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A possible case of Sporadic Aurora in 1843 from Mexico

José Manuel Vaquero*, María Cruz Gallego and Fernando Domínguez-Castro

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Resumen

Recientemente, algunos autores han mostrado que algunas auroras pueden ser observadas a latitudes relativamente bajas cuando la actividad geomagnética es baja o moderada. Este tipo tan especial de aurora recibe el nombre de "aurora esporádica". Presentamos y analizamos en este trabajo un posible caso de "aurora esporádica" observada desde México el 19 de abril de 1843. Además, estudiamos la actividad solar y auroral alrededor de este evento.

Palabras clave: Aurora esporádica, actividad geomagnética, actividad solar, México, historia de la Geofísica.

Abstract

In recent years, some authors have shown that some auroras can be observed at relatively low latitude when the geomagnetic activity is quiet or moderate. This very special type of aurora is called "sporadic aurora". We present and analyze in this work a possible case of "sporadic aurora" observed in Mexico on the 19 April 1843. Moreover, we study the solar and auroral activity around this event.

Key words: Sporadic aurora, geomagnetic activity, solar activity, Mexico, history of Geophysics.

J.M. Vaquero*
Departamento de Física
Centro Universitario de Mérida
Universidad de Extremadura
Av. Santa Teresa de Jornet, 38
06800 Mérida, España
*Corresponding author: jvaquero@unex.es

M.C. Gallego
Departamento de Física
Universidad de Extremadura
Badajoz, España

F. Domínguez-Castro
Departamento de Física
Universidad de Extremadura
Badajoz, España

Introduction

In general, low-latitude auroras are related to great events of space weather, usually associated with huge Coronal Mass Ejection (CME). Vázquez *et al*. (2006) show that low-latitude aurorae occur mainly in the decaying phase of the solar cycle, as defined by the sunspot number, coinciding with the maximum of the Open Magnetic Field (OMF) that is a better descriptor of the state of the heliosphere. Nowadays, the studies of these episodes are important because they provide additional information on potentially damaging space weather events (Lanzerotti, 2007). In fact, there are some studies of important space weather events in the past. Some of them can be highlighted such as the cases that have occurred on 2 September 1859 (Cliver, 2006; Tsurutani *et al*., 2003; Ribeiro *et al*., 2011), 24–25 October 1870 (Vaquero *et al*., 2008), 25 September 1909 (Silverman, 1995), 14–15 May 1921 (Silverman and Cliver, 2001), and 25 January 1938 (Barlow, 1938; Botley, 1938; Bernhard, 1938; Hess *et al*., 1938).

However, Silverman (2003) provided sufficient data to demonstrate that an auroral phenomenon can be observed at low-latitude under conditions of quiet to moderate magnetic activity. This infrequent phenomenon was called "sporadic aurora" by Silverman (2003) and constitutes a puzzle in magnetospheric physics. Later, Willis *et al*. (2007) demonstrated that at least 29 out of the 42 Chinese and Japanese auroral observations (from 1840 to 1911) occurred at times of weak or moderate geomagnetic activity (*aa* or *Ak* index ≤ 50). Moreover, Vaquero *et al*. (2007) presented a case of "sporadic aurora" observed from Spain on the 29 December 1845.

Therefore, we have some reports of "sporadic aurora" in USA (Silverman, 2003), Asia (Willis *et al*., 2007), and Spain (Vaquero *et al*., 2007) but records of this phenomenon from other places of the world are not available. The aim of this paper is to present a possible case of "sporadic aurora" observed from Mexico on the 19 April 1843.

Historical record

Mexico is a country with an interesting historical and scientific heritage, despite its location far from main centers of scientific research in the 18th and 19th centuries (located generally in European countries as England, France or Germany). Some examples can be cited in the branch of solar physics as the historical sunspot observations preserved in its archives (Vaquero, 2004; Vaquero and Moreno-Corral, 2008) or the records of the great aurora observed in 1789 (Vázquez *et al*., 2006).

