passed from before the face of the Sun and the Eclipse terminated as here represented.

Besides the dark shadow of the Moon already mentioned, there is another fainter one, called the Penumbra, which always accompanies a Solar Eclipse, and takes place upon those parts of the

Earth which are only partially deprived of the Sun's rays. This fact will be next represented as well as the penumbral Shadow of the Earth upon the face of the Moon during the progress of a Lunar Eclipse – indeed, you will I hope perceive by the ingenious mechanism which gives motion to the next Scene, all the circumstances and varieties which attend both Solar and Lunar Eclipses.

<u>Scene</u>

We here represent the Sun, Earth and Moon, and in the first place allow me to call your attention to the contrivance by which [**8**|**9**]

f. 482 [cont.] the Moon as she travels in her orbit round our Globe has her enlighten'd side turned constantly towards the Sun, as she actually appears in nature. The Moon is now approaching to the change when she will become a new Moon. The Nodes or two points of intersection will then be in a right line with the centre of the Sun, and a Solar Eclipse will consequently take place. You now, I hope, perceive the penumbra or faint shadow passing along this spot. The dark shadow now passes also, and to the inhabitants of this part of the Globe the Sun now suffers a total Eclipse: which to those situated within the circle of the penumbra a partial Eclipse only take place. The entire shadow has passed over the Earth and the Solar Eclipse is at an end.

Having shewn the appearances of Solar Eclipses upon the Earth, I shall now illustrate a lunar Eclipse. You will presently perceive that the Earth's dark shadow is also encompassed by a penumbra in the same manner as the Moon's, which is faint towards the edges, and more obscure towards the centre, and this is the reason why it is so difficult to observe exactly either the beginning or end of a lunar Eclipse [**9**|**10**]

[b] [cont.] even with a good Telescope – for the Earth's shadow is so faint and ill-defined about the edges, that when the Moon is either just touching or leaving it, the obscuration of her Limb is scarcely sensible – But both the beginning and end of Solar Eclipses are visible instantaneously for the moment the edge of the Moon's Disc touches the Sun's his roundness seems a little broken on that part; and the moment she leaves it, he appear perfectly round again. The Moon is now falling into the fainter shadow of the Earth, and the Eclipse begins – she now enters into the darker part, or centre of the Conical Shadow, and becomes what is called totally eclipsed – but the Moon when totally eclipsed is seldom invisible, but generally appears of a dusky colour, resembling tarnished Copper, which some have thought to be owing to her own native light; but the true cause of this appearance is the scattered beams of the Sun, which are so <u>bent</u> into the Earth's shadow, in their passage through the atmosphere, as to afford us a sufficient quantity of light to render the Moon still visible. – She has now passed thro' the dark shadow and again becomes – partially illuminated – She now emerges from the [**10**|**11**]

[cont.] Penumbra, and is again exposed to the full light of the Sun. These are the principal particulars relating to the doctrine of Eclipses which admit of a familiar illustration; and if they be properly considered it will not be difficult to conceive how Astronomers are able to foretel [*sic*] the <u>exact</u> <u>time</u> when any Phænomenon of this kind will <u>happen</u>. For as an Eclipse can only take place at the time of a New or full Moon, it appears, that if the two Luminaries are <u>within</u> the proper limits of the Node – there will be an Eclipse; or otherwise not, agreeably to what has been already observed upon this subject. **f. 483**

<u>Tides</u>

Having taken a general view of total Solar and Lunar Eclipses, we now come to speak of that most interesting subject the nature and cause of the Tides.

The Ocean, it is well known, covers more than one half of the Globe; and this large body of Water is found to be in continual motion, ebbing and flowing alternately, without the least intermission. What connection these motions have with the Moon, we shall see as we proceed; but, at present, it will be sufficient to observe that they always follow a certain general rule. For instance, if the Tide be now at high water mark, [**11**|**12**]

[b] [cont.] in any port or harbour which lies open to the Ocean, it will presently subside, and flow regularly back, for about six hours, when it will be found at low-water mark. After this, it will again gradually advance for six hours, and then return back, in the same time, to its former situation; rising and falling alternately, twice a day, or in the space of about twenty-four hours.

