

A possible reference to the solar corona in a contemporary report of the AD1239 eclipse

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Abstract

The codex kept at the Arnamagnean Institute, in Copenhagen, with the number 805 4° (København, Det Arnamagnæanske Institut, Københavns Universitet, AM 805 4°), contains a combination of texts featuring legal and short historiographic pieces. In the latter we find a few astronomical references, among them a contemporary mention of the solar eclipse of June 3, 1239 containing what seems to be a reference to the solar corona. This reference could be added to the only other commonly accepted timed report of the corona from medieval times in the *Annales Sangallenses* regarding the total solar eclipse of the year AD968.

Keywords

Astronomical sources, medieval astronomy, solar corona, solar eclipses

Introduction

The solar corona is one of the most distinctive features of the solar disk. It is the outermost part of the Sun's atmosphere, and is usually hidden by the bright light of the Sun's surface because it is a million times less bright than the photosphere. It can only be seen when the disk of the Sun is blocked off in a total solar eclipse or by using a special instrument (a coronagraph) that artificially blocks the disk of the Sun so that the regions surrounding the Sun can be observed.

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Throughout history, we have many reports of total solar eclipses, but the references to the solar corona have been, with a single exception, questionable or vague. The eventual earliest dated mention of the solar corona in the solar eclipse of the year 1063BC had already been dismissed by Newton,¹ due to the dating errors included in the record. However, he accepts the possibility that it is a generic definition of a solar eclipse, and it may be the first description of the corona.

Later in 1980, Wang and Siscoe² examined some Chinese references to solar eclipses found not only in annals but also in poems, and proposed physical phenomena that could be related to visual phenomena observed during alleged total solar eclipses. In particular, the authors consider between the dated material three possible mentions of the solar corona numbered (1), (2), and (4) in their paper. The first reviews of the total eclipse of 1063BC again assuming that, while it is impossible to establish accurately the date of the total eclipse, there is a description of the solar corona or the solar prominences. In this regard, Stephenson³ quotes a translation by Prof. David N. Keightley according to which the record describes a meteorological phenomenon; The second is that of July 17, 709BC with a possible, though difficult to verify, reference to the crown also discussed by Stephenson.⁴ Reference (4) corresponds to the eclipse of January 1, AD1292, which was annular, so no reference to the corona could have been made.

In Western sources, the earliest reference to the solar corona during an eclipse seems to be in Plutarch⁵ (c. AD90) in describing an eclipse: (. . .) *a kind of light is visible about the rim which keeps the shadow from being profound and absolute*. Not all scholars accept that this text alludes to the corona. While Stephenson assumes, though not stating for sure, that Plutarch is narrating the eclipse of March 20, AD71, Golub and Pasachoff⁶ point to a slight annularity in addition to suggesting, as Newton⁷ did, that the description of the eclipse would correspond to a literary allusion and not to an actual eclipse.

For the sake of completeness, we should also mention the reference made by Eddy⁸ to a Philostratus (c. AD170–c. AD250) report in his *Life of Apollonius of Tyana*, written around AD210: *About the time that [Apollonius] was busy in Greece a remarkable phenomenon was seen in the sky. A crown⁹ like a rainbow formed around the sun's disk and partly obscured its light*. Eddy himself is skeptical, which is reasonable since, regardless of the historical veracity of the work, this phenomenon could refer to the eclipse of March 20, AD71, which was hybrid in Greece. Our suggestion is that Philostratus may be describing the eclipse of December 28, AD186, which was annular or partial, depending on whether he was in Rome or Athens, respectively, and in which the sun set before the end of the eclipse.

From that instance, there is a time gap in which, although there are many references to total solar eclipses, there are no explicit mention of the solar corona in Eastern or Western literature until the 10th century, and the Byzantine historian Leo Diaconus (c. 950–994), and his observations of the total eclipse of December 22, AD968 from Constantinople¹⁰:

(,,) *Everyone could see the disc of the Sun without brightness, deprived of light, and a certain dull and feeble glow, like a narrow headband, shining round the extreme parts of the edge of the disc (. . .)*

This text contains the earliest known reference to the corona, which is definitely recognizable. In fact, there is no other clear mention known until Kepler's in his *Astronomiae pars Optica*,¹¹ as the one in the *Annales Breves* (11th century)¹² is nothing more than a dubious assumption. Even Kepler's allusion is vague since he considers the corona a Moon's property instead of the Sun's.