The record of an aurora borealis seen from Mexico on 19 April 1843 appears in a book entitled *"Apuntes para la Historia del Gobierno del General D. Antonio López de Santa-Ana"* (Notes for the History of the Government of General Antonio López de Santa Anna) (Bustamente, 1845, p. 136). Full text of this report is reproduced in original ancient Spanish in Appendix. The author of this book was Carlos María de Bustamante (Oaxaca, 4 November 1774 – Ciudad de México, 21 September 1848) a lawyer, journalist and politician. He published several newspapers as *Diario de Mexico, El Juguetillo* or *Correo Americano del Sur* all of them with ideas in favor to the independence. He was member of the parliament by Chilpancingo.

According to this report, Mr. Soyano, professor of philosophy of the Seminary- College, observed a light in the sky to the north on the night of 19 Apri. Despite the weather and clouds, the light was visible. This light was observed from 21:00 to 23:00 approximately (Local Time). Although the clouds did not allow to see its exact form, the observer indicates that it was a semicircle whose center was in the direction NNO1/4. The reporter indicated that it was not the zodiacal light. The phenomenon was not caused by the light of the moon, nor by flashes of lightning. This was clearly an aurora borealis.

Discussion

This record can be associated to a sporadic aurora establishing that the phenomenon was observed under conditions of quiet to moderate magnetic activity and from a low-latitude place.

We would like to compare the date of this aurora observed in Mexico with geomagnetic activity to establish clearly that it is a sporadic aurora. However, note that the more usual magnetic indexes are not availables for early dates. For example, Ak index is only available since 1844 (Nevanlinna and Kataja, 1993; Nevanlinna, 2004) and aa index is only available from 1868 (Mayaud, 1980). Therefore, we can compare the observation date with the geomagnetic IDV index (Svalgaard and Cliver, 2005, 2010), available from 1835, and with some proxies of geomagnetic activity, namely sunspot number and the number of auroras observed at middle latitudes.

Figure 1 shows the Inter-Diurnal Variability (IDV) index from 1835 until 1855 introduced by Svalgaard and Cliver (2005) and improved by Svalgaard and Cliver (2010). IDV is computed as the average difference from one day to the next between hourly mean values of the horizontal component, H (measured one hour after midnight), without regard to sign. The most interesting characteristic of IDV index is that correlate highly with the near heliospheric magnetic field (HMF) strength B. Data provided by Svalgaard and Cliver (2010) shown low

values of the IDV index (and, therefore, low values of the HMF strength B) around the date of observation of the event considered here.

Figure 2 shows the yearly number of auroras observed in middle latitudes according to Křivský and Pejml (1988). Auroral activity during the period 1830-1870 was relatively high with peak values in the years 1830, 1841, 1850, 1859 and 1870 (Figure 2, upper panel). Auroral activity was relatively low in early and late 19th century, corresponding with secular solar activity minima. In the year 1843, auroral activity was low with only 39 auroras observed (Figure 2, lower panel).

As similar picture is obtained from the sunspot numbers (Figure 3). We use two different versions of the sunspot number: International Sunspot Number (Clette *et al*., 2007) and Group Sunspot Number (Hoyt and Schatten, 1998). Figure 3 (upper panel) shows these solar indexes from 1820 to 1860 corresponding to solar cycles 7, 8 and 9. Solar activity around 1843 was low or very low. In October and November 1842, sunspot number values were in the range 30-40. However, the values decrease to10 approximately after December 1842. The values corresponding to April 1843, when the aurora was observed from Mexico, are very low: 9.5 (ISN) and 7 (GSN). Obviously, the low solar activity corresponding to the year 1843 can also be checked in sunspot areas (Vaquero *et al*., 2004).

Long-term variation of the geomagnetic latitude of Mexico for the last two millennia was studied in Vázquez *et al*. (2006) varying between low values of 14º and 30º N. The geomagnetic latitude of México in 1843 was 29.5º N approximately.