The interval between its flux and reflux, is however, not precisely six hours, but about eleven minutes more; so that the time of high water does not always happen at the same hour, but is about three quarters of an hour later every day, for thirty days, when it again recurs as before.

This exactly answers to the motion of the Moon; she rises every day about three quarters of an hour later than upon the proceeding one; and, by moving in this manner round the Earth, completes her revolution in about thirty days, and then begins to rise again at the same time as before.

It will be proper to observe, that the Earth and Moon mutually attract each other; in consequence of which they would approach towards the same point, if it were not for a contrary force acting in an opposite direction; which being such as [**12**|**13**]

f. 484 [cont.] to cause an equilibrium of the two, their mean distance is preserved. The latter of these is called the centrifugal force, being that by which revolving bodies have a tendency to recode from their centres of motion; as a stone, when whirled round in a sling, has a tendency to fly off, and which requires a greater or less force to counteract it, according to the velocity with which it revolves. And as the Earth and Moon may be considered as revolving about their common centre of gravity, it is obvious, that they will have a mutual tendency to recede from each other, or from their common centre of gravity.

Now this centrifugal force by which the Earth is prevented from approaching towards the Moon, acts equally on all its particles; since each of them, moving with the same velocity, has the same tendency to recede. But the force by which they have a tendency to approach, is not equal in every particle; it being a law of attraction, that the force increases as the squares of the distances decrease. Whence it is obvious, that the surface of the Earth, or Ocean, nearest the Moon, is attracted by a greater force than the centre; and therefore the Waters will have a tendency to rise in those parts [**13**|**14**]

[cont.] immediately under the attracting body." **[b]**
We shall illustrate this by a new optical instrument now for the first time presented to the public which the inventor respectfully hopes will render the subject more distinctly intelligible to those previously unacquainted with it, than any of the usual modes of explaining it[.]

Scene

I will first explain the principles of the motion of the Tides, and then cause this newly invented apparatus to be put in motion, which will I hope clearly illustrate to the sight this interesting subject.

First Figure of Tides.

We here represent the Earth and Moon and for the sake of perspicuity let us suppose the Earth entirely covered by the Ocean – Then the Moon will act upon the surface of the Sea at these points, as well as upon the centre here –

But this point being nearer to the Moon than this point which represents the centre of the Earth the attraction at this place will be greater than at this – and at any other intermediate points, the attractive force will be different, according to their different distances from the Moon. [**14**|**15**]

f. 485 Now as every particle has an equal tendency to recede from the Moon, but an unequal one to approach towards it; and since the attractive force is greatest on the part of the Ocean, which lies immediately under the Moon, the waters will, of course, flow ~~constant~~ constantly to that part, and be elevated or depressed at different places, according as her situation changes with respect to those places. So far then it must appear perfectly clear, that the tides are occasioned by the attractive power of the Moon: – but what is the reason that twelve hours afterwards, when she passes the meredian [*sic*] below the horizon, the waters at the same place, are then also elevated? –

We know from experience, that, whether the Moon be in the zenith or nadir, the phænomenon is nearly the same; it being high water with us at the same time that it is high water with our Antipodes.

This circumstance seemed, at first, so opposite to the nature of attraction, that some philosophers, who did not examine it with proper attention, thought it a sufficient refutation of that doctrine. But the edifice of Newton is built upon a Rock, and is not to be shaken by every idle wind that blows.

We have before seen that the Waters at this [**15**|**16**]

[b] [cont.] point, nearest the Moon, will be elevated, because this point is more strongly attracted by the Moon than the centre here – and because this point is still more remote than the centre, the attractive power of the Moon will be still less at this point than at this – whence, since every particle has an equal tendency to recede from the Moon, but an unequal one to approach towards it, it follows that these parts which are the least attracted with recede the farthest – that is; the waters here will recede the farthest from the Moon, and consequently be equally elevated at this as at this" – so that the attractive force of the Moon will evidently raise the Waters on this side of the Globe, and by her diminished attraction will allow the centrifugal force to act on the waters opposite in an equal degree, which will cause them to fly off from the centre and produce a corresponding Tide in that direction.

