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Hermetic Atomism: Christian Adolph Balduin (1632–1682), *Aurum Aurae*, and the 1674 Phosphor

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The synthesis of phosphors, or light-bearing matter, figured largely among the activities of early scientific societies and within the first scientific journals. They were prestige objects during the formative institutionalisation of experimental natural philosophy. Nevertheless, early phosphors have often appeared within the historiography of chemistry as a throwback to an earlier era. They have been represented as a fundamental epistemic and theoretical divide between a mystical alchemy (exemplified by Christian Adolph Balduin) and modern chemistry (prefigured by progressives such as Robert Boyle). The parallel phosphoric researches of Boyle and Balduin belie this divide. Recovering the theoretical context of Balduin's phosphor can both resituate it in relation to phosphoric research of the 1670s and 1680s, as well as further illuminate the intellectual sources and development of chymical atomism.

Introduction: comparing Boyle and Balduin

Robert Boyle (1627–1691), F.R.S. and Christian Adolph Balduin (1632–1682), F.R.S. currently occupy two very different positions in the history of chemistry. Balduin's publications are rarely read today for the sake of understanding his matter theory, although they are certainly interesting sources in and of themselves for understanding contemporary fusions of atomism with occult qualities.[1] Rather, Balduin and his works are mentioned because his wider interests resulted in the synthesis of a famous phosphor in 1674, the first widely known luminescent body to be synthesised since the discovery of the Bologna stone in 1602 by Vincenzo Casciarolo.[2] Balduin's

[1] An exception is the brief mention in Bernard Joly, "L'alkahest, dissolvant universel ou quand la théorie rend pensable une pratique impossible," *Revue d'histoire des sciences* 49 (1996): 305–44, on 341–42.

[2] Fortunio Liceti, *Litheosphorus sive de lapide Bononiensi lucem in se conceptam ab ambiente claro mox in tenebris mire conservante* (Udine: Schiratti, 1640). I refer to Balduin's invention as a "phosphor" rather than phosphorus, in order to distinguish it from today's chemical element.

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phosphor is not the element known as phosphorus today, but what we would call calcium nitrate. It was quickly followed by the news of the synthesis of other phosphors, including the element phosphorus, and by much discussion, display and experimentation across Europe.

In narratives of chymical luminescence, Balduin's work, which is rarely analysed, has been seen as couched in impenetrable alchemical beliefs. Meanwhile, his contemporary Boyle's interest in phosphors often appears as indicative of a new experimental approach and a rational matter theory, even though the writings of both on magnetic aerial effluvia could be compared and will be in this essay.[3] Drawing upon shared alchemical and natural philosophical authorities, Boyle and Balduin had arrived at comparable views concerning aerial magnetic effluvia even before Balduin developed his phosphor. Although Balduin's phosphor has been described as an accidental discovery made while pursuing an unrelated occult goal, he was searching for solar particles hidden within the pores of the air and discussing the materiality and magnetism of light prior to discovering his phosphor.[4] The latter was but one product of years of experimentation with the chemical components of the air, and it elegantly supported the matter theories Balduin had already developed.

Balduin's 1673 work, *Aurum Aurae* (Gold of the Wind) presented a vigorous view of the abundant and diverse atoms held invisibly within the pores of the air.[5] Through magnetic attraction, such particles bound with particular bodies in measurable ways. These particles were both of terrestrial and of celestial origin. Balduin hoped to invent a chemical magnet capable of attracting powerful, life-giving celestial matter out of the air. In 1674, Balduin first developed an account of what he considered his "universal magnet," which he published in a further two updated editions, under a slightly altered title, in 1675.[6] As the hidden "fire of nature," Balduin thought this substance could be used for additional discoveries, such as Van Helmont's alkahest. In preparing the alkahest from his magnet, Balduin then

[3] For example, E. Newton Harvey, *A History of Luminescence from the Earliest Times until 1900* (Philadelphia: American Philosophical Society, 1957), 124–25: "Of all the distinguished group on the roster of the Royal Society of London, the only member to make an extended study of luminous phenomena was Robert Boyle … he became one of the outstanding experimentalists in this field." Balduin was "devoted to the fashionable pursuit of alchemy" (321). See also J. V. Golinski, "A Noble Spectacle: Phosphorus and the Public Cultures of Science in the Early Royal Society," *Isis* 80 (1989): 11–39 and Susana Gómez, "The Bologna Stone and the Nature of Light," *Nuncius* 6 (1991): 3–32, discussed further in the conclusion. By contrast, F. Krafft (1969) is sympathetic to the alchemical theories giving rise to seventeenth-century phosphors: F. Krafft, "Phosphorus: From Elemental Light to Chemical Element," *Angew. Chem. International Edition* 8/9 (1969): 660–71.

[4] Harvey, *Luminescence*, 321: "The discovery resulted by chance, from Baldewein's attempt to collect the universal world spirit."

[5] John Flood, *Poets Laureate in the Holy Roman Empire: A Bio-bibliographical Handbook* (Berlin: de Gruyter, 2006), vol. 1, 111–13. Christian Adolph Balduin, *Aurum Aurae, Vi Magnetismi universalis, attractum* (N.A: N.A., 1673); reissued as Christian Adolph Balduin, *Aurum Aurae, Vi Magnetismi universalis, attractum* (Cologne: Völcker, 1674). I describe Balduin's position as atomist rather than corpuscularian, since "atom" is the term Balduin employs, and it can be understood in an early modern sense as discussed in William Newman, "The Significance of 'Chymical Atomism,'" *Early Science and Medicine* 14 (2009): 248–64.

[6] Christian Adolph Balduin, *Aurum Superius & Inferius Aurae Superioris & Inferioris Hermeticum* (Frankfurt: Frommann, 1675) and Christian Adolph Balduin, *Aurum Superius & Inferius Aurae Superioris & Inferioris Hermeticum* (Amsterdam: Waesberge, 1675).

found that it glowed when exposed to either light or heat. This was when he further developed it into his phosphor, which he described in an appendix, "Phosphorus Hermeticus, sive Magnes Luminaris" (The Hermetic Phosphor or Light Magnet), to the 1675 edition of his work on the magnet. Balduin's name for his phosphor referred to his cognomen, Hermes, as a member of the Central European *Academia Naturae Curiosorum* (Academy of the Curious about Nature). The 1675 edition, including the "Phosphorus Hermeticus," also appeared within the journal of the Academy in 1676 and 1688.[7] All these iterations made Balduin's work widely available and allowed him to incorporate new evidence for his theories in subsequent editions. Such new evidence included but was not limited to his phosphor.

This essay seeks to restore Balduin's phosphor to its theoretical and experimental context. It will thus follow Balduin's trail of publications closely. Paying particular attention to subsequent editions of the same work by Balduin, it will illustrate how he continually updated his editions as he discovered new evidence for his theories. Balduin's *Aurum Aurae* deserves to be read in its own right as an interesting account of chymical atomist views synthesising a great deal of previous literature. It further shows how such views related to debates concerning phosphors, which were high prestige objects in early scientific societies. Resituating Balduin's phosphor can thus shed light on much wider debates and their sources.

Balduin's 1673 *Aurum Aurae*

Balduin made his (creative) re-use of a prior corpuscularian tradition very clear. The *Aurum Aurae,* although a slim work, is citation heavy.[8] Only a few of Balduin's many sources can be reviewed here. Balduin began by citing his definition of air from Van Helmont's work on the plague. Air is transparent, free from weight, naturally cold, but everywhere full of pores, which allows it to be extended and compressed (as discussed by Van Helmont and Scaliger).[9] He cited Cornelis Drebbel to the effect that the four elements were but terms for states of varying thickness

[7] Christian Adolph Balduin, "Aurum Superius & Inferius Aurae Superioris & Inferioris Hermeticum," *Appendix ad annum quartum et quintum ephemeridum medico-physicarum naturae-curiosorum in Germania*, hereafter *Appendix* (Frankfurt: Fritzsch, 1676), 155–66; Balduin, "Phosphorus Hermeticus, sive Magnes Luminaris," *Appendix* (Frankfurt: Fritzsch, 1676), 167-72; Balduin, "Aurum Superius & Inferius Aurae Superioris & Inferioris Hermeticum," *Appendix* (Frankfurt and Leipzig: Gleditsch, 1688), 91–146; Balduin, "Phosphorus Hermeticus, sive Magnes Luminaris," *Appendix* (Frankfurt and Leipzig: Gleditsch, 1688), 147–51. It was also printed in Jean-Jacques Manget, *Bibliotheca Chemica Curiosa* (Geneva: Chouet, 1702), vol. 2, 856–75.