For all this, the appearance of a contemporary text from the 13th century that mentions the solar corona is very interesting. Curiously, the eclipse to which the text refers is one of those that has more historical references, the one of 1239AD, June 3, since the band of totality is almost horizontal and it swept over practically all of southern Europe. Thus, there are innumerable references to it.¹³ It is not surprising that new contemporary sources still appear today.¹⁴ In the next section we will briefly describe the manuscript in which the reference was found, and then discuss it along with two other minor astronomical phenomena that were also registered.

The manuscript AM805

The possible reference to the solar corona appears in a codex kept at the Arnamagnean Institute, in Copenhagen, under the signature 805 4^o (København, Det Arnamagnæanske Institut, Københavns Universitet, AM 805 4^o), from now on referred to as AM805. It was already described in the 19th century¹⁵ but it was later forgotten as it was probably confused with a copy made at the beginning of the 19th century, which is also preserved in Copenhagen, in the Royal Library, as København, Kongelige Biblioteket, Ny. Kgl. S. 114 fol 1.¹⁶

AM805 is part of the tradition concerning annals of the Iberian Peninsula.¹⁷ Although peninsular annals texts up to the end of the 13th century are relatively well-referenced and recorded, there are still some unknown or lesser-known pieces that are gradually being edited and that, on occasions, provide astronomical references that we are currently studying.

AM805 is a manuscript written approximately in the AD1235–1240 period, with some additions from around AD1242. It consists of 115 parchment folios, whose content can be summarized as follows¹⁸: The first eight folios consist of a calendar and counting tables. This is followed by several legal documents: *Lex visigothorum* (fol. 9r-47r) and the Aragonese and Navarrese Codes and jurisdictions (fol. 53v-101v). Then, a catalog or royal list of Visigothic kings *Laterculus regum visigothorum* (fol. 47r-47v) followed by a continuation of the royal list from Recesvinto with the *Libro de las generaciones y linajes de los reyes* (f. 47v-52r); Finally, the *Anales navarro-aragoneses hasta 1239* (102r-104v) and some documents referring to King Jaime I of Aragon (104v-115r).

The folios containing astronomical references are 102r-115v and were recently published by Bautista.¹⁹ It is noteworthy that the language in which they were written is Romance, with a few exceptions in Latin. Bautista discusses the dating of this part of the document, combining paleographic data with the contents of the manuscript, and concludes that the preparation of the manuscript can be placed in a brief period between 1235 and 1242, while its geographical origin must be attributed to an area included in the old kingdom of Aragon, which was in expansion at that period, under Jaime I, and included a large part of the east of the Iberian Peninsula, with Aragon, Catalonia, the

Kingdom of Mallorca (from AD1231), the Kingdom of Valencia (from AD1238), the county of Ribagorza and Roussillon.

Astronomical references in AM805

The AD1239 eclipse is not the only astronomical reference contained in the document. Additionally, this recently edited text provided us with a few poor-quality astronomical references, perhaps motivated by the fact that the author was not an eyewitness and limited himself to copying them from other annals or chronicles. However, the last of them, referring to the eclipse of June 3, 1239, was a surprise for its descriptive clarity:

Murio el sol el primer viernes de iunio en el medio dia ^[fol. 104v] e parecieron las estrelas a par del sol e fizos negro et aderredor del sol grandes ramos blancos. Era .M.CC.LXX.VII

The sun died on the first Friday of June at noon and the stars appeared next to the sun and turned black and around the sun large white palms.²⁰ Era .M.CC.LXX.VII

The word “Era” at the end of a paragraph refers to the Spanish era. In order to translate the date to Anno Domini, we must subtract 38. The Spanish, Hispanic, or Caesar era refers to the dating system used in Hispania from the third to the fourteenth centuries, when the Anno Domini system was adopted. It began with year 1 in 38BC, probably the date of a new tax following the definitive pacification of the Iberian Peninsula after the Roman Conquest.

As previously stated, the eclipse of AD1239 is one of the most recorded in history. This record includes the main characteristics of the eclipse that also appear in the best-known reports that have already been commented on by other authors: the eclipse occurred on the first Friday of the month of June at noon, and it was total. It is mentioned that stars were seen simultaneously with the Sun. What makes this record interesting is its final part, which reports the white palms that appeared around the sun. Especially if we consider that the contemporaneity of the text and its geographic origin, suggests that the author was an eyewitness to the event.

