The Universe in Images: an Art-Historical Approach to the Plurality of Worlds

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Abstract. The idea of a plurality of worlds, consolidated in the seventeenth and eighteenth centuries, is one of the most inspiring and exciting chapters in the history of astronomy. Nevertheless, one crucial aspect has yet to be written. In this paper I propose to recompose the fascinating visual mosaic around the subject, in order to establish the basis for a largely forgotten iconography. It represents a key period in the evolution of the notions around the large-scale structure of the universe, one of the milestones in Early Modern cosmology. This tradition continued until the nineteenth century, when astronomers such as William Herschel still considered the existence of multiple similar inhabited systems. Today, when extrasolar planets and the cosmic web are in the forefront of the astrophysical vocabulary and its images are so popular, reflecting on the visual genealogy of this field acquires special relevance. This paper invites the reader to look at the sky through a telescope provided with art historical lenses.

1. Worlds

> This infinite number of worlds is called, to distinguish it from the rest, the new system, which is the same as the Copernican, in regard to the situation of the sun and the planets revolving round him. But whereas the Copernican hypotheses supposes the firmament of the fixed stars to be the bounds of the universe, and to be placed at equal distance from its centre the sun; the new system supposeth there may be many other systems of suns and planets, besides this in which we reside; namely, that every fixed star is a sun.[1]

[1] This description of the so-called 'new system' is part of the footnote of an English translation of the novel *Entretiens sur la pluralité des mondes* written by the French author Fontenelle in 1686: Bernard Le Bovier de Fontenelle, *Conversations on the Plurality of Worlds* (Dublin: Peter Wilson, 1761), p. 152. Fontenelle's translator took this paragraph almost literally from William Derham, *Astro-theology: or A demonstration of the being and*

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In 1600 Giordano Bruno was condemned to death for defending the infinitude of the universe. Notwithstanding, in the following generations, the idea of a cosmos composed of many different 'worlds' spread widely across Europe, opening a new era in astronomy. Its scientific and philosophical significance was eventually stronger than the Inquisition, which could not subdue its influence from then on. The basic principle was simple and far-reaching: the Solar System does not entail the entire universe, but is just one component of a much more complex whole. People from the seventeenth century understood that there are many other planetary systems in the existing physical space. It was Descartes especially, through his vortices model, who gave a scientific explanation to the notion of a many-systems universe and who contributed the most to spreading it. Thus, during the seventeenth and eighteenth centuries, the plurality of worlds consolidated its position as one of the leading models in cosmology.

The visual genealogy of the plurality-of-worlds tradition is one of the most intriguing and unexplored fields within the history of astronomy.[2] The German astronomer, the visionary and writer Eberhard C. Kindermann, visualized it in a magnificent way (see Figure 1).[3] His textbook of astronomy included the representation of a three-dimensional model: an armillary sphere of the plurality of worlds. Many branches spread beyond the outer bounds of the 'classical' rings of the sphere, showing central stars, planets, satellites and comets, in which Sirius and the Pole Star ('Polar') are labeled.

Images like this can only be understood when integrating them in a broader context, namely the epistemological, scientific, and visual changes that took place in Early Modern astronomy. Nevertheless, this

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attributes of God, from a survey of the heavens (London: W. Innys, 1715), pp. xl-xli.

[2] See Lucia Ayala, 'Entretiens sur la Pluralité des Mondes' de Fontenelle. Visualizaciones astronómicas de una pluralidad de mundos' (PhD Thesis, Humboldt University of Berlin and University of Granada, 2011); Lucia Ayala, 'El pluriverso en la historia del arte', *Anales de Historia del Arte* (Madrid: Universidad Complutense, 2011), pp. 57-67; Lucia Ayala, 'Worlds and Systems in Early Modern Europe', in Michael J. Way and Deidre Hunter (eds.), *Origins of the Expanding Universe: 1912-1932* (San Francisco: Astronomical Society of the Pacific Conf. Ser., Vol. 471, 2013), pp. 193-204.

[3] Eberhard C. Kindermann, *Vollständige Astronomie oder sonderbare Betrachtungen derer vornehmsten an dem Firmament befindlichen Planeten und Sternen* (Rudolstadt: Deer, 1744).

three-dimensional model of the plurality of worlds is a unique example that stands out among the usual representations.

The following pages present a critical analysis of the main images of this cosmic model for the first time. We will see how Kindermann's copy of Wolf's globe is a rare case in this context, in which two-dimensional diagrams and figurative representations of the universe from book illustrations are the most common visual paradigms.

