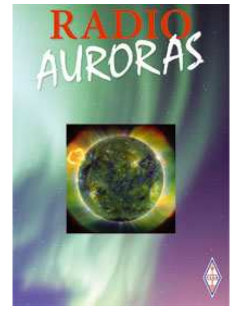

Title: ***Rado Auroras***
Author: Charles Newton, revised edition edited by Steve Telenius-Lowe
Publisher: Radio Society of Great Britain (RSGB)
ISBN: 9781-9050-8681 8
Date published: 2012 (original edition published in 1991)
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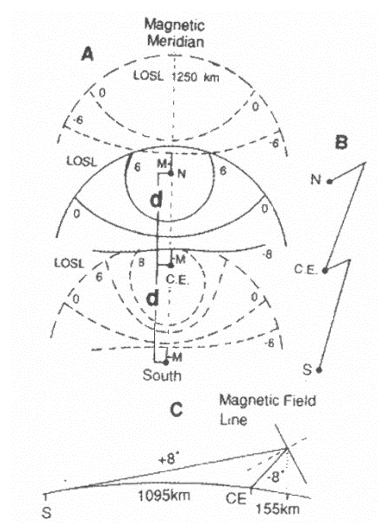
Status: In print
Availability: Available for 13 USD from ARRL (http://www.arrl.org/shop/Radio-Auroras/) and 7 GBP from RSGB (http://www.rsgbshop.org/)

I still remember being awakened in the middle of one winter night when I was about 15 years old by bright flashing lights of all colors shining in my 2nd story bedroom window. I looked out and saw the Northern Lights brighter than I had ever seen them before or since. I still live in Anchorage, Alaska but because of light pollution nowadays I seldom see the Aurora Borealis, another name for the Northern Lights. However, as I traveled around Alaska during winter from the early 1960s through the late 2000s, I have seen them many times in many places, never tiring of the view.

As one might expect, visible aurora and radio aurora are related. Both types of aurora are manifestations of solar activity but their production mechanisms are quite different. This book explains radio aurora in a non-mathematical way according to the scientific understanding in the late 1980s. Much research has been done since then and has added many details, but the basic explanations of the phenomena have remained unchanged.



Radio amateurs noticed after World War II that when their antennas were pointed north, they sometimes experienced successful contacts at very high frequencies over very long distances (VHF DX) often when the aurora was visible at night but occasionally during daytime too. What was especially interesting was that contacts were made with stations beyond line of sight to the south when the directional antennas were pointed north (bottom of image right, from figure 4.6). The name *radio aurora* came into use to describe this type of communication but *radar aurora* and *auroral scatter* are equally valid names.

Radio Auroras is written from a radio amateur's viewpoint. It is my own experience that overall knowledge and acknowledgement of radio aurora is very low among radio amateurs. A few years ago, I gave a presentation to the Anchorage Amateur Radio Club about geomagnetism and the effects of geomagnetic storms. I asked the group if they had any experience with radio propagation anomalies associated with aurora and, surprisingly, all I received were blank stares. Surely Alaskan radio amateurs would know of radio aurora – the entire group of about 50 people at the meeting lived right below the southern edge of the auroral oval where radio aurora is most often experienced, but no one knew of or at least acknowledged its existence.

Another surprising thing is that amateur radio magazines (except DUBUS, http://www.dubus.org/) rarely mention radio aurora. Reports of radio aurora occasionally appear in the Aurora Section of the *Journal of the British Astronomical Association*, http://britastro.org/baa/, but no details are given. I suspect that some of the discussions in radio amateur magazines concerning sporadic-E propagation at VHF may be radio aurora, but how does one know the difference or is there a difference? One recent publication (QST, March 2013, Pole Vaulting on Six Meters) mentioned the increase in 6 m (50 MHz) openings over the last several years. This is coincident with the increasing solar activity associated with sunspot cycle 24. Radio aurora was never mentioned in this article, only "a phenomenal sporadic-E (E_s) opening to Europe on the morning of June 29, 2012" from the Pacific Northwest of North America and a number of other contacts in this area. Interestingly, my observatory records show considerable solar radio bursting at HF and VHF on 29 June 2012 and a severe geomagnetic storm on 30 June. Both are indications that radio aurora could have existed.

The original edition of ***Radio Aurora*** had seven chapters, the last two of which described events that took place during sunspot cycles 19, 20 and 21 (1950s through the 1980s). It has been found that enhanced propagation due to radio aurora is related to the sunspot cycle peak, so the book was re-printed in 2012 as we approach the peak of cycle 24, (although it may already have passed or is just ahead – take your choice). To make the book attractive to modern readers, the two outdated chapters were replaced in the current edition by one new chapter covering radio auroras from 2000 to 2012, written by a new author (the original author is now deceased). This book draws on many sources, particularly ***Scientific American*** magazine, which published several very informative articles on auroras in the 1970s and 1980s.