[8] Occupying eighty pages in the 1673 edition, the *Aurum Aurae* expanded to 172 pages in the 1675 edition, not including the appendix, "Phosphorus Hermeticus."

[9] This section is missing in Balduin's 1673 edition. That he intended to include it, however, is indicated by the fact that the next quote from Van Helmont, which is present (see n. 10), refers back to a previous citation. Balduin, *Aurum Aurae* (1674), 7: "Elementum illud intelligimus, primigenium, transparens, tamque levitiatis quâm ponderis expers, impermutabile ac perpetuum, frigore praeditum naturali, nisi situum & commistorum robore impediatur: Poris autem ubivis refertum, & hactenùs extensionem aut compressionem sui tolerans: Joh. Bapt. Helmontius, in Tum. Pest. infra coelum ac supra aquam terramque existens: uti loquitur Scaliger, se Subtil. Exerc. 27." J. B. van Helmont, *Tumulus Pestis* (Amsterdam: Elsevier, 1648), 51: "Aër itaque in se, est alterum ex elementis primigeniis, transparens, tamque levitatis, quàm ponderis expers, impermutabile ac perpetuum, frigore praeditum naturali, nisi situum & commistorum robore impediatur: Poris autem ubivis refertum, & hactenus extensionem, aut compressionem sui tolerans."

and thinness, and Emanuel Maignan's view that the air is full of "spirituous parts of bodies"; aether differs from air only in purity. Balduin again cited Van Helmont: "The pores of the air are either empty or are full of foreign vapours."[10]

According to Gaspar Schott, Balduin noted, there were two spirits that rose up either through the heating power of the sun or stars, or through subterranean fire, or through innate heat. Representing Aristotle's views, Schott had differentiated between vapour (thinner and lighter, extracted from liquid bodies) and exhalations (extracted from dry bodies).[11] Balduin, however, was not interested in the distinction between vapour and exhalation, but in Schott's description of the many heating mechanisms responsible for elevating diverse effluvia into the air as well as the multiple natures of effluvia in the air. There were, he said, foreign effluvia in the air, composed (*concreti*) differently *per accidens* according to the nature of the place where they were exhaled. Therefore virgin earth, when exposed to the wind, would bear plants since the air was impregnated with the seeds or spirits of the plants. Likewise, earth was only a matrix, not a mother of bodies. The spirits of nitre and vitriol fly through the air. That was why, after extracting the spirit from vitriol or nitre, if you put its colcothar (vitriol calcined to redness) in the air for a few days, and then put it back in a retort and on the fire, you could again extract a very effective spirit. Emanuel Maignan offered this experiment and argued from it that this was why the air was sometimes healthy or not, or sweet- or foul-smelling.[12] Maignan related that nitre, vitriol and alum could all be collected from the air. Within the "atmosphere," air was never pure.[13] In London, so many inhabitants used coal for heat that the air was full of smoke and salt. Rooms, halls and any instrument whatsoever, no matter how bright and shining they had been before, were quickly darkened.[14] Schott noted that the air in the seaside town of Trapani in Sicily was so impregnated by sea salt that it corroded iron. Therefore, Balduin wrote, the constitution of air varied from causes depending on the site, the nature of the earth, the proximity of seas and lakes, the presence of mines, and the time of year, as Sennert had described at length.[15] Balduin thus drew on a wide array of corpuscularian thinkers such as Van Helmont, Scaliger and Sennert who were also contributors to the development of Boyle's matter theory.[16]

[10] Christian Adolph Balduin, *Aurum Aurae* (1673), 8: "Pori, vel Porositates, quibus refertum Aërem esse diximus, vel planè hiant expertes corporis, in sui integritate manentes, vel replentur vaporibus alienisque exhalitibus [sic] … *Helmontius d. l.*"; Van Helmont, *Tumulus Pestis*, 51: "Cujus porositates, vel replentur vaporibus, alienisque exhalatibus; vel planè hiant, expertes corporis, in sui integritate manentes (quod alibi tractatu de vacuo necessario demonstravi)."

[11] Gaspar Schott, *Physicae Curiosae Pars II* (Nürnberg: Endter, 1667), 1182.

[12] Balduin, *Aurum Aurae* (1673), 10.

[13] Emanuel Maignan, *Philosophiae Naturae* (Lyons: Gregoire, 1673), 434.

[14] Balduin, *Aurum Aurae* (1673), 11. Balduin may have derived this idea from Digby's work on the sympathetic cure of wounds, which Balduin cites elsewhere.

[15] Balduin, *Aurum Aurae* (1673), 11; Daniel Sennert, *Institutiones Medicinae* (Wittenberg: Schurer, 1620), 752.

[16] William R. Newman, "Corpuscular Alchemy and the Tradition of Aristotle's Meteorology, with Special Reference to Daniel Sennert," *International Studies in the Philosophy of Science* 15/2 (2001): 145–53; William R. Newman and Lawrence M. Principe, *Alchemy Tried in the Fire: Starkey, Boyle, and the Fate of Helmontian Chymistry* (Chicago: University of Chicago Press, 2002); William R. Newman and Lawrence M. Principe, "Alchemy and the Changing Significance of Analysis," in *Wrong for the Right Reasons*, ed. Jed Z. Buchwald (Dordrecht: Springer, 2005),

Summing up these views, Balduin concluded

> Thus, the varying effluvia in the air always in great abundance are continually mixed from different things, or of spirits of all sorts, that is, terrene, aqueous and igneous, from earth, water, and fire, but also from minerals, and plants, animals, and even from the bodies of men. Dispersed either through an extrinsic heat or through an intrinsic one, they are carried aloft due to their lightness. Then, attracted to homogeneous bodies through a magnetic power, they are again turned into bodies.[17]

Magnetism offered a solution to the important problem of elective affinity which allowed particular bodies to form again and again from this chaos of many diverse particles.[18]

To prove this, Balduin offered yet another experiment, this time including a weight measurement. He boiled ground iron pyrites (the Hessian *minera martis solaris*; today, FeS_2) in water until they were tasteless. Then he exposed twelve ounces to cold air for fourteen days. The solution continually attracted a "wet, sweet salt of Vitriol, so that when weighed it will be found to be two ounces heavier."[19] Balduin's experiment supported the view that that the pores of the air were full of a massive amount of diverse particles. These might be invisible to the eye, but they affected the salubrity and smell of the air. Furthermore, they could be discovered through experiment. According to Balduin's theory, a vitriolic salt was attracted out of the air and concreted together with the exposed pyrites.

Moving on from exhalations of sub-lunar bodies carried in the air to celestial matter carried in the air, Balduin began his Chapter III, "Even celestial matter flies about in the wind," by citing, of all people, Descartes. Descartes had described the air as a congeries of terrestrial particles moving in a motion following the orbits of the heavenly bodies (although Balduin conceded that Boyle interpreted this passage differently in the latter's *Experiments upon Air*). Balduin alluded to Boyle's entertainment of Descartes's idea of a "restlesse agitation of the Celestial Matter." Descartes's theory obviated the need to explain the corpuscles of the air

[16] *Continued*
73–90; William R. Newman, *Atoms and Alchemy: Chymistry and the Experimental Origins of the Scientific Revolution* (Chicago: University of Chicago Press, 2006); and Christoph Lüthy, "An Aristotelian Watchdog as Avant-Garde Physicist: Julius Caesar Scaliger," *The Monist* 84 (2001): 542–61. On Schott as a corpuscularian, see William Clark, "The German Nations," in *The Scientific Revolution in National Context*, ed. Roy Porter and Mikulas Teich (Cambridge: Cambridge University Press, 1992), 90–114, on 108.