"Following this system, then, it is to be observed that at any port or harbor which lies open to the Ocean, the action of the Moon will tend to elevate the Waters there, when she is on the Meridian of that place, whether it be above the horizon or below it. But the water cannot be raised at one place, without [**16**|**17**]

[cont.] flowing from, and being depressed at another; and these elevations and depressions will obviously be the greatest at opposite points of the Earth's surface. When the Moon raises we will say, the waters, here and here – they will be depressed at these points – and when raised by her here and here – they will be depressed where you now see them elevated – And as the Moon passes over the meridian and is in the horizon, twice every day, there will therefore be two tides of floods and two of Ebb in that time, at the interval of about six hours and eleven minutes each; which is exactly conformably to theory and experience. **f. 486**

From what has been hitherto said, it may be supposed that the Moon is the sole Agent concerned in producing the Tides. But it will be necessary to observe, before we quit the subject, that the influence of the Sun would also produce a similar effect; though in a much less degree, than, from his superior magnitude, we should naturally be led to imagine.

The whole attractive force of the Sun is far superior to that of the Moon; but as his distance from the Earth is near four hundred times greater, the forces with which he acts upon different parts of it, will [**17**|**18**]

[cont.] approach much nearer to equality than those of the Moon; and consequently will have a less effect in producing any change of its figure. Newton has calculated the effect of the Sun's influ- **[b]**

ence, in this case; and found that it is about one third of that of the Moon. The action of the Sun alone would, therefore, be sufficient to produce a flux and reflux of the Sea; but the elevations and depressions occasioned by this means, would be about three times less than those produced by the Moon. Properly speaking then there are two Tides, a solar, and a Lunar, which have a joint or opposite effect, according to the situation of the bodies that produce them. When the actions of the Sun and Moon conspire together, as at the time of new and full moon, the flux and reflux becomes more considerable: and these are then called the Spring Tides. But when one tends to elevate the waters, whilst the other depresses them, as at the Moon's first and third quarters, the effect will be exactly the contrary; the flux and reflux, instead of being augmented, as before, will now be diminished; and these are called the Neap Tides.

But as this is a matter of some importance, [**18**|**19**]

f. 487 [cont.] we will now enter into a more minute explanation of it. For which purpose we will call another object to our aid.

Second Figure of Tides.

Which let us call the Sun – this the Earth and this, the Moon – Then because the Sun and the New Moon are nearly in the same right line with the centre of the Earth their actions will conspire together, and raise the waters about the zenith, or the point immediately under them to a greater height than if only one of these forces acted alone. But it has been shown, that when the water is elevated at the zenith, it is also elevated at the opposite point, or Nadir, at the same time, and therefore in this situation of the Sun and Moon the tides will be augmented. –

The Moon will now be seen moving round the Earth and receding from the Sun, and now the causes of the Neap tides will be clearly explained. – You plainly perceive that the waters appear to be following the course of the Moon in obedience to the attraction of that Planet, and you will please to notice that as the Moon retreats farther from a right line with the sun, the forces of the Sun and Moon will tend to produce contrary effects; because the one raises the [**19**|**20**]

[cont.] waters in that part where the other allows them to be de- **[b]**
press'd. – The Sun's attraction on these points will diminish the effect of the Moon's attraction at these – so that the Water's will rise a little at the points under and opposite the Sun, and fall as much at the points under and opposite the Moon; and (of course) the Lunar Tides will be diminished at these times. This respects the Moon in her first quarter; where she is at present situated; – and the same reasoning will evidently hold when she presently appears in her third quarter. –

As the Moon approaches the full and comes to her opposition to the Sun, she raises the waters on one side, and allows them to be raised on the other, and the Sun still acting in a right line, will also raise the waters on his side, and allow them to be raised on the other by his diminished attraction; therefore, in this situation also the Tides will be augmented: their joint efforts and diminished power, being nearly the same at the full as at the change, and in both these cases they occasion unusual elevation of the waters, and these are called Spring tides.