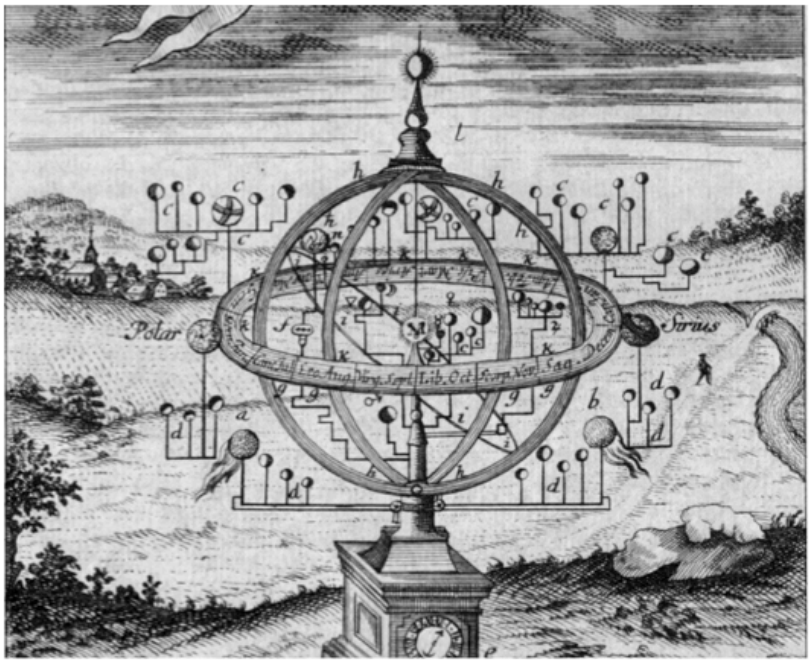

Figure 1. 'Copy of the great original by Wolf', three-dimensional model of the plurality of worlds in Kindermann, *Vollständige Astronomie…*, 1744. Digital Library E-rara.ch

2. Main visual precedents

Many religious images from the Middle Ages and the Renaissance represent the Christian cosmos according to the Bible and Western tradition. In these representations, the sphere of fixed stars is usually depicted as a surface of starry heavens covering the background of the scenes.

From the numerous examples of this context, let us select just three cases to illustrate this kind of iconography. The 'Majestas Domini'

in the *Hitda Codex* from the eleventh century is an early example of this motif.[4] In this scene, Christ, seated on his throne, shows himself as ruler of the creation. The figure is framed by a mandorla comprising a multitude of golden stars, which represents the sphere of fixed stars, i.e. the outermost boundary of the cosmos. The 'Death of the Sun, the Moon and Stars Falling', a scene of the end of the world by Cristoforo de Predis, is a later example from the fifteenth century. It also depicts a field of golden stars, this time not bounded in a closed frame, but falling and spreading throughout the entire surface of the illuminated page.[5] Similar motifs related to the Christian worldview can be found in later periods too. Just to mention one more example taken from book illustrations, in Johannes Zahn's *Specula Physico-Mathematico-Historica* the background in the scene of the creation of the world according to the Book of Genesis is covered by stars.[6] Visually, they are presented in a similar way than the apocalyptical view of the last example: without boundaries, completely spreading over the background.

These theological images do not involve any revolution in astronomy. However, even though religious goals were the main motivation behind them, they also address scientific topics: the macrostructure of the cosmos in the case of the *Hitda Codex*, the end of the Solar System in the de Predis, and the origins of the universe in Zahn's scene. Approached from a very different perspective, these topics are even today a focal point of scientific theories in cosmology. Nevertheless, this time we will not focus on the religious or scientific arguments that explain these images. Instead, we will consider only their visual configuration.

There is a link between these religious scenes and the early manifestations of the universe as a plurality of worlds at a visual level. When people started to realize that every star in the sky might actually be the central body of a planetary or star system and not just a 'background element' of the outer sphere, they started to represent them as these religious images depicted the fixed stars. Whereas the *Hitda Codex*

[4] 'Majesta Domini', in *Hitda Codex*, Ottonian illumination from Cologne (Universitäts- und Landesbibliothek Darmstadt, ca. 1000).

[5] Cristoforo de Predis, 'Morte del Sole, della Luna e caduta delle stelle', in *Storie di San Gioachino, Sant'Anna, di Maria Vergine, di Gesù, del Battista e della fine del mondo*, illumination (Turin: Biblioteca Reale, 1476).

[6] 'Creation of the world', in Johannes Zahn, *Specula Physico-Mathematico-Historica* (Nuremberg: Lochner & Knorz, 1696).

remains in the iconographical tradition of the spheres, de Predis and Zahn, for different conceptual reasons, already made use of the non-bounded field of stars that we will see in the first images of the plurality of worlds.

3. Diagrams

We can group the images on the plurality of worlds into several categories. The first type consists of abstract diagrams and comprises four major tendencies. The first one is related to the openness of the outer cosmic sphere, which was, philosophically and visually, the starting point for the first images of the new cosmological model.[7]

The main early examples of this group are the famous diagrams by Thomas Digges in the sixteenth century, and by William Gilbert one century later.[8] In both cases, the traditional diagrams of concentric circles representing the Solar System were enriched with a surface of stars without borders. Whereas the fixed stars were previously literally *fixed* in visual terms, insofar they were bounded inside a frame as we have seen in the *Hitda Codex,* the seventeenth century finally liberated them. In these diagrams, the outer sphere disappears and the stars expand in all directions, echoing the religious iconography of de Predis and Zahn described above. As a result, the stars are dispersed over the space with the only limit set by the piece of paper on which they were printed. This type of images became a common motif in the visual lexicon at that time. We find it in varied examples, as in the curious 'Labyrinth' by the Spanish theologian and astronomer Juan Caramuel, who adopted the elements of the diagrams by Digges and Gilbert.[9]

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[7] For a philosophical and historical approach to this topic, see Edward Rosen, 'The Dissolution of the Solid Celestial Spheres', *Journal of the History of Ideas*, Vol. 46, no. 1 (1985): pp. 13-31; Miguel A. Granada, *El debate cosmológico en 1588: Bruno, Brahe, Rothmann, Ursus, Röslin* (Naples: Bibliopolis, 1996); Alexandre Koyré, *From the closed world to the infinite universe* (New York: Harper & Brothers, 1958).