Conclusion

We have presented a historical record that clearly describes the aurora borealis seen from Mexico on 19 April 1843. However, geomagnetic, solar and auroral activity during this time was low according to the evolution of the IDV index, sunspot number and the number of auroras observed at middle latitudes respectively. Furthermore, the geomagnetic latitude of Mexico at that time was low (approximately 29.5° N). Therefore, we think that this is a case of "sporadic aurora".

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Appendix

Original text (in ancient Spanish) describing the aurora:

En la noche del 19 de abril observó el Lic. Soyano, catedrático de filosofía de este colegio Seminario, una luz apacible (son sus palabras) cerca de las nueve de la noche por el rumbo del Norte, y á pesar de la obscuridad de la noche y de las nubes, vibraba notablemente. Su duracion, que fué hasta cerca de las once, no me dejó dudar que no era una ilusion, aunque las nubes gruesas impedían ver con exactitud sus contornos, pues sin embargo, se percibia que su figura se acercaba á la del círculo, cuyo centro estaba en el NN. O. 1/4, y cuya mitad inferior ocultaba el orizonte. Ella no podía ser

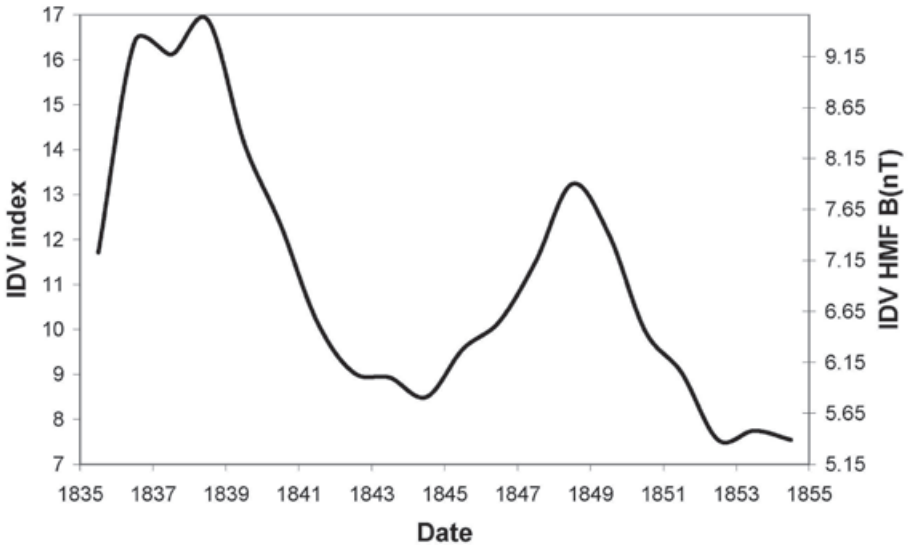

Figure 1. IDV index measured from 1835 until 1855. Right axis indicates the estimated heliospheric magnetic field from IDV index.