As the Moon approaches her third quarter, the tides will be diminished – for, as the Sun and Moon again act in right angles, they must produce the [**20**|**21**]

[cont.] same diminution as before, and in the cases of the first and **f. 488**
third quarters, they occasion what is called Neap Tides.

These are the principal phænomena of the Tides; and where no local circumstances interfere, the theory and facts will be found to agree. But it must be observed, that what has been here said; relates only to such places as lie open to large oceans. In Seas and Channels, which are more confined, a number of causes concur, which occasion considerable deviations from the general rule.

Thus, it is high water at Plymouth about the sixth hour; at the Isle of Wight about the ninth hour; and at London Bridge about the fifteenth hour, after the Moon has passed the meredian [*sic*]. And at Batsha, in the Kingdom of Tonquin [xx], the Sea ebbs and flows but once a day; the time of high water being at the setting of the Moon, and the time of low water at her rising. There are, also, great variations in the height of the Tides, according to the situation of Coasts, or the nature of the streights [*sic*] which they have to pass thro'. Thus, the Mediterranian and Baltic Seas [**21**|**22**]

[b] [cont.] have very small elevations; which, at the Port of Bristol, the height is sometimes Forty feet; and at St. Malo's [xxi] it is said to be near a hundred.

Having proceeded thus far with the Lecture, allow me to express my respectful acknowledgments for the attention with which you have honour'd what has hitherto been submitted to your observation – and express my hope that the display of the extensive Orrery, which, like the Planetarium, has been prepared with infinite labour and expence; and with, it is hoped, great accuracy of calculation, for the concluding Scene, will receive that approval which it is so much our Ambition to obtain.

The Orrery

As the figure and motion of the Earth are now sufficiently established, it will be proper to turn our attention to the rest of the Planets; and to exhibit a summary view of the whole system.

I have already observed that the Planets are all opake spherical bodies like our Earth, that have no proper light of their own, but shine by means of the borrowed light which they receive from the Sun; and therefore, only that side of them which is [**22**|**23**]

f. 489 [cont.] turned towards him, can receive the benefit of his light. This fact as imitated with great truth and accuracy on the machine I have now the honor to submit to your observation. – All the

Planets have their enlighten'd sides constantly opposite to the source of that light: and it will be particularly worthy your attention, that this beautiful effect is invariably produced on the Earth & Moon, throughout their entire journey round the Sun, as well as during their Monthly journey round their common centre of gravity – which motion you will find to be distinctly visible on this apparatus. –

The Planets are also not only similar to our Earth in form and structure, but they are likewise known to perform their revolutions round the Sun in the same manner; and, this is here represented with mathematical accuracy.

Mercury, the nearest planet to the Sun, goes round him in about 87 days, and 23 hours, or, a less than three Months; which is the length of his year. But being seldom seen, on account of his proximity to the Sun, and no spots appearing on his [**23**|**24**]

[cont.] surface, or disk, the time of his rotation upon his axis, or the length of his days and nights, is not so accurately determined as in most of the other planets[.] His distance from the Sun is computed (speaking in round numbers) to be about 36 Millions of Miles, and his diameter three thousand one hundred and twenty; and in his course round the Sun, he moves at the rate of a hundred and five thousand Miles an hour. **[b]**

This Planet, when viewed, in different positions, with a good Telescope, seems to have all the phases, or appearances of the Moon, except that he can, at no time, be seen entirely round, or quite full; because his enlightened side is never turned directly towards us, except when he is so near the Sun as to be hid in the splendour of his beams. Hence, from these phases, it is evident, that he shines not by any light of his own, as the Sun does, as he would in that case certainly appear, at all times, round like that luminary. – Venus, the next planet above Mercury, is computed to be 68 millions of Miles from the Sun, and by moving at the rate of 76 thousand miles an hour, she completes her [**24**|**25**]

f. 490 [cont.] annual revolution in 224 days and 16 hours, or about seven months and a half. Her diameter is seven thousand, seven hundred miles, and her diurnal rotation on her Axis, is performed in 23 hours, and 21 minutes.

