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*Letter to the Editor***Two early observations of aurora at low latitudes****J. M. Vaquero<sup>1</sup> and M. C. Gallego<sup>2</sup>**<sup>1</sup>Escuela Politécnica, Departamento de Física, Universidad de Extremadura, Avda. de la Universidad, s/n, 10071 Cáceres, Spain<sup>2</sup>Departamento de Física, Universidad de Extremadura, Avda. de Elvas, s/n, 06071 Badajoz, Spain

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**Abstract.** It is the purpose of this paper to present evidence concerning the observation of aurorae in the years 880 AD and 942 AD recorded by Arabs from the Iberian Peninsula and the north of Africa.

**Key words.** Meteorology and atmospheric dynamics (general or miscellaneous) – Atmospheric composition and structure (airglow and aurora) – Magnetospheric physics (auroral phenomena)

**1 Introduction**

Historical documents that provide information about variations of solar activity long ago are difficult to find and must be interpreted with caution. These documents include early observations of auroras and sunspots. The cultures of the Romans, Arabians, and Spaniard Empire in 16th century have left a rich historical and documentary heritage in the Iberian Peninsula that has not yet been investigated from the point of view of solar activity history.

The Arabian culture arrived in the Iberian Peninsula at the beginning of the 8th century from the north of Africa and definitively left at the end of the 15th century. Astronomical and geophysical phenomena registered by the Arabs of the Iberian Peninsula and the north of Africa have been scarcely investigated up until now. Francisco Codera was one of the first interested in this kind of study at the beginning of the 20th century (Codera, 1910). Some partial investigations have appeared which take advantage of new Arabian documentary sources (Vernet, 1982; Rius, 1998; Vaquero et al., 2000). The majority of the recorded phenomena are eclipses or comets. Nevertheless, sometimes other phenomena such as bolides, supernova (Goldstein, 1965), sunspots (Vaquero and Gallego, 2001) or aurorae borealis appear.

In this work we show two aurorae borealis recorded in Arabian documentary sources and observed from the south

**Table 1.** Characteristics of Aurorae

Date	Julian Day	Place of observation	Brief description
25 Jan 880	2042502	Fez Lat.: 34° 0' N Long.: 5° 0' W	Great red splendour during all the night.
27 Apr 942	2065240	Córdoba Lat.: 37° 53' N Long.: 4° 47' W	Redish colour. Multiple rays. It appeared from Occident.

of the Iberian Peninsula and the north of Africa. At low geographic latitudes, we would expect that the typical aurora would be most often red, diffuse, and without rapid movements. Two factors are important in the occurrence of this aurora: the geomagnetic latitude of the site, and the variability of the Sun and the interplanetary field over periods of millennia (Silvermann, 1998).

**2 Two early descriptions of aurorae**

The first description of aurora borealis that we present is recorded in the oeuvre titled *Rawd al-qirtas* by the Arabian historian Ibn Abi Zar. This historian lived in Fez (north of Africa) during the 14th century. In his oeuvre five centuries of the history of the north of Africa are narrated (from AD 762 to AD 1326). Actual editions of the *Rawd al-qirtas* in Arabic (Ibn Abi Zar, 1976) and in Spanish (Ibn Abi Zar, 1964) exist. A red splendour in the sky during the entire night of the day 25 January 880 is described as follows:

It was a great red splendour in the sky, from the beginning of the night to the end. An equal thing was never known before. It happened the night of the Saturday 19 of safar of the cited year [25 January 880].

**Table 2.** Some aurorae during the 9th century described in Link (1962)

Date	Julian Day	Type and Color	Place
10 Mar 861	2035607	Ray	France
870 (3 times)	2025128	1. Corone	Germany
		2. Ray, red	
		3. Brightness, red	
13 Jan 888	2031533	Arc	Sea
1 Jan 890	2032251	Brightness	England

The second description of aurora borealis we present is recorded in the oeuvre known as *Al-Muqtabis V* by the Arabian historian Ibn Hayyan. In this document diverse facts during the epoch of the caliph an-Nasir from the year AD 912 to the year AD 942 in the Iberian Peninsula are narrated. This source is very well studied (Chalmeta, 1975) and actual editions in Arabic (Ibn Hayyan, 1979) and Spanish (Ibn Hayyan, 1981) exist. A redish colour in the west horizon and some lights that were reflected on palm trees and buildings during the night of 27 April 942 are described as follows:

Toward the end of the night of the Thursday [27 April 942] a redish colour as fire in the sky, from which a lot of rays that were reflected on the branches of the palm trees and on the top of the palaces emerged, appeared in the horizon. People thought that it was the daybreak light when Sun rises until the red colour became lost with the arrival of the morning and disappeared with the clarity of the day. It appeared from the Occident.

