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The first scientific description of aurora borealis: the 10 September 1580 event in Transylvania, recorded by Marcello Squarcialupi

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Abstract

The first scientific treatise on aurora borealis was published by Marcello Squarcialupi, an Italian medical doctor working in the court of the Hungarian Prince of Transylvania. His book, *De coelo ardore*, described the aurora of 10 September 1580 in great detail, providing exact data from his personal observations on the time, direction, shape, colour, and variability. He invoked a rational explanation, bringing up only natural causes, and confronted these with the ruling Aristotelian view. The original Latin text describing the aurora is provided, with an English translation.

Keywords: Aurora borealis, Marcello Squarcialupi, Transylvania, Hungary, *De coeli ardore*, English translation, Early modern science, Protestantism, Unitarian

Background

Aurora borealis, the northern light or polar light, if appearing in middle or low latitudes, was a feared phenomenon in the Middle Ages and beyond, carrying ominous meanings, foreshadowing menacing changes for the future. Exact descriptions, although existing since the fourteenth century (Schröder 2006; see also the discussion by Silverman 2007; Schröder 2007), are rare and do not go beyond a kind of literary exercise.

In the present paper, we introduce a treatise, which describes an auroral event by a contemporary witness with attention to scientific detail. This is the book titled *De coelo ardore* by Marcello Squarcialupi (1581a, b). We provide the original Latin text and an English translation the first time, and put his observations in context.

Marcello Squarcialupi (~1538–1592/1599)

Marcello Squarcialupi was born in Piombino (Tuscany, Italy) in about 1538. He studied medicine in Padua. Becoming a Protestant (anti-trinitarian or unitarian)

heretic, he had to leave Catholic Italy. He lived first in Basel (Switzerland), then moved to Transylvania and stayed there from 1580 to 1585 as medical doctor in the court of Voivode Christopher (Kristóf) Báthory (1530–1581). He was responsible for the education of the Voivode's son, Sigismund (Zsigmond) Báthory (1572–1613). Later he lived in Poland and Switzerland until his death in Poschiavo in 1592 or 1599 (Balázs and Waczulik 1994; Bundi 2006; Masi 2013:33–39).

Squarcialupi published several works: amongst others an essay on comets (*De cometis dissertationes novae clarissimae*, Erastus et al. 1580); a textbook of moral concepts for the benefit of the young prince (*M.T. Ciceronis eloquentissimi et sapientis viri moralis definitiones. Et in easdem schola philosophica*, Claudiopoli, Helti, 1584) (Borsa et al. 1971, nr. 546); and a treatise on subterranean waters: *De fontium et fluviorum origine*. Claudiopoli, Helti, 1585 (Borsa et al. 1971, nr. 567; Holl 1969).

De coeli ardore

The study we discuss in the following is on the observations of 'celestial fire': *De coeli ardore* (Cibinii, Greus, 1581). This book is extremely rare, known only in two copies: one is in the Brukenthal Museum in Sibiu,

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Romania, whilst another is in the Bibliothèque Nationale in Paris. Both are incomplete: the Sibiu specimen misses some parts of the text, and both lack the woodcut illustration referred to (Borsa et al. 1971, nr. 498). This is known only in the second edition printed in Cracow: *De coeli sive aeris ardore* (Alexii Rodecii, Cracoviae) (Przykowski 1959). Fortunately, the critical part describing the aurora is preserved in full in the Sibiu copy. We studied it on microfilm, kept in the National Széchényi Library in Budapest, Hungary (call number 385. FM 2/2962).

The title page is this: *De coeli ardore, hoc anno 1580. X. Septembris die in Dacia viso. Marcelli Squarcialupi illustriss. Princip. Transylvaniae etc. Archiatri opinio. Cibinii MDLXXXI Gregorii Greus*. The booklet contains 14 unnumbered pages.

A short preface is followed by four chapters. Chapter 1. Aristotle and others on celestial fire. Opinion of the author. Ch. 2. On the celestial fire: parts, time, place, shape, colour and varieties. (See Latin text and English translation in Appendix.) Ch. 3. Causes of the celestial fire. Ch. 4. Effects of the celestial fire; real and fake miracles; morals of this book. A conclusion follows (which is partly missing in the copy we studied).