The book's Introduction discusses the early history of radio aurora dating as far back as 1951 and in a few pages takes the reader to 1957. It is stated that radio amateurs had discussed among themselves the sporadic contacts they made when visible aurora was present but no large-scale scientific investigation of this peculiarity had been made until the 1957 International Geophysical Year (IGY 1957). Because this book was written for RSGB it is natural that it focuses on participation by British radio amateurs, including the original author, in some of these studies.

The next two chapters (1, How and Aurora Begins – The Sun's Part, and 2, The Magnetic Fields of Earth and Sun) discuss sunspots and sources of solar activity and the interaction between the magnetic fields of the Sun and Earth. Chapter 2 has a flawed and jumbled description of Earth's magnetic field components, dip angle (inclination) and declination. If the reader is an aviator or mariner, these problems will be readily apparent. However, readers who are unfamiliar with the terminology could have problems understanding a later chapter that explains the dependence of radio aurora on the angle the geomagnetic field lines have on Earth's surface.

It was originally thought that radio aurora is caused by solar flares, but it was eventually determined that disturbances in the solar wind and associated interplanetary magnetic field (IMF) interact with Earth's magnetosphere and ionosphere and, under certain conditions, cause radio aurora. Certainly solar flares can affect the solar wind, but flares are only one type of solar activity that has been found to be responsible. Coronal mass ejections, solar sector boundary crossings and, in particular, coronal holes can cause solar wind disturbances that may lead to radio aurora. The illustration on the next page from chapter 2 shows sunspots and coronal holes on the Sun and correlates their appearance with amateur radio contacts using radio aurora (marked with an A just above the central meridian date).

Chapter 3, How Does an Aurora Come About?, explains that both visible and radio aurora are caused by charged particles, mostly electrons, flowing in the solar wind from the Sun. Visible aurora involves collisions between particles that have entered Earth's upper atmosphere and (mostly) the nitrogen and oxygen atoms located there. These collisions result in energy released as visible radiation – the aurora.

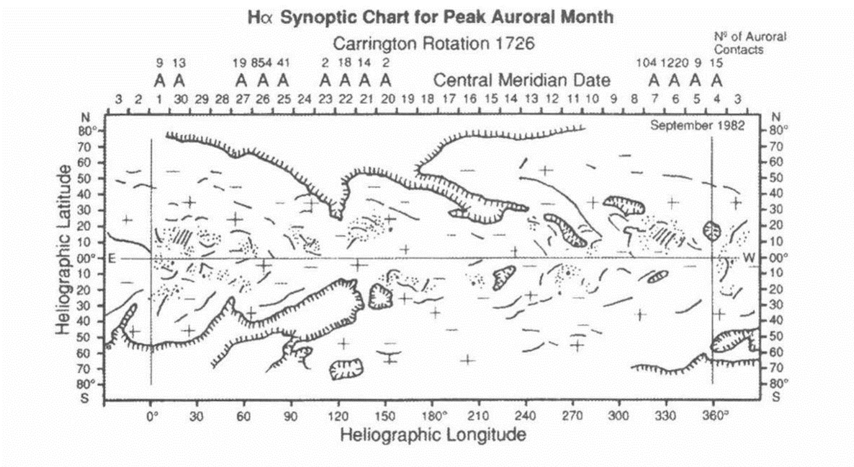


Fig 1.9. A synoptic chart of the coronal holes and tongues for cycle 21's peak auroral month, September 1982. 'A' denotes auroral contacts. The hatched areas are where the coronal holes were, the lines filaments, and the dots, spot groups. Data provided by WDC-A for Solar-Terrestrial Physics.

Radio aurora, on the other hand, involves clouds of electrons at ionospheric E-layer altitudes (about 100 to 150 km) that have flowed in the solar wind and get trapped in columns aligned with Earth's magnetic field lines. These clouds have relatively little depth north-south but can extend great distances east-west like a curtain as they are stretched by the auroral electrojet (electric currents in the magnetosphere of the auroral oval region). These electron clouds are moving and cause Doppler shift and fluttering of the signals scattered by them. The author also frequently refers to "buzz saw" sounds that he says are manifestations of radio aurora but he never makes clear if these are auroral modulations of terrestrial radio transmissions or a separate emissions mechanism. This sound is not mentioned in other technical literature on the subject of radio aurora.