### 3 Discussion

Table 1 lists the main characteristics of the described aurorae. Arabian dates have been reduced to the dates in the Julian calendar because they are prior to 4 October 1582. We also enclose the Julian day of the observation date. The two given descriptions agree with the aspect of the aurorae observed at low latitudes.

Few antique data of aurorae exist. A great part of the antique observed aurorae is recorded in a valuable oeuvre of 18th century written by Mairan (1733). There have been several other catalogues of European auroral observations since the first edition of Mairan's book. Two of these oeuvres have also been used in this work (Fritz, 1873; Link, 1962). In Table 2 and Table 3, we have listed the aurorae observed in the 9th and 10th centuries, respectively, by Link. Not all of them are included in the aforementioned tables; only the ones whose observation dates are around those cited in Table 1. In both Tables 2 and 3, the auroral observations following the criterions of date, type and color, and place (all extracted from Link, 1962), and the julian day (approximate if day unknown) are summarized.

**Table 3.** Some aurorae during the 10th century described in Link (1962)

Date	Julian Day	Type and Color	Place
14 Oct 934	2048609	Ray, arc	France
14 Feb 937	2049462	Ray, red	France
Dec 940	2050863	Ray, several colors	France
941	2051060	Brightness	Switzerland
15 Sep 945	2052597	Brightness	Germany
25 Oct 945	2052637	Ray	England
Jun 955	2056158	Arc	France

We also have data about sunspots that we can compare with the two described aurorae. From naked eyed observations of sunspots, Wittmann and Xu (1987) found an useful numerical approximation for the maximum epochs of the solar cycle:  $Year(Max) = 4.0 + 11.16N$ , where  $N$  is an arbitrary cycle number ( $N = 178$  for the maximum of 1980/81). Note that for  $N = 84$ , we have the end of the year 937, as a date of the maximum of solar activity. For  $N = 79$ , the date of the maximum of solar activity is the beginning of the year 882.

Table 4 lists naked eye observable sunspots during the 9th and 10th centuries and their different sources. We also enclose the Julian day of the observation date (approximate if day unknown). One can see that the sunspots of the years 874 and 875 are the closest in time to the aurora observed in the year 880. Similarly, the sunspot of October 939 is close in time (two years and a half) to the aurora observed in April 942. Effectively, there is not a one-to-one correspondence between the date of the sunspot maximum and the date of the observed aurorae in the south of the Iberian Peninsula and the north of Africa.

### 4 Conclusions

Two aurorae borealis observed at low latitudes by Arabs in the 9th and 10th centuries are presented. These are the only two auroral phenomena encountered in the consulted sources. These two facts show the interest of the antique Arabian chronicles belonging to the Iberian Peninsula and the north of Africa for the history of the Solar-Terrestrial Physics, as Vaquero and Gallego (2001) had aforementioned. We entrust that an attentive reading of other Arabian sources will provide us with some other references on this topic.

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**Table 4.** Naked eye observable sunspots during the 9th and 10th centuries described in different sources

Year	Date	Julian Day	Place	Source
807	17 and 24 Mar	2015890	Germany	Yau and Stephenson (1988)
826	7 May	2022881	China	Yau and Stephenson (1988)
826	24 May	2022898	China	Yau and Stephenson (1988)
832	21 Apr	2025057	China	Yau and Stephenson (1988)
832	6 May	2025072	China	Yau and Stephenson (1988)
837	22 Dec	2027128	China	Yau and Stephenson (1988)
840	25 May, 23 Aug	2028013	Middle East	Yau and Stephenson (1988)
841	30 Dec	2028597	China	Yau and Stephenson (1988)
851	22 Dec	2032241	Japan	Yau and Stephenson (1988)
865	31 Jan, 1 Mar	2037045	China	Yau and Stephenson (1988)
874	–	2040438	China	Yau and Stephenson (1988)
875	–	2040803	China	Yau and Stephenson (1988)
904	19 Feb	2051293	China	Yau and Stephenson (1988)
925	29 Dec	2059277	China	Yau and Stephenson (1988)
927	9 Mar	2059712	China	Yau and Stephenson (1988)
934	–	2062353	Portugal	Wittmann (1978)
939	14 and 20 Oct	2064317	Spain	Vaquero and Gallego (2001)
947	26 Nov	2067279	China	Yau and Stephenson (1988)
974	3 Mar	2076873	China	Yau and Stephenson (1988)

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