[8] Thomas Digges, 'A Perfit Description of the Caelestiall Orbes according to the most aunciente doctrine of the Pythagoreans, latelye revived by Copernicus and by Geometricall Demonstrations approved', in Leonard Digges, *A Prognostication everlasting of right good effecte…*, 3rd edition corrected and augmented (London: Thomas Marsh, 1576); William Gilbert, *De mundo nostro sublunari philosophia nova* (Amsterdam: Ludovicum Elzevirium, 1651).

[9] Juan Caramuel y Lobkowitz, Labyrinth *Coelum lilivel dense*, graphic collection of the Spanish National Library in Madrid.

This typology endured in the eighteenth century. Otto von Guericke, in his famous book about the vacuum, included a representation of the 'systematis mundi' that reproduces this same motif (see Figure 2).[10] The label '*stellæ fixæ'* is multiplied up to four times to identify these elements. The stars are shown as a manifold of entities spread in all directions, instead of being confined to a closed space.

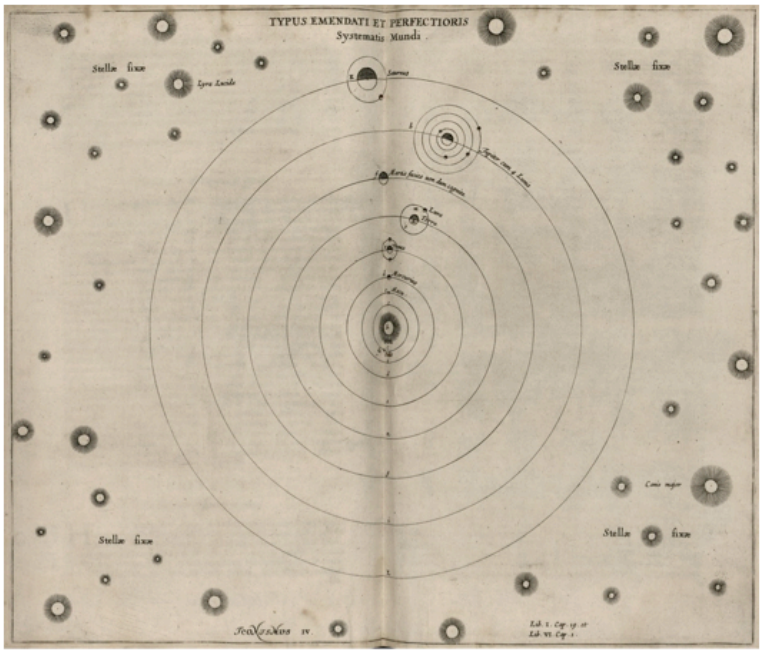

Figure 2. Otto von Guericke, 'The world system', *Experimenta nova…*, 1672. Digital Library E-rara.ch

It is important to note that the 'liberation' of the stars implied principally the idea that each star is actually an independent sun; that is, the stars belong to autonomous structures similar to the Solar System. In this sense, it is not coincidental that von Guericke's engraving shows the Sun and the rest of the stars exactly the same, with light rays streaming from the core, following the common way of depicting our Sun. By means of this visual strategy, the reader understands immediately the nature of the

[10] Otto von Guericke, *Experimenta nova (ut vocantur) Magdeburgica de vacuo spatio* (Amsterdam: Janssonius a Waesberge, 1672).

stars as *suns*, inferring from it the existence of planetary systems external to the Solar System.

Until now I have shown the first image type of the plurality of worlds, characterized by the transformation of the traditional diagrams representing the Aristotelian cosmos as a consequence of the dissolution of the outer sphere. The second visual path we can follow derives from René Descartes' worldview. A remarkable example appeared in *Philosophia Naturalis,* a book by the Dutch philosopher and physician Henricus Regius that included a schematic representation of the system of vortices (see Figure 3).[11] He was one of the authors who defended and spread the Cartesian theories.

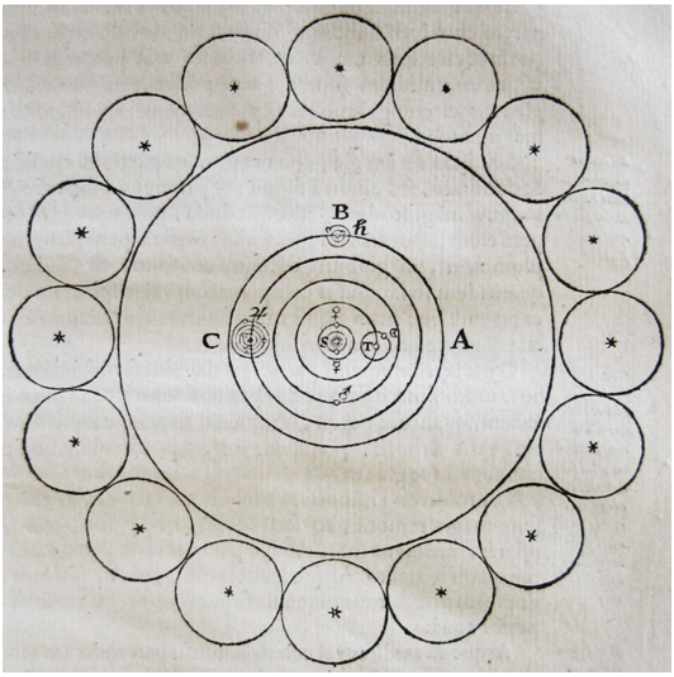

Figure 3. Regius, *Philosophia naturalis*, 1654. Digital Library Gallica

In this case, the image does not emphasize the free dispersion of stars, but rather their function and nature. They are not shown as a plurality of simple items, but clearly as a plurality of complex systems, evidently