[17] Balduin, *Aurum Aurae* (1673), 11–12: "Quemadmodùm ergò variarum in aëre rerum permista varia continuò effluvia, sive omnisgeneris spiritus sunt, terrei puta, aquei atque ignei, è terra, aqua, igne, mineralibus quoque, plantis item, animalibus, adeoque hominum corporibus, magnâ semper copiâ, vi caloris seu extrinseci, seu intrinseci resoluti & ob levitatem ascititiam in altum evecti, ita à corporibus homogeneis vi magneticâ attracti iidem corporificantur."

[18] William R. Newman, "Elective Affinity before Geoffroy: Daniel Sennert's Atomistic Explanation of Vinous and Acetous Fermentation," in *Matter and Form in Early Modern Science and Philosophy*, ed. Gideon Manning (Leiden: Brill, 2012), 99–124.

[19] Balduin, *Aurum Aurae* (1673), 12: "Utor Minera Marti-Solari (quam ex *Hassiâ* adferunt, tribusque diobolis libram Lipsiae aestimant, non carius) flavâ intùs, aureae instar Marcasitae, caeterum planè insipida. Quam enim si in pulverem redigas diuque in aquâ coquas, ne colorem ista quidem mutabit, nec saporem alium, quàm qui aquae est, habebis. Hujus Unicas duodecim, per integros quatuordecim dies, non ita pridem aëri frigido exposui. Quô facto, peculiarem illa humidumque atque dulcem, talemque, qui Vitrioli est, salem attrasse continuò. quid? quod duabus unciis aucta & ipsa pondere esset."

as spring-like in shape, since they would be moved around anyway by the moving "fluid *Ether*."[20]

In any case, continued Balduin, he believed that celestial matter was scattered throughout nature, and especially in the air, as the most noble element and the one in which hid the spirit of life, as Sendivogius wrote. Citations from Johann Sperling, Rudolph Goclenius and Marsilio Ficino illustrated that a vital astral spirit "accommodated itself to metals, stones and plants," and thrust itself into their substance, serving as a spur to generation. Van Helmont called this aetherial substance the "magnale magnum." As Balduin noted, Athanasius Kircher, Heinrich Nollius, Friedrich Hoffmann, Pierre Jean Faber, Johann Tackius, Bernard Penotus, Gerhard Dorn, Nicholas Papin, Cornelis Drebbel, Johann Poppius, Olaus Borrichius, Johann Rudolph Glauber, Johann Ludwig Gottfried, Johann Rothmann, Clovis Hesteau de Nuysement and Andreas Nitner all discussed this substance further.[21]

Based on such authors, he decided that the most likely candidate for a universal magnet was nitre, in which the aetherial substance was abundantly disseminated, for no salt is more universal. Due to its role in concreting sub-lunar mixts, it was well worthy of further study, he said, citing Boyle.[22] Balduin referred to Boyle's discussion of "experiments concerning various parts of nitre," in which the latter argued that few other substances better supported the corpuscular hypothesis. Among other authorities, Balduin also noted Thomas Henshaw's microscopic views of the prepared salt of maydew published in English and French journals, showing how its microscopic shape resembled that of nitre.[23]

Balduin hoped to use his nitre-based magnet to attract a shining body from the sun, for according to both Kenelm Digby and Van Helmont, "the substance of light is material and corporeal."[24] This explained how the heat of the sun reached the earth; it was far too distant to heat the earth directly. The earth was heated, rather, by a fiery solar material which was scattered through the air. That material communicated not only heat, but also a nourishing solar balsam. As Johann Tackius had argued, we imbibe aetherial spirits daily from the air.[25] Balduin continued to discuss at length the many methods and best times for preparing a magnet

[20] Balduin, *Aurum Aurae* (1673), 15–16: "*Cartesius part. IV. Princ. Phil. N. 48. Lipstorpius p.3. specim. Philos. Cart. C. 2.* asserere videntur: aërem nihil aliud esse, quàm congeriem particularum terrestrium. tàm tenuium, & à se mutuô disjunctarum, ut quibuslibet motibus globulorum coelestium obsequantur. Licet *Dn. Robertus Boyle,* in Experimentis de aëre, *Exper. 1. Cartesium*, aliter interpretetur. Credendum tamen est, naturam, cui peculiaris semper fuit cura, ut indefessum Coeli ac terrae commercium, velut admirabilis harmonia totius mundanae machinae perduraret, à primô mundi ortu, etiam coelestem quandam substantiam vel materiam per universum orbem disseminasse." Robert Boyle, *New Experiments Physico-Mechanical Touching the Spring of the Air and its Effects* (Oxford: Hall, 1662), 14.

[21] Balduin, *Aurum Aurae* (1673), 20.

[22] Balduin, *Aurum Aurae* (1673), 22: "Est autem, ut aperriùs [sic] dicam, Magnesia Nitrum nostrum, sive sal Petrae, in quô aetheria illa substantia copiosissimè disseminata. Nam nullus Sal est, qui sit, illô, magis catholicus." Compare Robert Boyle, *Tentamina Physico-chymicum continens Experimentum circa varias partes nitri* (Amsterdam: Elzevier, 1661), 1: " … ita ut quavis asseveratione confirmare liceat, nullum Salem esse, qui sit isto magis Catholicus."

[23] Balduin, *Aurum Aurae* (1673), 26.

[24] Balduin, *Aurum Aurae* (1673), 32.

[25] Balduin, *Aurum Aurae* (1673), 33. Johann Tackius, *Chrysogonia animalis et mineralis* (Darmstadt: Abel, 1663), 29: " … cum aëre quotidie in solatium nostri haurimus, quique rubedinis tincturam abundantissimè habet."

which could attract a vital essence from the sun. In the middle of the night the air most abounded with these "balsamic aethereal atoms," he argued.[26] His discussion of the vital virtues of this essence in the mineral, vegetable and animal realms included experiments on the relationship between extracted bodily essences and the body; to explore this further, Balduin made a thermometer from his own blood to test whether its temperature and colour would fluctuate with his health.[27]

Balduin's universal magnet and the light magnet

Long before his discovery of his phosphor, therefore, Balduin was discussing the corporeity of light and how it might be attracted to and combine with other bodies concreted from diverse aerial effluvia. He tested these theories in diverse ways, including with his blood thermometer. Continuing his chymical investigations of effluvia, he discovered further phenomena which he incorporated in subsequent editions. In 1675, Balduin re-issued his *Aurum Aurae* (the dedication of which dated to March 1673), now updated with his newest discoveries from September 1673 and March 1674. He also inserted further accounts of aerial magnets. One new account he copied from a letter communicated by Friedrich Clodius (Samuel Hartlib's son-in-law) to Johann Moriaen concerning an aerial magnet built in London in 1658 by the Küffler brothers (Cornelis Drebbel's sons-in-law). They had calcined nitre with the rays of the sun using a burning mirror, and then, climbing a tower or mountain, they had exposed it to the air. They were able to attract a ruby liquid before sunrise and a white liquid following sunrise.[28]

The Küffler experiment, as well as the theories of Sendivogius and others, indicated that nitre was the important ingredient. In Balduin's very own city of Hayn were copious amounts of nitre efflorescing on rocks, known as "aphronitrum." He added a "certain type of earth" to a spirit of nitre, when lo and behold (Figure 1),

> On the 15th of September, 1673, at 11 o'clock during a full moon … after my magnet had been spread before the air three hours, it showed a figure corresponding exactly to a circle, remarkable in its white round margin. The body was very hard, of a yellow colour, corresponding to a star, decorated inside with rays.[29]

[26] Balduin, *Aurum Aurae* (1673), 35: "aër atomis aetheriis balsamicisque quasi redundat."