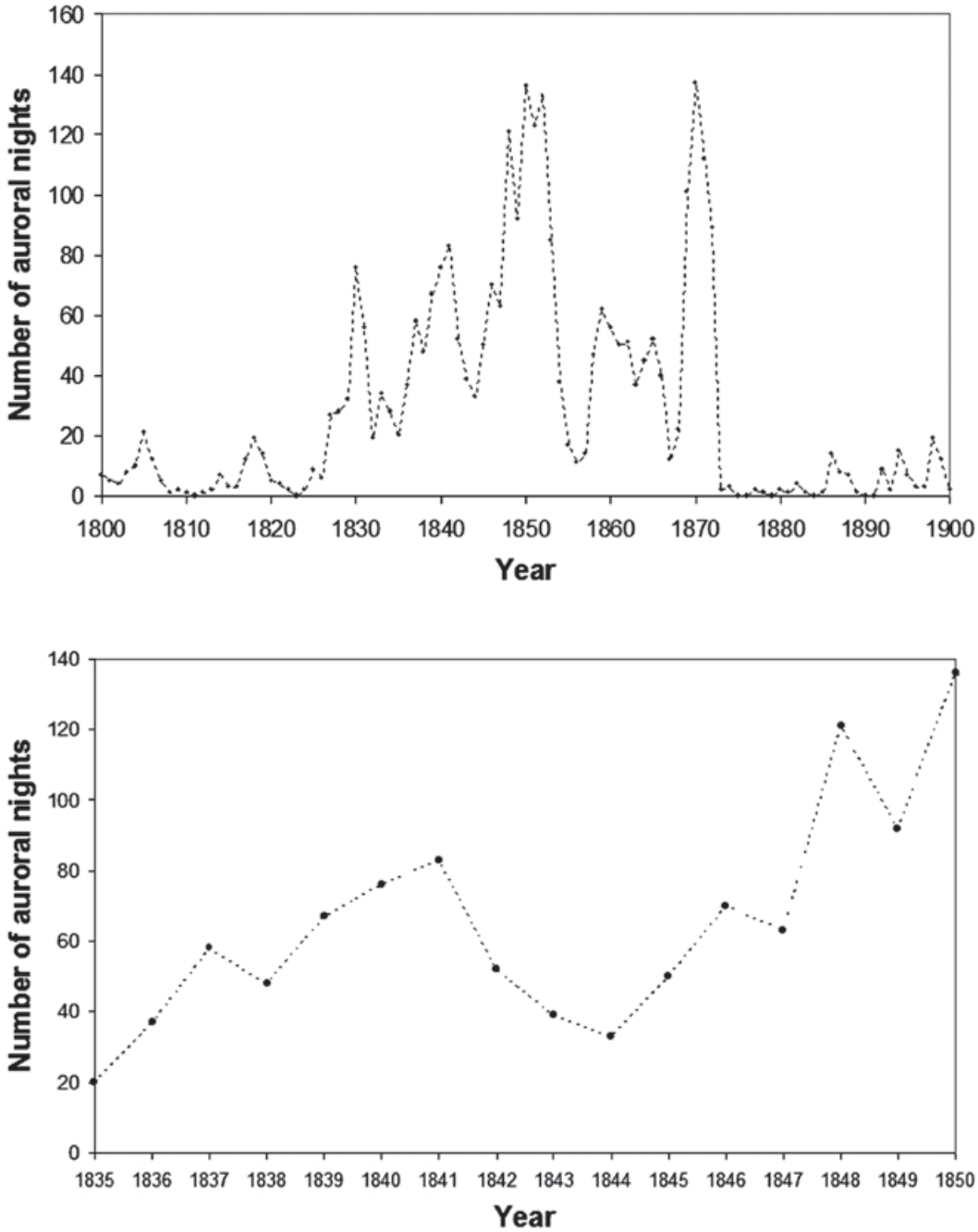

Figure 2. Yearly number of auroras observed in middle latitudes according to Křivský and Pejml (1988) catalogue during the 19th century (upper panel) and the period 1835-1850 (lower panel).

luz zodiacal, pues ni aparece su forma circular, ni por el Norte; tampoco de la luna porque ésta se encontraba oculta, ni causada por los relámpagos, pues estos eran intermitentes y aquella constante; éstos iluminaban todo el cielo, aquella solo el Norte, y tan lejos de causar la impresion en parte para percibirla, resulta que era una aurora boreal. Esta reflexion, y la de que la aurora boreal figura su situacion y sus vibraciones, convienen cabalmente á la letra con las de todos los fisicos estar de acuerdo cuando la describen, y todo ello me induce á creer que fué una verdadera aurora boreal.