[11] Henricius Regius, *Philosophia Naturalis*, 2nd edition (Amsterdam: Ludovicium Elzevirium, 1654).

differing from the Aristotelian and Christian worldviews. Descartes and his later influence contributed to a great extent to create a new cosmological paradigm, which was accompanied by new ways of representing the structure of the universe. The Cartesian theory of vortices, which argued the existence of many planetary systems in constant evolution, was strongly linked to the idea of the plurality of worlds. Their histories were indeed intertwined.

Some decades later, among the numerous figures in one of the plates of Antoine Le Grand's *An Entire Body of Philosophy,* we find a small reproduction of Regius' diagram.[12] In both cases, the vortices are homogeneously attached to the outer circle, regularly distributed beyond the Solar System. This arrangement emulates again the disposition of the ancient cosmos, in which the fixed stars were constrained by a ring representing the outer sphere; conceptually they are radically different models, but visually they offer similar features.

We arrive now to a third step in the development of diagrams, which started in response to the previous one. The English natural theologian William Derham proposed in 1715 an alternative visual model in which the plurality of systems—or worlds, as they were named in this period—spread freely again (see Figure 4), like the stars in the first examples.[13] As in the case of the fixed stars, the representation of the planetary systems evolved from being limited to a ring circling the outer orbit of the Solar System, to a free disposition, spreading themselves in all directions with no boundaries. In Derham's image, the systems placed at the right side even break the line that frames the plate, escaping from the boundaries of the paper to stress their free dispersion over the space.

Another important innovation of Derham concerns the structure of the 'worlds'. Visually, they are presented equal to the Solar System, both in its general structure as in the cases of Jupiter and Saturn, the only planets with satellites: a central star is surrounded by the orbits of several celestial bodies. The analogy between our system and the others is therefore strongly reinforced from a visual perspective. We do not need to read the text; upon observing this diagram one immediately

[12] Antoine Le Grand, *An Entire body of philosophy, according to the principles of the famous Renate Des Cartes* (London: Richard Blome, 1694). Original in Latin: *Institutio Philosophiae secundum Principia D. Renati DesCartes, Nova Methodo adornata et explicata* (London, 1672).

[13] Derham, *Astro-theology*.

understands this crucial idea: our Solar System is of a similar nature to many others, which spread beyond our boundaries.

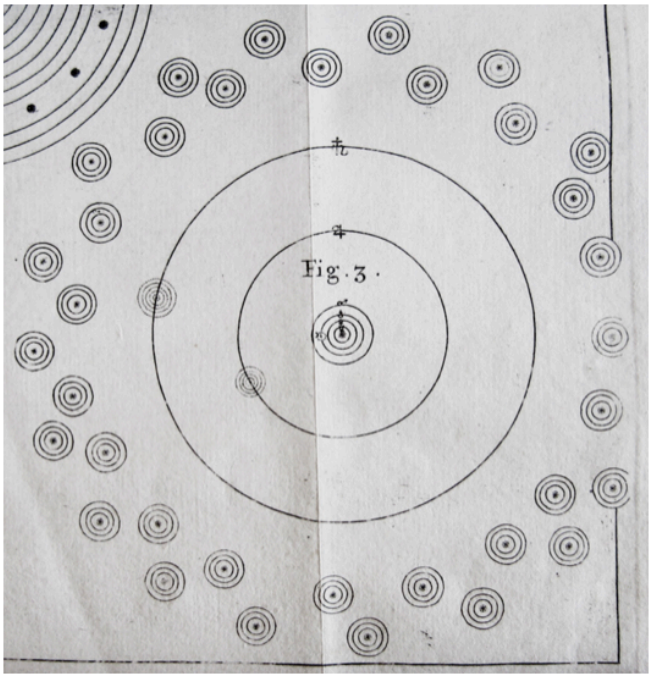

Figure 4. The plurality of systems in Derham's *Astro-theology*, 1715. Eighteenth Century Collections Online / ECCO

The last class of diagrams is actually a hybrid between Regius and Derham, and appeared in an English translation of the *Conversations on the Plurality of Worlds* by Fontenelle.[14] This cosmos comprises a ring of elements regularly ordered beyond the orbit of Saturn (the furthest planet known at that time); these elements are clearly depicted as systems, with structures comparable to the Solar System. The novelty here is the fact that the diversity of structures is visually emphasized: the number of orbits (i.e. orbiting planets) and the size of the systems are different in each case. The idea of the cosmos manifest through this image points out that there are many other systems similar to ours as a type, but

[14] 'The new system', in Fontenelle, *Conversations on the Plurality of Worlds* (Dublin: Peter Wilson, 1761). The definition of the 'new system' quoted in the first section of the present text has been taken from this same edition.

heterogeneous in their concrete materializations. The structure of the universe is visibly manifold.