The original Latin text of Chapter 2 is reproduced in the Appendix below. We add an English translation, supported by two Hungarian editions of this chapter by Kelecsényi (1979) and Waczulik (1984, pp. 117–121).

Discussion

Squarcialupi used the term *ardor coeli* (Latin: fire of the sky). This has been a common term for any luminous phenomena of the night sky since Antiquity (Stothers 1979). The term *aurora borealis* was coined after Squarcialupi's time, either by Galileo in 1619 or by Gassendi in 1649 (Siscoe 1978). It means 'northern dawn' in Latin, the language of science in that age, relating to its nightly appearance on the northern sky. We maintain using it in an anachronistic way for the benefit of the reader.

The auroral event of 10 September 1580

It is noted here that the date of 10 September 1580 as mentioned in the title of the book is the date of the auroral event in the Julian calendar, equivalent to 20 September 1580 in the Gregorian calendar.

Squarcialupi was the first to publish a detailed, scientific report of an auroral event. His booklet appeared in print in January, 1581. Maestlin, a contemporary astronomer, discussed the same aurora of 10 September 1580 and another, the 16 February 1581 event in a single treatise; therefore, his book (Maestlin 1581) certainly appeared after Squarcialupi's. (Any other, earlier or later auroral observations in Hungary are listed in the catalogue of Réthly and Berkes 1963).

Squarcialupi provided a solid, detailed scientific description: he provided (1) time in hours from sunset to sunrise, (2) directions (northeast, southwest, etc.), (3) descriptors of shapes (rays, clouds, etc.), and (4) described colours. He repeated data as necessary to provide record of changing variations. The significance for the development of science lies in the fact that he dedicated his book to prove that celestial fires can be described and interpreted by rational means only.

Locations where the event was recorded extend from Switzerland in the west through Germany and the Czech lands as far as Transylvania in the east. Fritz (1873, p. 22) and Link (1963, pp. 369–370) provide a list where the auroral event was seen and recorded. These are as follows (reference to original sources in parentheses):

- Switzerland: Zürich and Glarus (Scheuchzer 1746, p. 75).
- Germany: Bavaria, Augsburg (an illustrated broadside of Kaeppler 1580, reproduced by Paech 2009 ad Beer et al. 2012; see also Scheuchzer 1746).
- Germany, Baden-Württemberg, Backnang (Maestlin 1581).
- Germany, Brandenburg and Berlin (Maestlin 1581; Gronau 1794).
- Bohemia: Trautenau (today Trutnov in Czech Republic) (Hüttel 1881).
- Bohemia: Leitmeritz (now Litoměřice, Czech Republic) (Katzerowsky 1886).
- Gyulafehérvár (Latin: Apulum, German Karlsburg or Weissenburg, Romanian Alba Iulia, Hungarian Gyulafehérvár; now in Romania): Squarcialupi (1581a, b).

None of the cited descriptions are as detailed and as comprehensive and logically presented as that of Squarcialupi. The *De coeli ardore* is one of the first natural history books in the modern sense.

Why did the Italian medical doctor study the sky and publish his observations in Transylvania? There are two major reasons: one regards religion, whilst another the peculiar situation of Transylvania after Ottoman Turkey occupied much of Hungary in 1541.

The Principality was well known for religious tolerance. John Sigismund Szapolyai (1540–1571), the elected king of Hungary, made the diet of Torda to accept a law on religious freedom in 1568, the first such one in Europe. The king himself joined the Unitarian faith. Catholics, Lutheran and Calvinist protestants, and the Unitarians (a version of anti-trinitarians in Poland and Transylvania) lived in peace and their priests were allowed to preach undisturbed. This unusual freedom attracted those in Europe who were prosecuted for their faith. Additionally,

the highly educated King (he studied in Italy for a couple of years, he was fluent in eight languages) maintained a vibrant cultural life in the court, which was effectively the royal court of Hungary. The presence of several Italians (ranging from medical doctors to commander of the guard) in high positions can be explained by the studies of King John Sigismund in Italy and the strong political ties there (Barlay 1986:77–93). Humanists, like Squarcialupi, considered its high level of culture and religious freedom as special place negotiating knowledge.