[27] Balduin, *Aurum Aurae* (1673), 68.

[28] Christian Adolph Balduin, *Aurum Superius & Inferius Aurae Superioris & Inferioris Hermeticum* (Frankfurt: Frommann, 1675), 59–60. A letter from Johann Moriaen to Samuel Hartlib of 14 June 1658 describing this survives in the Hartlib Papers: Samuel Hartlib, *The Hartlib Papers CD* (Sheffield: HROnline, Humanities Research Institute, University of Sheffield, 2nd ed., 2002), 31/18/29A-30B. Boyle would also draw explicitly upon the interests of Hartlib and his contemporaries in aerial effluvia by publishing a circa 1657 letter from Benjamin Worsley to Samuel Hartlib as "Of celestial Influences or Effluviums in the Air," in Robert Boyle, *The General History of the Air* (London: John Churchill, 1692), 67–82. See Hartlib, *Hartlib Papers*, 26/56/1A-4B. As discussed by Antonio Clericuzio, "New Light on Benjamin Worsley's Natural Philosophy," in *Samuel Hartlib and Universal Reformation: Studies in Intellectual Communication*, ed. Mark Greengrass, Michael Leslie, and Timothy Raylor (Cambridge: Cambridge University Press, 1994), 236–46.

[29] Balduin, *Aurum Superius* (1675), 71–72: "Contigit hoc A. AE CIC DC LXXIII d. 15. Sept. quem excipiebat, hora 11 noctis, plenilunium. Effusus, quô dixi, post meridiem, die, Magnes meus aëri commitebatur, cùm effluxis omninò tribus horis, exactissimè respondens Circulo, margine & ipso orbiculari albo notabilis, se figura exeruit. Durissimum corpus, colore luteo, stellam referens, radiis intùs distinguebatur."

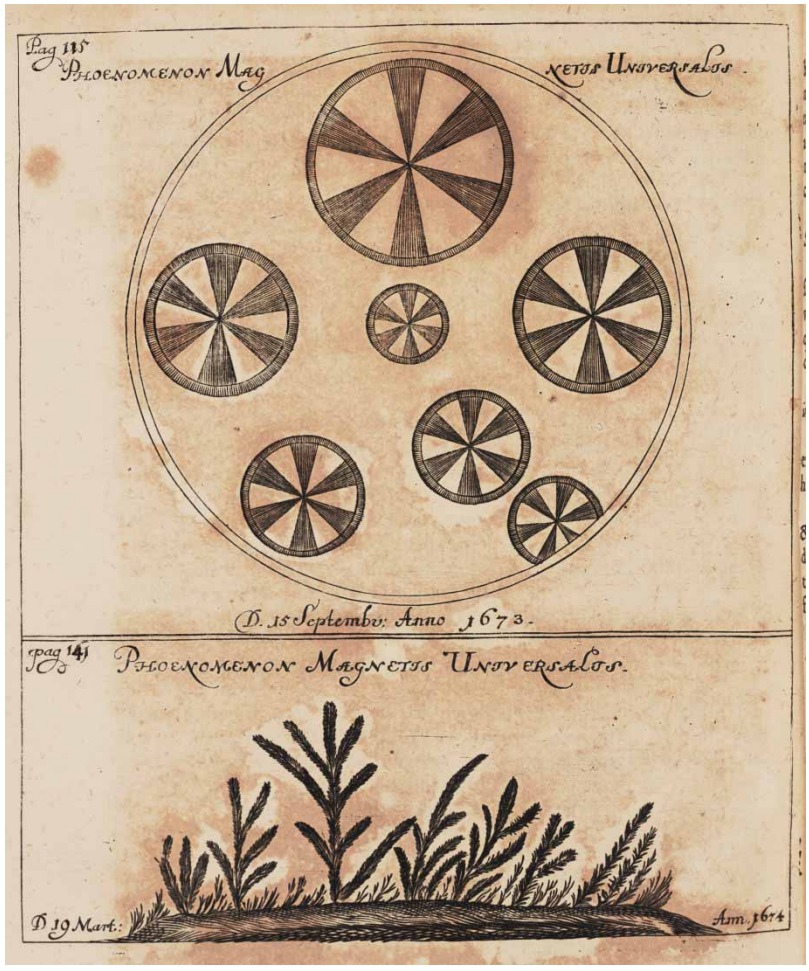

FIGURE 1 Balduin's "Universal Magnet," dated 15 September 1673. Christian Adolph Balduin, "Aurum Superius & Inferius Aurae Superioris & Inferioris Hermeticum," *Appendix ad annum quartum et quintum ephemeridum medico-physicarum naturae-curiosorum in Germania* (Frankfurt & Leipzig, 1688). With permission of the Linda Hall Library of Science, Engineering & Technology.

Balduin was looking for a substance involving nitre, stone and the ambient air which would bear some relationship to the sun. He believed he had found it. In the 1675 edition of his work (unlike in the 1673 edition), he represented it with the date of its discovery (Figure 1). He described it as the "fire of nature" which could be used to make further chymical discoveries, such as the *alkahest* of Paracelsus and Van Helmont.[30] This has been misunderstood as Balduin's light magnet, but

[30] Balduin, *Aurum superius* (1675), 74.

it was not; this was his universal magnet.[31] He likewise represented and dated to March 1674 another phenomenon, his "vegetable magnet," a plant-like form he "grew" from his universal magnet which illustrated, he argued, how salts concreted out of air and water to form plants (Figure 1).[32]

The light magnet was a separate discovery that same year. In a pamphlet entitled "Phosphorus Hermeticus," Balduin described how he had been ruminating upon various forms of artificial light, wondering whether he might be able to prepare it from his universal magnet, since he believed that the latter held the philosophic fire.[33] His ruminations included Boyle's experiments upon Clayton's luminescent diamond, the various discussions of the Bologna stone, and Van Helmont's statement that "*lumen* is a real entity outside of *lux*."[34] Then, while attempting to prepare the *alkahest* from the universal magnet, his glass retort, although cold, began to glow like a heated iron. His *alkahest* had indeed penetrated to a great wonder of nature, he believed.[35] He subjected the substance to various tests, discovering that it shone when exposed either to light or to heat, whether in a liquid or solid form, and whether open to the air, in glass, or submerged in various liquids. He further wondered whether from the same principle, that is, from the *alkahest* or concentrated fire, he might be able to build the long-lost fire of the ancients described by so many.

The discovery of the "light magnet" might indeed be understood as an accidental discovery made in pursuit of the alkahest (despite Balduin's claim that he had already been theorising about sources of light). However, Balduin was already exploring the ability of a celestial magnet to attract the "fire of nature" via aerial atoms beforehand. It was while pursuing a course of trials attempting to demonstrate these phenomena that his discovery occurred. Like other evidence he uncovered, he continued to deploy the phosphor as further support for his prior views concerning atomism.

Balduin's "light magnet" was made of nitric acid and chalk. Unlike elementary fire, it could burn cold, within water, and without air. It did display a curious relationship to air, since air turned it to a liquid. One of the main features distinguishing Balduin's phosphor from the "constant phosphorus" later prepared by Krafft, Kunckel and others was considered by its inventor to be its most important asset. The light magnet could not shine on its own, but only when exposed to sun,

[31] cf. Lynn Thorndike, *A History of Magic and Experimental Science: The Seventeenth Century* (New York: Columbia University Press, 1958), vol. 8, 381.

[32] Balduin, *Aurum superius* (1675), 166.

[33] Christian Adolph Balduin, *Phosphorus Hermeticus, sive Magnes Luminaris* (Frankfurt: Frommann, 1675), [)(5]. "Quae dum mecum aliquotiens ponderarem, coepi eâdem operâ & de Lapide Luminari cogitare, & annon idem ex Materiâ nostrâ Universalissimâ possit parari. Quò quidem me passus Rationes istas adducere sum: quòd eidem Philosophicum Ignem scirem inesse."