4. Traces of d'Olivar

The Spanish artist Juan d'Olivar engraved for the first edition of Fontenelle's above-mentioned book an impressive version of the cosmos (see Figure 5).[15]

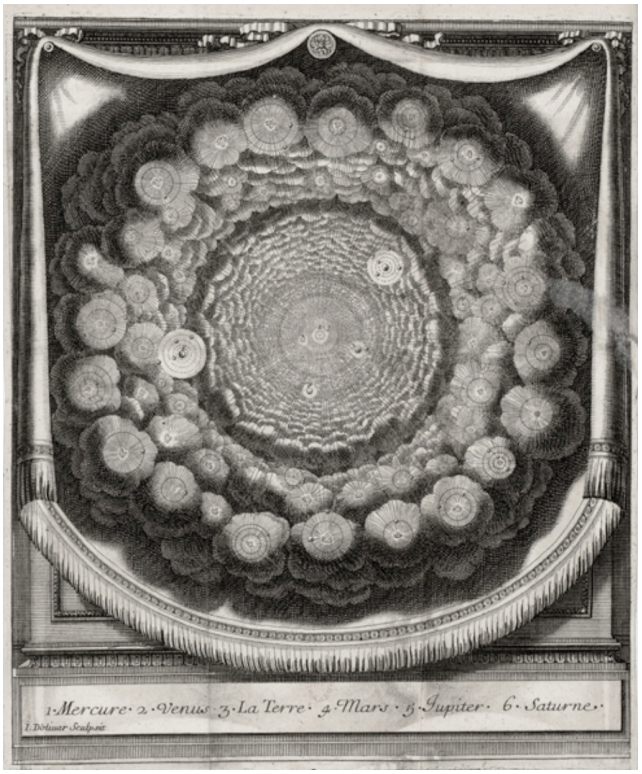

Figure 5. Engraving by d'Olivar for Fontenelle's first edition of the *Entretiens sur la Pluralité des Mondes*, 1686. Digital Library Gallica, signature: 1992

Emerging over a curtain, the universe opens to us to show its internal configuration, especially the central position of the Sun and the vortices (i.e. the planetary systems according to Descartes' physics) that make up

[15] Juan d'Olivar, universe as a plurality of worlds engraved for Fontenelle, *Entretiens sur la pluralité des mondes* (Paris: Chez la Veuve C. Blageart, 1686).

the general structure. Not in vain are Copernicanism and Cartesianism the main theories supported in the book.

Instead of the *abstract analysis* of the *structure* that the previous diagrams show, d'Olivar's image helps us to get an insight into the *supposed external appearance* of the universe. This figurativeness challenges us to conceive astronomical theories in visual terms according to the logics of perception. If at that time, thanks to the telescope, it was possible to know quite accurately what the surface of the Moon was like, why do we not apply the same principle to the representation of the whole universe? Even though there was not observational evidence revealing any hint of the structure of the universe on its largest scales, cosmology participated in the taste for this kind of representation too. Thus, scientific images, as religious images did in the past, depicted the cosmos figuratively to make their theories more easily understandable. The key implication and novelty of this figurative style was to give an impression of the universe in terms of three-dimensional, actual, physical space.

Designing a diagram requires mathematical and geometrical knowledge. But to design a figurative representation dealing with the (possible) appearance of things demands additional artistic skills. Thanks to the cooperation between artists and scientists, as in this case, the emergence of such images was possible. The visual sources of this engraving were indeed taken from different realms of the art at that time, mainly from stage designs for the opera or theatrical scenes according to baroque style. Thus, the image implies an additional (visual) argument for the idea of the physical world as *theatrum naturæ,* which Fontenelle addressed in the text.

There are many other relevant issues around this engraving,[16] but here we can only stress its role in establishing a new visual paradigm for the representation of the universe according to the latest astronomical theories at the time. Given the great success of Fontenelle's book, which was published and distributed numerous times across the centuries and in different countries, d'Olivar's image, its reproductions and reprints, contributed in a substantial way to shape the collective imagery around the plurality of worlds.

[16] For a detailed account, see Ayala, 'Entretiens sur la Pluralité des Mondes'.

5. Hybrids combining plane diagrams and three-dimensional scenes

Later images followed the tendency of presenting the plurality of worlds in a figurative way. However, several authors opted for hybrid representations, and integrated plane diagrams of the cosmos in figurative scenes. Such is the case of the frontispiece of the *Atlas Cœlestis* published by Doppelmayr, designed by Preisler and engraved by Reinsperger (see Figure 6).[17]

Figure 6. Frontispiece by Preisler and Reinsperger for Doppelmayr's *Atlas Cœlestis*, 1742. © Staatsbibliothek zu Berlin, Preußischer Kulturbesitz, Kartenabteilung

It repeats some elements present in d'Olivar's image: the Solar System is placed at the center of a plurality of systems, which are surrounded by a

[17] Johann G. Doppelmayr, *Atlas Cœlestis* (Nuremberg: Homannus, 1742).

cloudy-shaped ring, being the cosmos depicted as a backdrop. Contrary to d'Olivar, the plurality of systems as such is here depicted as a flat, two-dimensional surface, while the rest of the motifs are in a figurative style and give the impression of three-dimensional volumes. The aesthetics of artistic images is therefore combined with the lack of depth distinctive of diagrams.