Squarcialupi arrived to Transylvania upon the invitation of the ruling voivode, and felt compelled to engage in science beyond fulfilling his medical and educational duties. While there, he published the *De coelo ardore* soon upon his arrival. Just before his departure he published another natural history book, the *De fontium et fluviorum origine* (1585). This is still awaiting scientific assessment.

The interpretation

In Chapter 1, Squarcialupi reviewed previous works on celestial fire. He emphasized that the custom of uncritical reference to authorities has to be replaced by detailed examination of natural phenomena. Naïve credibility is to be substituted by reliable observation. Any opinion formulated must be supported by convincing arguments. In Chapter 3 is written that although naturalists call the phenomenon as celestial fire, it has nothing to do with the skies or stars. The sky cannot burn; it is a figurative expression only. The phenomenon seen on 10 September 1580 was in the atmosphere: exhalations and vapours were burning, together with the surrounding air, as long as material fuelling the fire was available. This is fundamentally an Aristotelian view (Kelecsényi 1979; see Stothers 1979:88 on Aristotle's explanation), supported with an enormous amount of observational details, never described before.

In Chapter 4, Squarcialupi emphasized that any relation of the celestial fire to divine miracles, action of wizards and demons must be refuted. It is a natural phenomenon, as much as clouds and rainfall are natural.

Conclusions

Marcello Squarcialupi in his book 'On the celestial fire of 10 September 1580' (*De coeli ardore...*) was the first to publish a scientifically valid description of aurora borealis, even by modern standards. The details he provided (time, direction, shape, colour, variability), and the reasoning he brought forward to emphasize its natural origin put him to the forefront of early modern science.

Authors' contributions

Authors shared research and writing the manuscript equally. Both authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Appendix

De coeli ardore, hoc anno 1580. X. Septembris die, in Dacia viso. Marcelli Squarcialupi illustriss. princip. Transylvaniae & c archiatri opinio. Impressum Cibinii. Transylvaniae, in officina Georgii Greus. Anno MDLXXXI. mense Ianuarij.

Caput secundum

Facendii partiumque, singularum eius loci, temporis, formarum, colorum, varietatis omnis descriptio

Hora post solis occasum prima, cum esset sudum, & magna coeli puritas, in silentio Lunae, in quo tenebrae sunt maiores, primum apparuit in obscurissimo coelo, ad Aquilonem diluta & subalbida quaedam lux, sub qua luce fuscendo quaedam, tanquam nebulae tenuioris protendebantur.

Incepit utrumquae apparere inter Aquilonem & Argestem, postea lux crescebat ad Fauonium, occasum in quam aequinoctialem, manente tamen in Septemtrione hebeti luce, & obscuro sub luce tractu. Quae duae colorum species, magis recedente sole, clarius apparebat, non solum ad Aquilonem, sed Caeciam & Eurum pertinentes. Erat forma utriusque coloris & lucidi & nebulosi tanquam in arcum fusa, & a lucido illo Aquilonis tractu nostrum Hemisphaerium illustrabantur, ut umbram corpora redderent. Hora noctis, sesquialtera, colores ad Fauonium, ac Circium varii, lutei dilutiones, purpurei, punicei. Qui colores, tum ex lucido illo, & longo, & stabili tractu erumpebant, tum in aere ipso procul a lucida plaga variis locis accendebatur. Species per se apparentes diutius durabant, ac deinde euanescebant, & subinde renouabantur. Colores autem qui e lucido surgebant tractu, radios referebant accedentis ad Orizontem Solis, perque nubium rimas eosdem radios emittentis. Qui radii surgebant in coelum pyramidis erant figura, & coloris

austeritatem, in summis partibus gradatim perdebant, fueruntque semper maiores, frequentiores, & magis coloratae species, & eruptiones usque ad horam nonam in Circii plaga, & Fauonii, quam Aquilonis, Boreae, & Subsolani.