[34] Balduin, *Phosphorus Hermeticus*, [)(5]: "Lumen esse reverà Ens extra lucem." J. B. Van Helmont, "Magnum Oportet," in *Ortus Medicinae. Id est, initia physicae inavdita …* , ed. Franciscus Mercurius van Helmont (Amsterdam: Elzevier, 1648), 156.

[35] Balduin, *Phosphorus Hermeticus*, [)(5v]. "Itaque ante paucos admodùm dies, cùm in conficiendo Alkahest studium atque operam posuissem, destillatione peractâ, Retortam vitream, frigefactam, intùs deprehendi lucere, candentis ferri in modum, effectamque Lapidem Luminarem. Credibile erat, praestitisse, quod videram, meum *Alkahest*; qui penetrasset. Mirabilitatem verò Naturae!"

candlelight, or warmth. This, to Balduin's way of thinking, was evidence of its "magnetic" qualities. As he wrote to the Secretary of the Royal Society, Henry Oldenburg, in a letter published in the 1676 *Philosophical Transactions*, his light magnet contained "a real spark of the fire and light of nature." By February 1677, Balduin had been elected to the Royal Society in honour of his discovery.[36]

Although Balduin was a Fellow of the Society, an important source for later unsympathetic accounts of Balduin's texts can be found in the Society's journal. The 1809 abridged edition of the *Philosophical Transactions* offered an English translation of Balduin's letter. An editor (either Charles Hutton, George Shaw or Richard Pearson) noted that Balduin had "dissolved a quantity of chalk in nitrous acid" for "some purpose or other," and thus "the discovery of this chemical phenomenon" was "wholly accidental." The translator added that Balduin's letter represented "a tolerable specimen of the absurd mode of philosophising among the chemical or rather alchemical writers at this period of time."[37] These views were the source for E. Newton Harvey's dismissive account of Balduin's writings in Harvey's authoritative *History of Luminescence*, cited above.[38]

Boyle's 1674 *Suspicions*

While Boyle and Balduin have often been distinguished in studies of phosphors, Boyle's 1674 *Suspicions about some Hidden Qualities in the Air* might be compared to Balduin's 1673 *Aurum Aurae*. Lawrence Principe has suggested that more attention be directed to this tract, especially given its relevance to the ideas Newton was developing concerning "magnetic effluvia" in 1675.[39] John Henry has deployed it in order to offer a re-interpretation of Boyle's position concerning mechanism. *Suspicions*, he argues, addresses far more directly some hints Boyle had offered in his 1671 *Cosmical Qualities* about exotic corpuscles with occult qualities, whose existence might be proven through the manifest phenomena they caused.[40] If

[36] Royal Society Archives, EL/O2/173. A. Rupert Hall and Marie Boas Hall, eds., *The Correspondence of Henry Oldenburg* (London: Taylor & Francis, 1986), vol. 14, 65 and 175. Christian Adolph Balduin, "Extract of a Letter Written to the Publisher, Concerning a Factitious Stony Matter of Paste, Shining in the Dark like a Glowing Coal, after it Hath Been a Little While Exposed to the Day-or Candle-Light," *Philosophical Transactions* 11 (1676), 788. "Latet in Phosphoro isto ignis & luminis Naturae realis scintillula, imò secretissima anima, proindeque intrinsecus atque invisibilis Sophorum ignis, visibilem Solis ignem magneticâ ratione attrahens, splendoremque ipsius vicissim in Tenebris emittens ejaculansque."

[37] Christian Adolph Balduin, "A Letter from Christianus Adolphus Balduinus to Mr. Oldenburg, Secretary of the Royal Society," *The Philosophical Transactions, Abridged*, eds. Charles Hutton, George Shaw and Richard Pearson (London: Baldwin, 1809), vol. II, 368.

[38] Note 6, *supra*; Harvey, *Luminescence*, 321: "Baldewein's translators have all complained of his enigmatic language, known only to those initiated in the mysteries of alchemy." Harvey, note 26, cites the translation of Balduin's excerpted letter in the 1809 *Philosophical Transactions*, which is in fact the only translation Balduin's works have received. Harvey's description of Balduin as "devoted to the fashionable pursuit of alchemy" is also taken *verbatim* from the editorial note in the 1809 *Philosophical Transactions*, as is the incorrect date of 1673 for Balduin's discovery of the phosphor.

[39] Lawrence M. Principe, "Robert Boyle's Alchemical Pursuits," in *Robert Boyle Reconsidered*, ed. Michael Hunter (Cambridge: Cambridge University Press, 1994), 91–105; Betty Jo Teeter Dobbs, *The Foundations of Newton's Alchemy or 'The Hunting of the Greene Lyon'* (Cambridge: Cambridge University Press, 1975), 204.

[40] John Henry, "Boyle and Cosmical Qualities," in *Robert Boyle Reconsidered*, ed. Michael Hunter (Cambridge: Cambridge University Press, 1994), 91–105; 119–38.

understanding *Suspicions* can shed light on Boyle and Newton's views concerning the actions of corpuscles not defined only by size, shape, and motion, then it should also be helpful to understand Boyle's essay in the context of the wider debate concerning celestial magnets, including Balduin's *Aurum Aurae*.

It is even possible Boyle rushed *Suspicions* into print due to Balduin's 1673 *Aurum Aurae*. Hunter and Davis have suggested that "the similarity between the ideas put forward here by Boyle and those divulged by John Mayow in his *Tractatus quinque* of the same year [1674] ... may have acted as stimulus to put long-composed writings into print, as in other comparable cases";[41] if Mayow's 1674 treatise could offer such a stimulus, then Balduin's 1673 work may have done so as well. Boyle's "notorious sensitivity" concerning credit encouraged his "habit of rushing into print."[42] However, Boyle does not, by and large, refer to his sources. He only notes that "some years ago" he had begun to set down observations and experiments concerning the air arranged according to various titles.[43] Because he believed that this particular title might afford "hints" to others, he now excerpted it from the rest and published it (the rest of Boyle's collections on the history of air would not appear until 1692, in a still very unfinished state).[44] It would thus be difficult to argue that Boyle drew directly upon Balduin. He merely mentions "some of the mysterious writers about the Philosophers-stone" and the "mystical Theories of the Chymists."[45] It was appropriate to "discourse like a Naturalist" concerning the phenomena they broached, such as "Magnets of Celestial and other Emanations," since such phenomena were not considered "either by the Scholastic, or even the Mechanical, Philosophers."[46]

Like Balduin, Boyle argued that the "Atmosphere" is a "great receptacle or rendevouz of Celestial and Terrestrial Effluviums," some of which might possess as yet undiscovered and powerful virtues.[47] He also suggested that the air itself might transform these particles, acting as a *Menstruum*, which may be illustrated by phenomena such as the natural production of verdigris from copper (a preparation normally artificially produced through vinegar).[48] He further discussed a phenomenon "not so much as mention'd by Vulgar Philosophers, and very rarely, if at all, to be met with in the Laboratories of Chymists," that is, the efflorescence

[41] Robert Boyle, *The Works of Robert Boyle*, ed. Michael Hunter and Edward B. Davis (London: Pickering & Chatto, 2000), vol. 8, xv.

[42] For "notorious sensitivity," see Harriet Knight and Michael Hunter, "Robert Boyle's Memoirs for the Natural History of Human Blood (1684): Print, Manuscript and the Impact of Baconianism in Seventeenth-Century Medical Science," *Medical History* 51 (2007): 145–64, on 150. For "habit of rushing into print," see Peter Walmsley, *Locke's Essay and the Rhetoric of Science* (Cranbury, NJ: Associated University Press, 2003), 88. See also Michael Hunter, *Robert Boyle (1627–91): Scrupulosity and Science* (Woodbridge: Boydell Press, 2000), 137–38, 219–21.

[43] Robert Boyle, *Tracts containing Suspicions about some Hidden Qualities of the Air; with an Appendix touching Celestial Magnets, and some other Particulars* (London: Pitt, 1674), [A2].