When this planet appear to the West of the Sun, she rises before him in the Morning, and is called the Morning Star; and when she appears to the East of the Sun, she shines in the Evening after he sets, and is then called the evening Star; being in each situation, alternately; for about 290 days. –

The next Planet above Venus in our system is the <u>Earth</u>, with her attendant satellite, <u>The Moon</u>. Their distance from the Sun is 93 millions of miles, and by moving at the rate of 58 thousand miles an hour, the annual revolution is performed in 365 days and 6 hours, or the space of a year; which motion though 120 times swifter than that of a Cannon Ball, is but little more than half the velocity of Mercury in his orbit. The Earth's diameter is about Seven thousand nine hundred miles; and as it turns round it's Axis every 24 hours, from West to East, it occasions the apparent motion of all [**25**|**26**]

[b] [cont.] the heavenly bodies, from East to West in the same time. – The diameter of the Moon is about two thousand miles and her distance from the Earth Two hundred and Forty thousand Miles. –

Next above the Earth's orbit is <u>Mars</u> whose distance from the Sun is computed to be about 142 Millions of Miles. He moves at the rate of fifty five thousand miles an hour, and completes his revolution round the Sun in a little less than 2 of our Years. His diameter is four thousand three hundred and ninety miles; and his diurnal rotation upon his Axis is performed in about 24 hours and 39 minutes.

The next are the four newly discover'd Planets, Vesta, Juno, Pallas and Ceres. – The extreme minuteness of these Planets, as well as the little time since they have been discovered, and their great distance from us; render the results of all observations upon them, in some measure uncertain; we have, however, reason to conclude that none of their diameters exceed four hundred miles, nor are less than one hundred. – But, at present, no accurate estimate can be made of the time of their diurnal rotation. –

Thus far on this Orrery, the relative distances of the Planets from the Sun are correctly [**26**|**27**]

[cont.] represented and the periods of their several revolutions presented with great accuracy: The Sun itself excepted; **f. 491**

We come next to <u>Jupiter</u> – which is placed to the right hand of the Audience the largest of all the Planets, and is reckoned to be about Four hundred and Eighty five millions of miles from the Sun; and by going at the rate of 29 thousand Miles an hour, he completes his annual revolution in something less than twelve of our Years. His diameter is computed to be ninety one thousand five hundred miles; and by a prodigiously rapid motion upon his axis, he performs his diurnal rotation in 9 hours and 55 Minutes.

<u>Saturn</u>, the next planet in the system; which is placed opposite to Jupiter, is about eight hundred and ninety Millions of Miles from the Sun; and by moving at the rate of twenty-two thousand miles an hour, he performs his annual circuit round that liminary in a little less than 29 & 1/2 of our years. His Diameter is computed to be about 76 thousand miles; but, on account of his immense distance, and the deficiency of light occasioned by such a remote situation, the time of his diurnal [**27**|**28**]

[cont.] rotation upon his axis was formerly unknown. It is now however ascertained to be about 10 hours 16 minutes. **[b]**

The next and last planet in our system at present known is Uranus or the Georgium Sidus. which (is here placed at the top of the Orrery) first discovered by the late Sir William Herschel, March 13th 1781. The Elements of this planet have been now accurately determined; from which it appears, that its mean distance from the Sun is about one thousand eight hundred Millions of miles, and its diameter 35 thousand.

Its annual revolution is performed in about 84 Years; but the time of its revolving on its axis has not been discovered by observation; although, from analogy, La'place conceives that it must be performed in about the same time, or rather less, than that of Saturn."

I have already noticed and endeavoured to explain the secondary planets or Satellites with which the primary Planets are attended – These Moons revolve round their respective primaries themselves revolve about the Sun and as it is known that the Sun himself changes his [**28**|**29**]

f. 492 [cont.] place in the universe, together with the countless millions of Suns with which the firmament is spangled – it is hardly to be doubted that all the systems of Worlds we contemplate, & myriads more which neither Eye nor thought can reach, themselves revolve around some other centre.