Certissimum est omnia fuisse maiora, & creuisse puniceas maculas, quo longius ab Horizonte Sol ad medium coeli sub altero orbe rapiebantur. In tantum, ut media nocte, hora XI. & XII. punicei coloris, & pulcherrimi plane cruoris formae texerint dimidiam fere coeli partem. Et emicabant non raro in puniceis istis pyramidibus variae distinctiones, luteae, purpureae, tanquam vagarum a tremularum flammaram, quae ad coeli nostrum vertice, & polum, & lacteam viam interdum volitabant. Nequae tamen una forma ostendi diu manebat. Modo ad ortum, modo ad occasu pulchriores & maiores erant, flavae ac puniceae species areaequae. Demum in ipso septemtrione maximus quasi mons, cum basi fusa, & culmine acutiori extitit, totus puniceus ab imo arcus lucidi, utquae ad medium caeli porrectus.

Ibi, uti adumbravi pictura, haerebat croceus quidam fulgur, unde iri meridiem ad Euronothum, Nothum, & Libonothum puniceae nec magnae plagae tres aut quatuor declineabant. Luna & Sole adortum accedentibus remissio formarum & colorum est facta. Et hora circiter quarta post dimidiam noctem, nulla exsitit species. Atquae hoc factum est, Luna silente sub Libra, Sole vero in virgine ad mediam signiferi semitam, & aequinoctium autumnale delabente. Hactenus de specie visi. Videamus nunc singularum partium quae causae fuerint.

The English translation is based on the Latin original and two Hungarian translations of Kelecsényi (1979) and Waczulik (1984).

On the celestial fire, seen on 10 September 1580 in Dacia. Study of Marcellus Squarcialupi, chief medical doctor of the illustrious Prince of Transylvania. Printed in Sibiu, in the press of Georgius Greus, in the year of 1581, in the month of January.

Chapter two

The celestial fire—description of its parts, places, times, forms, colours, and varieties

In the first hour after sunset, in the fair sky in the north, whilst the new moon provided deep darkness, a faint, whitish light appeared. It was accompanied by brownish red cloud.

Both the white light and the brownish red cloud extended from north to southwest. Later, the white light spread westwards, towards the equinoctial point. These two, different colours became better visible later, when

the sun sank far below the horizon, extending from north to northeast, as far as southeast.

The light became so strong, that objects cast shadows. One-and-a-half hour after sunset light yellow, purple, and red colour appeared in the north and northwest. These colours radiated from the elongated light field. Additionally, flames appeared in various places, distant from the light-coloured field. These, seemingly independent features, lasted quite long, appearing again after a short break. Colours radiating from the light field were similar to sun rays radiating through openings in a cloud cover. These rays were projected on the sky in pyramidal form. Upwards the colour became gradually lighter. Large, dense and more colourful spots and eruptions appeared in the west, northwest, north and east. These lasted until the ninth hour.

The more the sun approached the zenith on the far side of the earth, the colours became the larger. At about 11–12 h, just before midnight, these beautiful purple spots grew so large as to look like the sky was dyed by gushing blood.

The pyramidal red rays, yellow and purple colours erupted repeatedly, quivering like flames. These reached the northern pole, even beyond that, as far as the Milky Way. Neither of the forms remained permanent. Either in the east or in the west larger and more fanciful yellow and purple lights and halos appeared. Finally, in the north, appeared an intense arc, purple in full, looking like a mountain in the sky, wide at the bottom, peaked at the top. Here, saffron-coloured light was attached. There were three smaller, purple spots to the south, southeast and southwest.

When the Moon and the Sun slowly appeared in the east, forms and colours decreased. About 4 h after midnight, there remained nothing to be seen.

When these phenomena were on display, New Moon was in the sign of Libra. Sun was in the Virgin, approaching the middle path of the Zodiac and the point of autumn equinox.

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