Radio aurora from a propagation standpoint is explained in chapter 4, The Problems of 'Field-Aligned Propagation'. The transmissions of interest to radio amateurs are a form of bi-static radar in which the transmitter and receiver are at different fixed locations and the radio waves are reflected or scattered by the electron clouds. These phenomena depend on the geometry involved – the reflections will not be observed unless the transmitter is in the right place with respect to the receiver (mage right). Thus, from a given location one may observe visible but not radio aurora. On the other hand, radio aurora may be observed during daytime but visible aurora is too faint to see during daytime. Geometric analysis indicates a maximum ground range along a north-south line of around 1000 km. Longer range, about 2000 km, is possible for east-west stations. Chapter 4 provides a lot of interesting discussion, most of it is related to stations in Europe but the concepts obviously apply anywhere at similar geomagnetic latitudes.

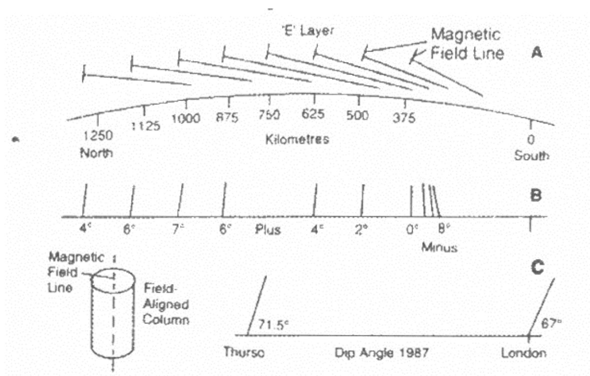
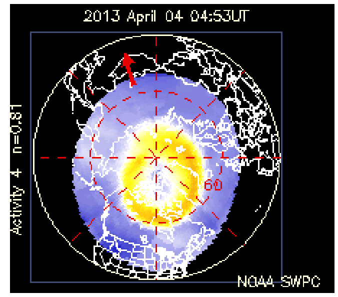


Fig 4.3. (A) The difference angles from London as seen looking up the magnetic north meridian at E layer height out to the line-of-sight horizon. (B) The changing angle as seen by the wave front at E layer height. (C) The change in magnetic field dip angle of London and Thurso.

Radio auroras generally are experienced at the higher latitudes corresponding to the auroral oval (yellow-orange area in image right viewed from above the geographic North Pole, from Space Weather Prediction Center, http://www.swpc.noaa.gov/pmap/). Solar activity greatly influences the latitudes at which the auroral oval resides, and it changes from day to night even with a quiet Sun. Amateurs at lower- and mid-latitudes generally will not experience radio aurora unless the auroral oval is pushed down in conjunction with a strong geomagnetic storm.



Most of the discussions in previous chapters have centered on the amateur 2 m band (about 144 MHz). The title of chapter 5, Auroras on Bands Other Than 2 m, indicates that radio aurora also may affect other frequency bands. However, this chapter really does not provide much information except at around 50 MHz. The last chapter, the new chapter 6, Radio Auroras 2000 – 2012, summarizes the increasing radio aurora through mid-2012 in Europe and the expectation that such activity will increase over the next few years. It has been found that radio aurora peaks 1.5 to 2 years after the sunspot cycle peak, corresponding to the increasing effects that coronal hole high-speed streams have on the solar wind and, ultimately, Earth's magnetosphere.

Readers will find that as the book progresses, the explanations become more involved. Concepts that are mentioned briefly in earlier chapters are discussed in greater detail in later chapters, but mathematics is avoided throughout the book. This is a good way to discuss a subject that operates on complex physics and could easily overwhelm the reader. With some research, the reader can extend the Europe-centric discussion to their location. The book has plenty of illustrations, but I did find that some of them were not clearly explained. I had to go back and forth between some illustrations, their captions and references in the text to figure them out. However, the text would have been hard to follow without the many illustrations so I was glad to have them. Readers who have studied the technical aspects of aurora will find some of the terminology in this book obsolete or uncommon and some of it is regionally specific, but these are minor distractions.

I believe that amateur radio astronomers will find reading ***Radio Auroras*** worthwhile for a number of reasons. First, it is easy to read, not very long and covers a number of different topics of interest – the Sun and Earth and their related magnetic fields and interactions. Perhaps some of it is dated. For example, never mentioned is magnetic reconnection, which is now a widely accepted explanation for an important way the IMF interacts with Earth's magnetosphere. Second, the book is useful not only to amateur radio astronomers but also to radio amateurs. Finally, the book will not break the bank, and If you are both an amateur radio astronomer and an amateur radio enthusiast, then you get double the bang for your bucks.

Reviewer - Whitham Reeve has lived in Anchorage, Alaska his entire life. He worked as an engineer and engineering firm owner/operator in the airline and telecommunications industries for more than 40 years and is now a director of SARA and contributing editor for the SARA journal.