[44] Boyle, *General History of the Air.*

[45] Boyle, *Tracts*, 48 and 50.

[46] Boyle, *Tracts*, 51.

[47] Boyle, *Tracts*, 5.

[48] Boyle, *Tracts*, 7–8.

of vitriol upon pyrites exposed to the air, a phenomenon also discussed by Balduin. It may be suspected, he wrote,

> that the formerly mention'd Salts found in Marchasites, in Nitrous and Aluminous Earths, &c. are made by the saline particles of the like nature, that among multitudes of other kinds swim in the Air, and are attracted by the congenerous particles that yet remain in the Terrestrial bodies, that are, as it were, the wombs of such Minerals.

Thus, Boyle suggested, as had Balduin, that magnetism could offer a means for elective affinity. Another possibility could be that the aerial salts, assisted by humidity, might release latent saline particles already hidden with these bodies.[49]

The death of hot animals deprived of air strongly suggested that some "vital substance" was "diffus'd through the Air," whether it be "a volatile Nitre, or (rather) some yet anonymous substance, Sydereal or Subterraneal."[50] Certainly, aerial effluvia might be responsible for widespread plagues, especially those targeting particular species, such as cats.[51] He wondered whether the dissolution of sunspots might be found to have an effect upon the weight of the air, as the solar material was thrown off into it. As evidence for interaction between celestial and terrestrial matter, Boyle noted that "the Sun will impart a lucidness to the *Bolonian* stone."[52]

Thus, Boyle shifted to the possibility of building celestial magnets which might serve as "Receptables, if not also Attractives, of the Sydereal, and other exotic Effluviums that rove up and down in our Air."[53] Without "receding from the Corpuscularian Principles," bodies could be spoken of as having "a greater resemblance to Magnets, than what I have been mentioning," via "a kind of precipitating faculty" which could "fetch in such steams as would indeed pass near it, but would not otherwise come to touch it."[54]

Boyle continued to develop this idea in his next essay, "Of Celestial & Aerial Magnets," which was devoted primarily to experiments upon vitriol. He cited Zwelfer on the colcothar of vitriol, a phenomenon that Balduin also cited and attributed to Maignan (although Balduin cited Zwelfer for other reasons).[55] Zwelfer hypothesised that the renewed bitterness of colcothar exposed to the air might arise from a salt, or exhalations, attracted out of the air into the colcothar.[56] Boyle tried this, but it did not work for him, perhaps due to "the peculiarity in

[49] Boyle, *Tracts*, 20–21.
[50] Boyle, *Tracts*, 27.
[51] Boyle, *Tracts*, 40.
[52] Boyle, *Tracts*, 47.
[53] Boyle, *Tracts*, 48.
[54] Boyle, *Tracts*, 49–50. Henry also cites this passage, "Boyle and Cosmical Qualities," 126.
[55] Boyle, *Tracts*, 57.
[56] Johan Zwelfer, *Animadversiones in Pharmacopoeiam Augustanam* (N.A.: By the author, 1652), 408: " … si optimè calcinatum & omninò â *spiritibus* liberatum fuerit, penitùs non sit corrosivum, neque (quod saepè expertus sum) statim à destillatione *sal* ex eodem affusâ aquâ elici queat, sed tùm priùs, ubi aliquandiu aëri expositum fuerit, tunc enim *sal* preabet quandoque candidum, quandoque purpureum, aspectu pulcherrimum, quod aliquandiu in copia acquisivi, & penes me asservo, quandoque etiam *nitrosum* … licet deinceps, ubi aliquandiu *astris & aëri* expositum fuerit, ab attracto *sale* ex aëre vel exhalationibus in eo contentis, aperitivam virtutem nanciscatur."

the Air in that part of London."[57] He also suggested further experiments, including weighing pyrites exposed to air, Balduin's very experiment. He did not give many details, "for certain reasons," but advertised that,

> several bodies, which experience has assur'd us do imbibe or retain something from the Air, as some calcin'd Minerals, some Marchasites, some Salts, as well factitious as natural, &c. may be fit to be often exposed to it, and then weighed again, and farther diligently examined, whether that which makes the increment of weight, be a meer imbibed moisture or also somewhat else.[58]

Reception of *Aurum Aurae* and "Phosphorus Hermeticus"

Despite Balduin's election to the Royal Society, little discussion of his theories can be found in the work of its English members. While Boyle, for instance, deployed Balduin's phosphor at length in observation and experiment in his 1680 *Aerial Noctiluca*, he did not address Balduin's theories.[59] The extract of Balduin's letter to Oldenburg published in the *Transactions* passed without comment on its content. We find only the wish expressed that Balduin would share his recipe for the magnet with the Society.[60] The neglect of open discussion of Balduin's theories can be seen further in the review of the 1676 issue of the German Academy's journal published within the *Philosophical Transactions* of the Royal Society that year. The review passed over the content of *Aurum Aurae* in silence. It briefly recorded a list of phenomena from the appendix, the "Phosphorus Hermeticus," instead.[61]

By contrast, Balduin's theoretical views of his phosphor were much discussed on the continent. Balduin's 1675 edition of *Aurum Aurae* and his 1675 "Phosphorus Hermeticus" were both printed in the journal of the German Academy in 1676, together with several other observations by Balduin and assorted responses to his work. Friedrich Hoffmann published a review of *Aurum Aurae*, and Christoph

[57] Boyle, *Tracts*, 60.

[58] Boyle, *Tracts*, 54–55.

[59] Robert Boyle, *The Aerial Noctiluca: or Some New Phoenomena and a Proces of a Factitious Self-shining Substance* (London: Snowden, 1680). Robert Boyle, "A Paper of the Honourable Robert Boyl's, Deposited with the Secretaries of the Royal Society, Octob. 14. 1680. and Opened Since His Death; Being an Account of His Making the Phosphorus, etc.," *Philosophical Transactions* 17 (1693): 583–84.

[60] Balduin, "Extract of a Letter," *Philosophical Transactions* 11 (1676), 789.

[61] Anon., "An Account of some Books: I. *Ephemeridum Medico-physicarum Germanicarum* ANNUS IV & V, Anni 1673 & 1674, &c. Cum Appendice: Francofurti & Lipsiae, 1676," *Philosophical Transactions* 11 (1676), 744: "Some observations of Dr. Balduin; concerning 1. the Regermination of Silver, by a new artifice; 2. the Urns of the pagan *Germans*. 3. a Factitious stone, shining in the dark, after it hath been a while expos'd to the Sun, as the natural *Bolonian* stone is said to do, though that artificial one is affirmed to do it in a more excellent manner, forasmuch as, when after the imbibition of the Solar light it is cast into a glass-full of Spirit of Niter, it doth notwithstanding shine in the dark; and that more is, when 'tis taken out of the said liquor, and dried again in the dark to make it lose its light, and then put again into a glassfull of cold water, and exposed to the day-light, it will for all this resume a splendent brightness even in the cold water itself: Again, being again taken out of the cold water and dried, and deprived of its light in the dark, and then put into a hot oven, it will there recover its light, though the room be dark. There is further mention'd and described in this work Dr. *Mentzelius* his Tract, comparing this Shining stone of D. *Balduin* with that of *Bolonia*."