"Having thus enumerated the Planets and their attendants; the Comets are now the only bodies belonging to our system, which remain to be mentioned; and of these the number is unknown. But from a variety of observations which have been made on some of the most remarkable ones, it has been found that they move round the Sun, and cross the orbits of the Planets in various directions. They are also solid opake bodies, of different magnitudes, like the Planets. The orbits in which these vast bodies move, are exceeding long ovals, or very excentric [*sic*] ellipses, of such amazing circumferences that in some parts of their journey through the Heavens, they approach so near the Sun, as to be almost vitrified by his heat; and then go off again into the regions of infinite space, to such immense distances, as must nearly deprive them of the light and heat which the rest of the Planets receive from that luminary[.] [**29**|**30**]

[b] We have prepared a representation of a Comet, describing its elliptical orbit round the Sun – which will here be shewn

Comet appears.

You perceive the Tail projects in opposition to the Sun, and it will not only retain that position till it reaches and passes the Perehelion [*sic*], but after it has pass'd the Sun, it will be the first to recede. – That is, the Nucleus will always be the nearest to that luminary.

The Mechanism is however so accurate, that, in fact, it will best explain itself, and therefore I merely solicit your attention to its progress.

Comet passes the Sun.

What a magnificent idea of the Creator and his works is here presented to the imagination! The Sun placed in the centre of the system; round whose orb, the Planets, Satellites and Comets, perform their revolutions. with an order & regularity that must fill our minds with the most exalted conception of their divine original! But what must be our astonishment when we are told, that this glorious system, with all its superb furniture is only a small part of the universe; and if it could be wholly annihilated, would be no more miss'd [**30**|**31**]

[cont.] by an eye that could take in the whole Creation, than a grain of sand from the Sea shore! **f. 493**

To form a proper idea of the extent of the universe, and the more glorious works of the Creation, we must turn our attention to the starry firmament; and visit those numerous and splendid orbs which are every where dispersed through the heavens, far beyond the limits of our planetary system.

By contemplating the magnitudes and distances of the fixed Stars, all partial Considerations of high and low, great and small, vanish from the mind; and we are presented with such an unbounded view of nature and the immensity of the works of Creation, as overpowers all our faculties, and makes us ready to exclaim with the Psalmist "Lord, what is Man that thou art mindful of him, or the Son of Man that thou regardest him? – [xxii]

To conclude, in the words of an admired writer on this subject "What an august, what an amazing conception (if human imagination can conceive it) does this give of the works of the Creator! Thousands of thousands of Suns, multiplied without end, and ranged all around us, at immense [**31**|**32***]

[b] [cont.] distances from each other, attended by ten thousand times ten thousand Worlds; yet calm, regular, and harmonious, invariably keeping the paths prescribed them; and these Worlds peopled with myriads of intelligent beings, formed for an endless progression in perfection and felicity. If so much power, goodness and magnificence, be displayed in the <u>material</u> creation, (which is the least considerable part of the universe) how great, wise and good must <u>He</u> be, who made and governs the whole!" [xxiii]

<u>Finis</u>

Annotations

i. Alexander Pope, *An Essay on Man*, Epistle II, 2.

ii. John Milton, *Paradise Lost*, Book 7: 12-14. Arnold frequently quoted Milton's work in the lecture. The main source of Milton's work in my annotations, if not otherwise indicated, refers to Thomas H. Luxon, ed., *The Milton Reading Room*, http://www.dartmouth.edu/~milton, Dartmouth College, accessed July 2015.

iii. Alexander Pope, *The Universal Prayer*, 5.

iv. Psalm 19: 1. Psalms quoted in the lecture are from King James Version.

v. Edward Young, *Night-Thoughts*, Night IX, 773. I refer to the edition edited by George Gilfillan, *Young's Night Thoughts: with Life, Critical Dissertation, and Explanatory Notes* (Edinburgh, 1853). Edward Young (1683-1765) was an English poet and best remembered for *Night-Thoughts*, in which the poet mused on death and immortality. This line was also quoted by James Ferguson in *Astronomy explained upon Sir Isaac Newton's Principles* (1756).