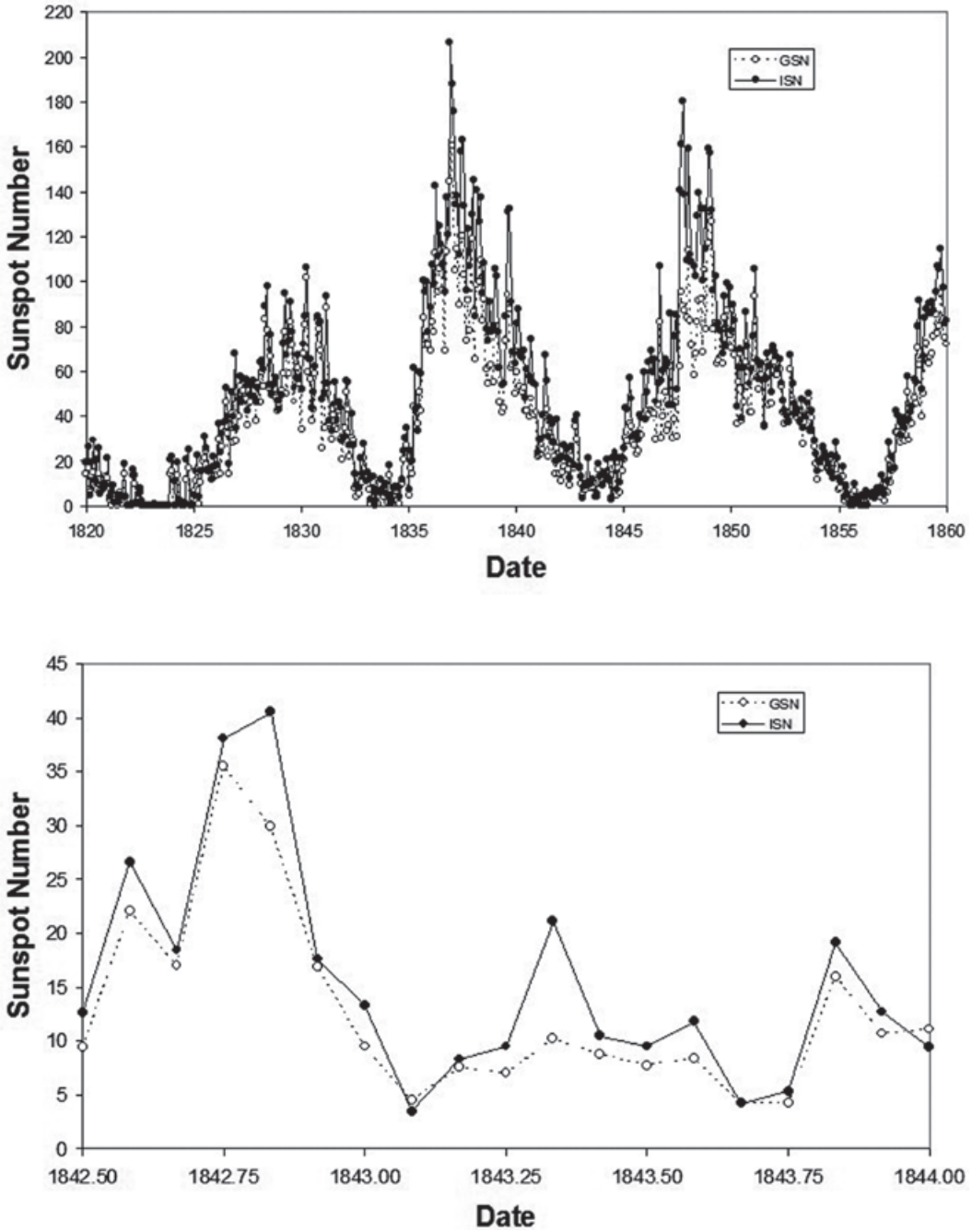

Figure 3. Monthly sunspot numbers from 1820 to 1860 (upper panel) and July 1842 - January 1844 (lower panel).

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