Mentzel contributed a long disquisition on the many ways in which the "Phosphorus Hermeticus" surpassed the Bologna stone (this was also published separately at Mentzel's expense).[62] Mentzel connected Balduin's phosphor back to Balduin's prior published theories on the universal magnet, as did other German commentators.[63] He also pointed out that the internal form of the Bologna stone, published in the journal, was similar to the stellar form of the universal magnet from which Balduin produced his "Phosphorus Hermeticus" (Figure 2).[64]

Elsewhere, others cited *Aurum Aurae* for both its theoretical content and the experimental phenomena it described, including but not limited to the light magnet.[65] In England, however, Edmund Dickinson referred to the "Aurum Aurae" of the Hermetic philosophers, but did not cite Balduin by name.[66] Giovanni Francesco Vigani, future professor at Cambridge, cited the *Aurum Aurae* of "the learned Rudolphus [sic] Balduinus" in 1682, although Vigani was a new arrival in England at the time.[67]

Balduin himself continually connected his phosphor to his theories regarding the existence of celestial effluvia in the air, the material nature of light, and the magnetic action of diverse kinds of atoms, all of which he argued, could be proven through observation and chymical trials. In a 1677 work concerning a chrysocolla supposedly produced by a lightning bolt, Balduin connected *Aurum Aurae*, the phenomenon of the light magnet, and the further evidence supplied by this object (which he subjected to eighteen chymical trials) in support of the existence of aerial "metallic atoms" (*metallicae atomi*).[68]

The interest in the theoretical content of *Aurum Aurae* is further illustrated by the fact that Balduin's 1674 edition of *Aurum Aurae* (not yet updated with his discoveries of 1673) was published by none other than Johann Sigismund Elsholz (1623–1688). Elsholz did so, according to an epilogue, due to the "novelty of its argument."[69] Elsholz, the court physician in Berlin, is a familiar figure in the history of phosphorus, for he witnessed the presentation by Johann Daniel Krafft,

[62] Friedrich Hoffmann, "Epistola viri cujusdam doctissimi continens Judicium e Auro Aurae," in *Appendix* (Frankfurt: Fritzsch, 1676), 173–79; Christian Mentzel, "Lapis Bononiensis in obscuro lucens, collatus cum Phosphoro Hermetico," *Appendix* (Frankfurt: Fritzsch, 1676), 180–214; and Mentzel, *Lapis Bononiensis In obscuro lucens : collatus Cum Phosphoro Hermetico Clariss. Christiani Adolphi Balduini, cognomine Hermetis, &c. nuper edito* (N.A.: By the author, 1675).

[63] See also Georg Caspar Kirchmaier, *De phosphoris et natura lucis* (Wittenberg: Ellinger, 1680), 8–9.

[64] Mentzel, "Lapis Bononiensis" (1676), 214.

[65] Those citing *Aurum Aurae* included Augustus Quirinus Rivinus, *Agrestis vitae sanitas* (Leipzig: Georg, 1677), [B2]; Caspar Cramer, *Collegium Chymicum* (Frankfurt: Erth, 1688), 47, 99, 117. At p. 9, Cramer deploys the Bologna stone and Balduin's light magnet to support a more general theory of universal motion.

[66] Edmund Dickinson, *Physica Vetus et Vera* (London: Ribotteau, 1702), 142.

[67] Giovanni Francesco Vigani, *Medulla Chymiae* (Danzig: Waesberge, 1682), 11. Vigani republished the work in London in 1685. Simon Schaffer and Larry Stewart, "Vigani and After: Chemical Enterprise in Cambridge 1680–1780," in *The 1703 Chair of Chemistry at Cambridge: Transformation and Change*, ed. Mary Archer and Christopher Haley (Cambridge: Cambridge University Press, 2005), 31–56, on 32.

[68] *Venus Aurea (in forma Chrysocollae fossilis) cum fulmine coelitus delapsa prope Haynam d. 28. Maii, 1677* (Hayn: Kramer, 1677), 44. Those citing the *Venus Aurea* included Johann Moritz Hoffmann, *Acta laboratorii chemici Altdorfini* (Nürnberg: Tauber, 1719), 131–32 and 185–87 and Michael Ettmuller, *Opera medica theorico-practica* (Frankfurt: Zunner, 1708), vol. 1, 754, 796 and 864.

[69] Balduin (1674), epilogue: "novitate argumenti."

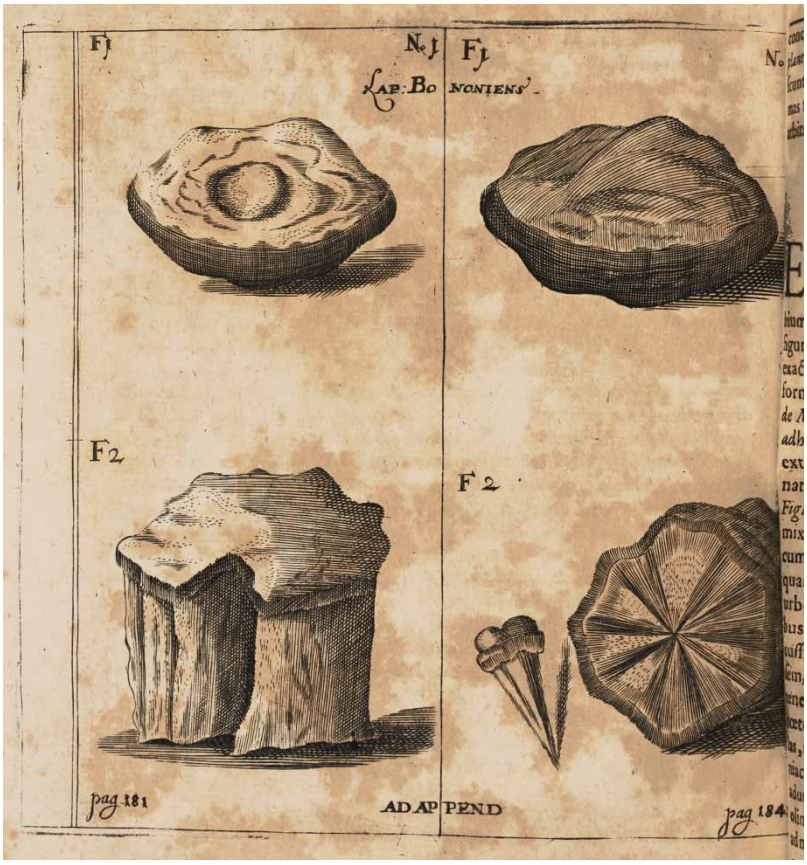

FIGURE 2 The Bologna stone, in Christian Mentzel, "Lapis Bononiensis in obscuro lucens, collatus cum Phosphoro Hermetico," *Appendix ad annum quartum et quintum ephemeridum medico-physicarum naturae-curiosorum in Germania* (Frankfurt & Leipzig, 1688). The lower right-hand corner shows the starry interior, which Mentzel compared to Balduin's universal magnet. With permission of the Linda Hall Library of Science, Engineering & Technology.

councilor of commerce to the Saxon elector, of four different phosphors at the Berlin court. Elsholz published his observations on the four in 1676.[70] He re-issued Balduin's *Aurum Aurae*, however, before Balduin discovered his phosphor, and due to Balduin's ideas alone.

To both Balduin and his German commentators, the production of his phosphor was not an accident, but the product of his research into non-obvious sources of the fire of nature, or the "inferior gold" hidden in the air. It further confirmed his theoretical commitments, including atomism. In his "Phosphorus Hermeticus," Balduin argued that the fact that his phosphor could be illuminated not only by the sun and the moon, but also by the weak light of a candle, supported the atomic theory. Although candles need to be kindled directly by a source, his light magnet

[70] Johann Sigismund Elsholz, *De phosphoris quatuor, observatio* (Berlin: Schultz, 1676).

could be kindled by the light of a candle even from afar, "for the fire hidden within my Phosphor attracted the light, or rather, fiery atoms, and thus made it shine … through this experiment, the doctrine of atoms can be established."[71]

In his history of phosphors, Leibniz presented Balduin's phosphor as an important event in debates concerning the corpuscular nature of light. He described how Balduin found that his phosphor would,

> imbibe the light, when expos'd thereto, and retain it for some time, and carry it along with it into a dark place, as a sponge does the water it has imbib'd. This experiment did not a little startle the *Cartesians* (very few of whom had seen the *Bolognian* stone) that light should of a sudden become a gross and portable thing, whose rays they suppos'd to consist in pression only, and to be propagated in an instant of time. Balduin concealedly describ'd his experiment in a treatise, entitled *Aurum Aurae*.[72]