vi. Aside from Magellan, Arnold listed three English naval officers who had accomplished voyages around the world: Francis Drake (1540-1596), the first Englishman and the second in the world carried out circumnavigation; George Anson (1697-1762), who led a mission to disrupt Spanish possessions in the Pacific and returned by way of China between 1740 and 1744; James Cook (1728-1779), who led three voyages of expeditions to the Pacific.

vii. Here meaning the Roman emperor Hadrian, whose reign was from 117 to 138 AD. Ptolemy was born circa 90 AD and died circa 168 AD.

viii. Bernard Le Bovier de Fontenelle (1657-1757) was a French writer, who was an influential figure in educated French society during the Enlightenment. Fontenelle was famed for his accessible writing on scientific subjects. His writing popularised the philosophical work of René Descartes.

ix. Milton, *Paradise Lost*, Book 8: 75-84.

x. Pierre Gassendi (1592-1655) was a French priest, philosopher, astronomer and mathematician. Gassendi was a skilled astronomical observer; he published the first record of the transit of Mercury in 1631. Gassendi clashed with his contemporary René Descartes on many scientific subjects.

xi. These four objects remained to be listed as planets in astronomy books and tables during the first half of the nineteenth century. Modern astronomers categorised Juno, Vesta, and Pallas, into asteroids. Ceres is classified as a dwarf planet, following the new rules adopted by the International Astronomical Union in 2006.

xii. Milton, *Paradise Lost*, Book 8: 15-27.

xiii. Milton, *Paradise Lost*, Book 8: 164-166. Other popular scientific books in the late eighteenth and early nineteenth centuries also quoted this passage when describing Earth's rotation, such as John Bonnycastle's *An Introduction to Astronomy* (1786) and Jeremiah Joyce's *Scientific Dialogues* (1809).

xiv. James Thomson, 'A Hymn on the Seasons', in *The Four Seasons, and Other Poems*, (London, 1735), p. 45.

xv. Milton, *Paradise Lost*, Book 1: 286-291.

xvi. It is unclear who this 'Dr Kitchener' was. A possible contemporary was William Kitchener (1775-1827), a popular writer and an optical-instrument enthusiast. Kitchener possessed a collection of telescopes and wrote books on optical instruments, in which he praised the *Ouranologia* and Bartley's lecturing. However, there is no evidence to indicate Kitchener had engaged in selenography.

xvii. It is unclear who this 'Sturmius' was. This was probably the Latinized name of German astronomer and mathematician Johann Christoph Sturm (1635-1703). This very description of the Comet of 1680, often beginning with "Sturmius tells us, …", appeared in many eighteenth and early-nineteenth centuries astronomy books or encyclopedias, including the *Encyclopaedia Britannica*.

xviii. Young, *Night-Thoughts*, Night VI, 677-688.

xix. Christopher Clavius (1538-1612), a German Jesuit astronomer and mathematician, was then a student in the University of Coimbra in Portugal.

xx. Tonquin, also spelled Tonkin or Tongkin, is the northernmost part of Vietnam.

xxi. Saint-Malo is a walled port city in Brittany, France, on the English Channel. This fortified port had a rich history since the Middle Ages, and became notorious as the home of corsairs and French privateers.

xxii. Psalm 8: 4.

xxiii. James Ferguson, *Astronomy Explained upon Sir Isaac Newton's Principles* (London, 1756), p. 6.

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1 **Joe Cain** *No Ordinary Space: A Brief History of the Grant Museum's New Home at University College London*. 2011.

2 **Simon Schaffer** *Mutability, Mobility and Meteorites: on Some Material Culture of the Sciences*. 2014

3 **Hsiang-Fu Huang** *Ouranologia: an Annotated Edition of a Lenten Lecture on Astronomy with Critical Introduction*. 2015

THE *OURANOLOGIA* is a lecture on astronomy by the playwright Samuel James Arnold. This lecture was delivered by the comedian George Bartley at the English Opera House during Lent between 1820 and 1828. The manuscript of the lecture is preserved at the British Library. This monograph provides an annotated transcript of the lecture with an introduction of its historical context.

HSIANG-FU HUANG works on the history of popular science in eighteenth- and nineteenth-centuries Britain. He was awarded his PhD from the UCL Department of Science and Technology Studies in 2015.

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