Only two years after publication of the atlas, the Berlin artist Ferdinand Helfreich Frisch took exactly this same universe for the frontispiece of *Theoria motuum planetarum et cometarum* by the well-known mathematician and astronomer Leonhard Euler.[18] Frisch copied the upper part of the image containing astronomical motifs but removed the scenography with famous astronomers at the bottom. In doing so, the combination of visual languages and the tension between abstraction and figurativeness becomes intensified through the contrast between the planetary systems, on the one hand, and the angels and the backdrop, on the other. Notwithstanding, in spite of the flatness of the cosmic space, the careful and detailed style still shows an image credible in perceptual terms. The impression of the cosmos is not reduced to the abstract language of diagrams, but the image still suggests what the universe would look like if it were feasible to observe it.

Going back to Doppelmayr, the second map of his atlas also contains a representation of the universe of similar characteristics.[19] This time it follows a general composition very well known thanks to Cellarius' *Harmonia Macrocosmica:* a large circular diagram is shown in the center, in such a way that the four corners are free so further details can be added.[20] In the top right-hand corner, many planetary systems emerge from a cloudy medium.

This motif representing the plurality of systems, as well as the general arrangement of the image, was taken by Doppelmayr directly from a book published one decade before: the *Kupfer-Bibel*.[21] This work

[18] Leonhard Euler, *Theoria motuum planetarum et cometarum* (Berlin: Ambrosii Haude, 1744).

[19] 'Systema Solare et planetarium', in Johann G. Doppelmayr, *Atlas Coelestis* (Nuremberg: Homannus, 1742).

[20] Andreas Cellarius, *Harmonia Macrocosmica* (Amsterdam: Johannes Janssonius, 1660).

[21] Friedrich after Füßli, Plate I in Johann J. Scheuchzer, *Kupfer-Bibel, In welcher Die Physica Sacra, Oder Geheiligte Natur-Wissenschafft Derer In Heil. Schrifft vorkommenden Natürlichen Sachen, Deutlich erklärt und bewährt* (Augsburg and Ulm: Pfeffel & Wagner, 1731-35).

comprises a text written by Scheuchzer and a collection of plates engraved by Friedrich after the designs of Füßli. This way of depicting cosmic space, later copied in Doppelmayr's atlas, is characterized by a hybrid visual language. Plane diagrams of circles and signs are immersed in a cloudy environment depicted in detail, in which the texture and formal concretion belong to a purely artistic language (see Figure 7).

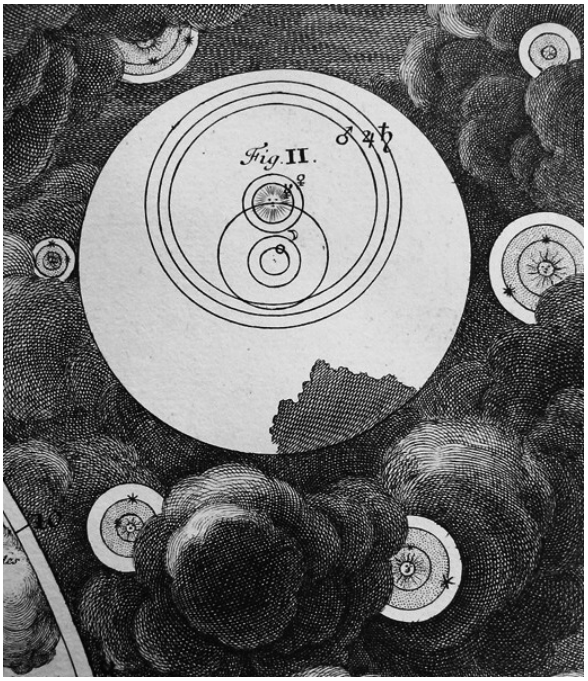

Figure 7. Plate I (detail), Scheuchzer's *Kupfer-Bibel*, 1732-35. Digital Library E-rara.ch

6. Decentralized structures

Up to this point, I have shown several variations for representing the universe on its largest scale. In actuality, all of them may be grouped together insofar they are all centralized models. The Solar System, and thus the Sun, is always placed at the center of the cosmos. One should consider these images in a context strongly marked by the final acceptance of Copernicanism. There are additional explanations too, like the politicization of astronomy in France at the time of the Sun King. Louis XIV symbolically identified himself with the Sun and justified his

absolute power by the natural order set by heliocentrism.[22] Since French scientists and artists were very active in spreading the idea of the plurality of worlds, their influence reached other European countries.

The first decentralized models were also introduced in France. In particular, they were triggered by the Cartesian system of vortices. Frans van Schooten the Younger, who made the illustrations for the *Principia* in collaboration with Descartes,[23] followed the idea of a complex universe in which the Solar System is just one component among many others. This initiated a worldview closer to modern notions, finally liberating cosmology from old human-centered models. Cartesian vortices were soon integrated, theoretically and visually, into the tradition of the plurality of worlds, owing mainly to Fontenelle's success.