Conclusion

Phosphors were extraordinarily prominent subjects in early scientific journals, with articles on the topic published in the *Philosophical Transactions*, the *Miscellanea Curiosa*, and the *Acta Eruditorum*. Leibniz published his history of the discovery of phosphorus in the very first issue of the journal of his Berlin Academy. The role of phosphors as a subject of learned debate illustrates the centrality of alchemy to the institutionalisation of experimental natural philosophy.[73] The reception of phosphoric research was very uneven, however. The English reception of Balduin, which celebrated and rewarded his phosphorus while neglecting his wider views concerning aerial atoms, has shaped current historiographic views. When reading, for example, Boyle's 1674 *Suspicions* or 1680 *Aerial Noctiluca*, it may seem as though Balduin produced the object, and Boyle the theory. This is indeed the view of one account of the history of seventeenth-century phosphorescence, according to which both the Bologna stone and Balduin's phosphor served as objects which more recognised scientific figures, such as Boyle, Newton and Lémery, might use to experiment and theorise upon; "the Bolognese stone and Baldwin's phosphorus became objects of the experimental verification of the corporeity of light, of the attraction between light and the rest of the substances and its blending with them."[74] Golinski has likewise distinguished between Balduin's "occult" understanding of phosphorus and the mechanistic views of the English Fellows of the Royal Society, arguing that if "English experimenters thought of phosphorus in the same [magnetic] way, they did not say so." In fact,

[71] Balduin, *Phosphorus Hermeticus*, [)(6v]: "Et reconditus tamen in isthoc *Phosphoro* meo ignis attrahit Lumen, vel atomos igneas, efficiturque, ipse ut luceat. … Quô experimentô Doctrinam de Atomis stabiliri liceat."

[72] G. G. Leibniz, "Historia inventionis Phosphori," *Miscellanea Berolinensia* 1 (1710): 91–92. Translation from Leibniz, "The History of the Invention of the Phosphorus," *Acta germanica* (London: Smith, 1742), 73.

[73] Golinski, "A Noble Spectacle," 11.

[74] Susana Gómez, "The Bologna Stone and the Nature of Light," *Nuncius* 6 (1991): 3–32, on 22.

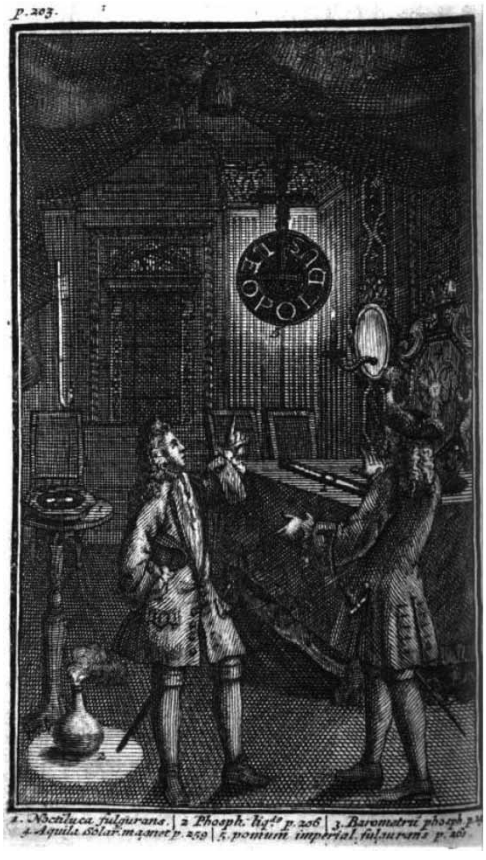

FIGURE 3 A later reconstruction of Balduin's phosphoric inventions for the Habsburg *Kunstkammer*. Johann Cohausen, *Lumen Novum Phosphoris Accensum, Sive Exercitatio Physico-Chymica, De Causa lucis in Phosphoris tam naturalibus quàm artificialibus* (Amsterdam: Oosterwyk, 1717), 203. With permission of the Linda Hall Library of Science, Engineering & Technology.

Boyle had already discussed the "*Bolonian* stone" in his 1674 essay on celestial magnets.[75]

Historiographically, Balduin's phosphor has been divided from his theories. Balduin and some of his Central European contemporaries, however, drew connections between the way the light magnet functioned and his more general theories concerning universal magnetism and chymical atomism. The light magnet was but one of several phenomena he described in the course of his experimentation upon aerial particles.

This is not to say that Balduin ignored the phosphor's particular potential for spectacle. He invented a number of wonderful phosphoric automata advertised in his *Hermes Curiosus*, published in two editions in 1680 and again in the journal

[75] Golinski, "A Noble Spectacle," 21. Boyle, *Tracts*, 47.

of the *Academia Naturae Curiosorum* in 1683. Balduin's automata included a Hapsburg eagle which rose and glowed with the sun, a luminescent imperial orb upon which the name "LEOPOLD" shone, and a barometric, time-telling perpetual motion device complete with an artificial sun (Figure 3). Even in his description of these curiosity objects, however, Balduin carefully placed them in the context of current theoretical debates, as befitted one who was a member both of the *Academia Naturae Curiosorum* and the Royal Society. For example, in describing his fourth invention, a shining glass sphere, Balduin referred to a 1666 article in the *Philosophical Transactions* "of our Royal Society," on the loss of the preparation of the Bologna stone. Balduin had invented something of much greater power than the Bologna stone, however, which he used in his solar eagle, in his shining imperial orb, and in a fiery Vertumnus, but he was not content with these. He wondered whether it might be possible to attract the fire or light from the human heart through the light magnet. The flame of the heart was much discussed by contemporary physicians, such as Jacob Holst, Walter Needham, and the illustrious Robert Boyle, he said, connecting the object to contemporary medical debates. When inserted into the mouth, his glass sphere would start to glow when heated by bodily heat. Suspended from the neck of a woman, it would glow between her breasts.[76]

The practical applications of phosphors were immediately recognised. Boyle suggested they could be used as a lighting source in the powder rooms of ships, or to attract deepwater fish, to show the hour on a clock at night, and so on.[77] The fact that the white phosphor was prepared out of inexpensive (indeed, waste) materials recommended it to commercially minded chymists such as Krafft and Kunckel. As the cameralist and chymist Wilhelm von Schroeder wrote, "he who can make a menstruum out of the spirit of urine can produce strange effects, such as the perpetual light [that is, the phosphor] and the like, which other and more expensive tinctures cannot effect."[78] Neither the practical nor the spectacular applications of phosphors detracted, however, from their deployment by chymists such as Balduin in debates concerning matter theory.

The phosphor illuminates the interface of commerce, theory and curiosity prominent in the research programs of seventeenth-century scientific societies. As the case of Balduin has shown, it is not at all the case that "the interest of these chemists or alchemists was of a very different nature than that of the mechanicist and corpuscularist philosophers that inquired about the nature of light or heat and attempted to explain it in mechanical terms of matter and motion," such as Boyle.[79] Seventeenth-

[76] Christian Adolph Balduin, *Hermes Curiosus sive, Inventa et experimenta physico-chymica nova* (Leipzig: Frommann, 1680), 17–19.

[77] Boyle, *Aerial Noctiluca*, 19–20.

[78] Wilhelm von Schroeder, *Wilhelm Freyherrn von Schrödern Fürstliche Schatz- und Rent-Kammer nebst seinem Nothwendigen Unterricht vom Goldmachen* (Leipzig: Fritsch, [1684], 1705), 62: "Dann zum exemple: diejenige, so ein menstruum aus dem Spiritu urinae machen treffen in ihrer arbeit viel seltsame effectus an, als de lumine perpetuo und dergleichen, welche andere, und zwar köstlichere tincturen nicht zu wege bringen können."

[79] Gómez, "Bologna Stone," 8.

century theories concerning phosphors have been seen as posed "in terms clearly alien to those of modern chemistry."[80] Those terms differed, of course, but they were more constitutive of modern chemistry than alien to it.

Notes on contributor

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[80] Gómez, "Bologna Stone," 4.