The white palms around the Sun seem to be a clear reference to the solar corona.²¹ The shape of the solar corona observable during total eclipses is variable with the phase of the 11-year solar activity cycle. During the maximum, the corona extends uniformly around the solar disk, but the brilliance of the corona is less intense and only extends in a fringe on both sides of the solar equator during the minimum of solar activity. Although some studies suggest that the year 1239 would be in a period of solar calm between two maxima,²² which would correspond to this last description, unfortunately we do not have enough data to confirm anything in this regard with certainty.

Finally, it is noteworthy that regarding the eclipse of AD1239 there is another record that could also mention a solar prominence. This is the one from Cesena (Italy) that mentions

“a certain fiery aperture (foramen ignitum) in the Sun’s disc on the lower part”.²³

In the *Anales navarro-aragoneses hasta 1239* we find two other astronomical references, both of which occurred some 30 years before the estimated preparation of the manuscript and which, perhaps for this reason, are less dependable. We include them, because although they do not support relevant astronomical data a few contemporary sources mention them:

En el çagero dia de fervero escurio el sol. Era .M.CC.XL.VI

On the last day of February the sun was darkened. Era .M.CC.XL.VI

In this case there is an error in the date: the era 1246 corresponds to the year AD1208, but in reality the record refers to the annular eclipse of February 28, 1207.²⁴ This contrasts with the accuracy with which the events are dated as a general rule. Taking the immediately preceding entry as an example: *Morio don Garçia Ferrandez, bispe de Ponplona, en el mes de maio. Era .M.CC.XL.III* (1206AD), which corresponds to the death of García Ferrández, bishop of Calahorra and Pamplona who died indeed on May 16, 1206. The path of annularity crossed Catalonia and Roussillon. This eclipse is also mentioned in the contemporary codex A of *las Crónicas de Teruel* from the *lista de los jueces de Teruel* with a concise *escurezió el sol* (the sun darkened),²⁵ also with the wrong year AD1208. In Teruel (40°20'N, 1°6'W) the eclipse was partial, with the Sun covered 94% by the Moon.

The last astronomical reference is a lunar eclipse:

Feria .III. escurio la luna, .IIIº. nonas febroarii. (. . .)Era M.CC.XL.VII

Feria IIII. The Moon was darkened. 3rd of February. (. . .) Era M.CC.XL.VII

It mentions the total lunar eclipse of February 3, 1208. Again there is an error in the eclipse date, since the era 1237 corresponds to AD1209, and the remaining historical events in the paragraph, which we have omitted, are correctly dated. They narrate the arrival in Sicily of Constanza of Aragon to marry Frederick II, Holy Roman Emperor, and the death of Alfonso II of Provence in February 1209 in Palermo, when he was accompanying her sister Constanza. The IIII Feria mentioned in the paragraph does not correspond to the eclipse, which happened on Sunday. Perhaps it is the date of the count's death, shortly after landing in Palermo on February 2.

Conclusion

The study of manuscript AM805 provides three astronomical observations, of which the one referring to the eclipse of June 3, 1239 is especially relevant since it was probably carried out by an eyewitness and apparently provides a description of the solar corona, which would be the second of the datable sources that refer to this solar characteristic in medieval times.