The great French artist Bernard Picart designed for a later edition of the *Entretiens* one of the first major examples in this context (see Figure 8).[24] Rotating the famous original images of the vortices by 90°, van Schooten/Descartes' influence becomes easily recognizable. Following the visual parameters set by van Schooten and the theories by Descartes, Picart represents a decentralized model, in which *plurality* is understood radically not as '*one* among *others*', but as '*many* among *many*'. In addition to not being placed at the center, the Solar System shares the same general structure with the others, which are depicted with identical level of detail, including comets, satellites, planets, and orbits.[25]

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[22] See Lucia Ayala, 'Decentralisation of the Sun as Beginning of Modernity. The Transition from Copernicanism to the Plurality of Worlds in French Engravings', in Wolfgang Neuber, Thomas Rahn and Claus Zittel (eds.), *Copernicus and his International Reception* (Leiden: Brill, in press).

[23] René Descartes, *Principia Philosophiae* (Amsterdam: Ludovicum Elzevirium, 1644). For a discussion about the authorship of these images, see Claus Zittel, *Theatrum Philosophicum* (Berlin: Akademie Verlag, 2009).

[24] Bernard Picart, 'Pluralité des mondes', in Fontenelle, *Entretiens sur la pluralité des mondes* (The Hague: Gosse et Néaulme, 1728).

[25] Picart was an enlightened intellectual who defended through his works the 'equality' of systems in an astronomical sense, and the 'equality' of human beings from a cultural perspective. See Lucia Ayala, 'Cosmological and Cosmopolitan Ideas of a Plurality of Worlds in the Early Enlightenment: Fontenelle, Juan Olivar and Bernard Picart', in Sonja Neef, Henry Sussman and Dietrich Boschung (eds.), *Astroculture. Figurations and Cosmology in Media and Arts* (Munich: Fink, 2014), pp. 45-60.

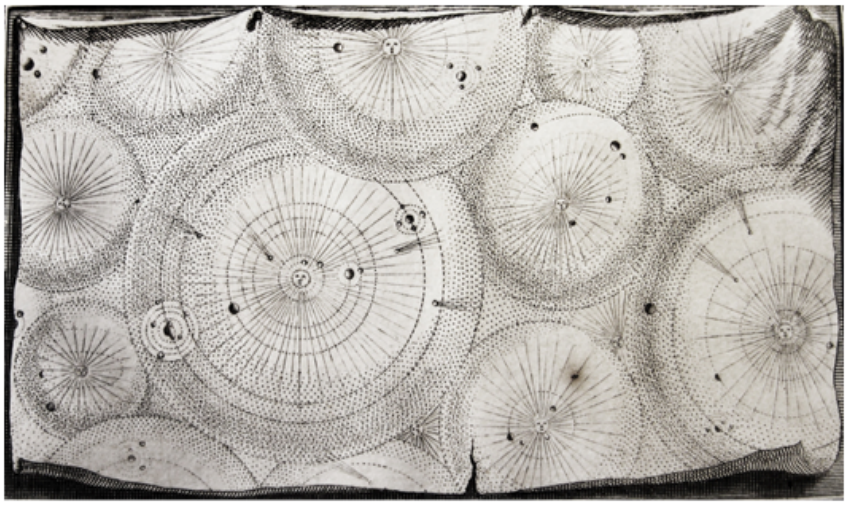

Figure 8. Picart's version of the cosmos for a new edition of Fontenelle's *Entretiens*, 1728. Image taken from the 1743 reprint. © Staatsbibliothek zu Berlin – Preußischer Kulturbesitz

Within this type of images there are several variations beyond the direct Cartesian influence. A further example of a decentralized cosmos is given by Dheulland, who engraved a frontispiece after Maugein's design for the book about the shape of celestial bodies written by Maupertuis in 1742 (see Figure 9).[26] The systems are depicted here in a schematic way using few elements, which blurs their differences. The space corresponding to each system is defined by a central area of light, an irregular bright mass projecting rays. Therefore, they appear like suns, i.e. like traditional figurative representations of our Sun. The background is colored in blue and enhances this feature. Superimposed on them are the orbital trajectories of planets, satellites and, more importantly, comets. The emphasis on the presence of the comets is a visual support to the text, where they are used to defend Newton's physics over Descartes.

The third type of decentralized models is closely connected with this last example, and appeared only eight years after Maupertuis' book. I

[26] Moreau de Maupertuis, *Discours sur les differentes figures des Astres* (Paris: Martin, Coignard, & les Frères Guerin, 1742) [1st edition, without frontispiece, Paris: Imprimerie Royale, 1732].

am referring to the images in Thomas Wright of Durham's famous *An Original Theory, or New Hypothesis of the Universe*.[27]

Figure 9. Frontispiece by Dheulland after Maugein, in Maupertuis, *Discours sur les differentes figures des Astres*, 1742. Digital Library Gallica, signature: 90/244.

[27] Thomas Wright of Durham, *An Original Theory or New Hypothesis of the Universe, Founded upon the Laws of Nature, and Solving by Mathematical Principles the General Phœnomena of the Visible Creation; and Particularly the Via Lactea* (London: H. Chapelle, 1750).

This book presents his personal interpretation of the constitution of the cosmos based on a hierarchical structure and contains many illustrations. One of the plates shows the internal composition of galaxies, made up of many planetary systems. This image is depicted following visual parameters very similar to the last example. The main difference lies in the emphasis of spherical forms, as Picart did.

Other plates in Wright's book show the general structure of the cosmos, which consists of many galaxies depicted as spheres. Whereas the image showing the inside of galaxies follows previous visual standards, the plate of the large-scale cosmic structure represents another iconographical type, whose later influence was minor.