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Notes

1. R.R. Newton, *Medieval Chronicles and the Rotation of the Earth* (Baltimore, MD: Johns Hopkins University Press, 1972).
2. P.K. Wang and G.L. Siscoe, "Ancient Chinese Observations of Physical Phenomena Attending Solar Eclipses," *Solar Physics*, 66 (1980), 187–93.
3. F.R. Stephenson, *Historical Eclipses and Earth's Rotation* (Cambridge: Cambridge University Press, 1997), pp. 218–9.
4. *Ibid.*, p. 226.
5. D. Russell, *The Loeb Plutarch*, H. Cherniss and W.C. Helmbold (eds), vol. xii (London: Heinemann, 1957). <<http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A2008.01.0357>>.
6. L. Golub and J.M. Pasachoff, *The Solar Corona* (Cambridge: Cambridge University Press, 1997), pp. 21–2.
7. Newton, *op. cit.* (Note 1).
8. See, for instance, J.A. Eddy, "The Maunder Minimum," in G. Parker and L.M. Smith (eds), *The General Crisis of the Seventeenth Century* (London and New York: Routledge, 1997), pp. 266–300.
9. In the translation by F.C. Conybeare the word used is "wreath," <<https://www.livius.org/sources/content/philostratus-life-of-apollonius/>>.
10. Text obtained from Stephenson, *op. cit.* (Note 3), p. 390.
11. J. Kepler, *Ad Vitellionem Paralipomena, Quibus Astronomiae Pars Optica Traditur* (Frankfurt, 1604), pp. 297–8.
12. S. Rudperti, *Salisburgensis Annales Breves*; MGH, IX, 758.
13. See Stephenson, *op. cit.* (Note 3), R.R. Newton, *Ancient Astronomical Observations and the Accelerations of the Earth and Moon* (Baltimore, MD: Johns Hopkins University Press, 1970) and Newton, *op. cit.* (Note 1); other reports from Spain may be found in M.J. Martínez, F. Marco and L. Ibáñez, "Oscurait Sol: Stone Engravings and Other Contemporary Spanish Records for the A.D.1239 and A.D.1354 Eclipses and Their Astronomical Implications," *Journal for the History of Astronomy*, 47 (2016), 61–75.
14. For instance, many Spanish sources mention it although none of them, as far as we know, contribute new relevant astronomical material. See for example, F. López Rajadel (ed.), *Crónicas de los jueces de Teruel (1176-1532)* (Teruel: Inst^o Est. Turolenses, 1994), pp. 94–5 and the different versions in the annals from Cataluña and Valencia (in prep. by the authors of this paper).
15. It was studied in the context of the works on the *Lex visigothorum* since it includes this text. See K. Zeumer, *Legum sectio I, Leges nationum Germanicarum*, t. 1. MGH (Hannoverae etc., 1973). <<http://www.mgh.de/>>.

16. A complete description and comment of the manuscript may be found in F. Bautista, “Anales navarro-aragoneses hasta 1239: edición y estudio,” *e-Spania*, 2017. <<http://journals.openedition.org/e-spania/26509>>.
17. A useful outline and description of the Annals and Regnal Lists in the Early Medieval Iberian Peninsula may be found in F. Bautista, “Breve historiografía: listas regias y anales en la Península Ibérica (siglos VII-XII),” *Talia Dixit*, 4 (2009), pp. 113–90.
18. Bautista, *op. cit.* (Note 16).
19. Bautista, *op. cit.* (Note 16).
20. The word “ramos” is similar to “ramas”, although it has different implications. While “ramas” should be translated as “branches”, “ramos” means a bunch or bunch of flowers, branches and herbs. We have chosen the translation of “ramos” as “palm” taking into account the use of this word in contemporary documents. See, for instance, “Dominica in Ramos” in documents of the same origin and century (see V. Urones Sánchez, “Procesión y Misa del Domingo De Ramos en el Monasterio de San Millán de la Cogolla (S. XI ex. – S. XV). Música, Liturgia y Espacios,” *Medievalia*, 24 (2021), 69–90.
21. In <https://update.lib.berkeley.edu/2019/08/25/philobiblon-n-4-agosto-de-2019-den-arnamag-naeanske-handskriftsamling-ms-am-805-4to-y-el-eclipse-del-sol-del-3-de-junio-de-1239/> the author Ch. Faulhaber shows pictures of the original manuscript containing the paragraph with the eclipse. The author implies that the “white palms” correspond to solar prominences but solar prominences are large, bright features extending outward from the Sun’s surface and they usually appear as flame-colored projections when the disk of the Sun is totally eclipsed so, in our opinion, this description does not describe solar prominences.
22. I.G. Usoskin *et al.* “Solar Cyclic Activity Over the Last Millennium Reconstructed From Annual 14C Data,” *Astronomy & Astrophysics*, 649 (2021), A141.
23. See Stephenson, *op. cit.* (Note 3), p. 398.
24. See Stephenson, *op. cit.* (Note 3). See also *Annales Colonienses Maximi. MGH*, XVII, 822 and *Trithemii Annales Hirsaugienses. MGH I*, 512 for the original sources.
25. A.C. Floriano, *Las efemerides Turolenses* (Zaragoza: Institución Fernando el Católico (C.S.I.C.), 1954).