Four years after Wright, James Ferguson copied his plate of the inner structure of galaxies for the frontispiece of *An idea of the material universe.*[28] The image, entitled 'siderial systems', thus took a step back regarding the general conception of the universe. While Wright had already shown the universe in terms of galaxies, here we go back to the previous idea of a plurality of planetary systems. Actually, Ferguson wrote that astronomy

> discovers to us such an inconceivable Number of Suns, Systems, and Worlds, scattered through boundless Space, that if our Sun, with all the Planets, Moons, and Comets belonging to it, were annihilated, they would no more be missed out of the Universe than a Grain of Sand from the Sea Shore.[29]

One of the main late examples of this type of image comes from Isaac Frost's *Two Systems of Astronomy*. This book spread the Muggletonian principles of a small Protestant seventeenth century sect that was against Newtonian physics. They believed that the true structure of the cosmos derived from the Holy Scriptures, especially from the Book of Enoch, and did not correspond to the scientific explanations available at the time. The representation of the Newtonian universe that appeared in the plate 1 of this book combines visual traces of Picart and Wright. The plate is explained as follows: 'Plate 1 represents part of the great universe, according to the Newtonian system: the stars as suns, with worlds

[28] James Ferguson, *An idea of the material universe, Deduced from a Survey of the Solar System* (London: printed for the author, 1754).

[29] Ferguson, *An idea…,* p. 9.

revolving round them, as is supposed'.[30] Frost presented the universe after Newtonian physics as a set of round and ordered systems with a central star. These systems reproduce the structure of the Solar System, which is in turn bigger than the others to be highlighted. Through the regular distribution of regular spherical systems, Frost takes part in Wright's conceptions; in addition, the representation of the inner composition of each system seems like Picart's cosmos.

Wright's ideas about the large-scale structure of the universe were the bridge linking the plurality of worlds and the galaxies. Known as *nebulae* at that time, from the middle of the eighteenth century on galaxies began to be conceived as the units that shape the cosmic structure. Thus they assumed the role that the worlds had previously played. This new worldview paved the path to Modern cosmology, initiating another genealogy of images that can be traced to the present day.

7. Conclusions

From this summary of the milestones in the genealogy of the images of the plurality of worlds I would like to derive three conclusions.

First: The role of images in the construction of knowledge.

I have presented a visual re-reading of the plurality-of-worlds tradition. By analyzing these engravings, it has been possible to extract the main concepts associated with this field: I have talked about anti-Aristotelian tendencies, heliocentrism as a problem, the importance of the comets, the relativization of the Solar System, the emergence of the idea of galaxies, and so on. In addition, there are some discourses that emerge just on a visual level and are not developed in the accompanying texts.[31] As a matter of fact, science is not only built by words but also by images. Consequently, the history of science gains depth when looking at its visual products not as mere 'illustrations' of texts, but also when considering the parallel and complementary significance of the image

[30] W. P. Clubb & Son after Isaac Frost, 'The Newtonian System of the Universe', Plate 1, in Isaac Frost, *Two Systems of Astronomy: First, the Newtonian System…; Second, the System in Accordance with the Holy Scriptures…* (London: Simpkin, Marshall & Co., 1846). I would like to express my gratitude to Michael Mendillo for pointing me out this example.

[31] Such is the case of the debate about the infinitude of the universe, in which many images took part, though I could not develop this argument in the present paper.

itself. This visual dimension of knowledge, though related to written theories, is autonomous and involves its own logic and discourses.

Second: The role of art in historical astronomical images.
Some astronomers had scientific and artistic skills, like Galileo (who studied drawing) and Hevelius (who engraved many of his own plates). However, this coincidence was not common and in past centuries collaborative work was needed in order to produce astronomical images. Engraving was a complicated technique and thus the artists had to provide visual tools for giving an image to the astronomers' work. As a consequence, scientific and artistic languages together shaped the images of the cosmos. This fact resulted, for instance, in the coexistence of different visual codes, the combination of the analytic abstraction derived from theoretical approaches with the symbolic figuration taken from the artistic tradition, as we have seen in some of the previous examples.

Third: The role of the plurality of worlds in the history of cosmology.
The plurality of worlds does not mean early science-fiction stories, or anecdotal ideas about Martians or Jupiterians, although they are also a part of it.[32] Its historical meaning lies rather in covering a gap in the sequence of cosmic models: it was developed just after heliocentrism and led to the intensive study of nebulae during the nineteenth century. The history of astronomy usually builds its arguments by taking the structure

[32] Let us remember that the most important references on this topic so far focus the attention on the idea of extraterrestrial life. This was actually part of the plurality-of-worlds model, but not its main aspect. The key principle underlying the structure of the universe is as described in the present text. See S.J. Dick, *Plurality of Worlds. The Origins of the Extraterrestrial Life Debate from Democritus to Kant* (Cambridge et al.: Cambridge University Press, 1982) and M.J. Crowe, *The Extraterrestrial Life Debate 1750-1900. The Idea of a Plurality of Worlds from Kant to Lowell* (Cambridge: Cambridge University Press, 1986).

of the universe as the guiding parameter. However, Descartes' significance is often disregarded in this context, and afterwards the historical focus is on gravity and the impact of Newton. Research on the plurality of worlds allows us to sketch a continuous history of the cosmic structure, which continued after Copernicus and is today still an ongoing process.