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# The Optical Aurora

with 54 figures

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# Preface

The aim of this book is to describe and discuss the aurora as an optical phenomenon, one which can be observed by the naked eye as well as with more sensitive optical detectors. It continues the tradition of studying that impressive and imaginative play of nature, the northern lights, seen and discussed by the Greek philosphers as early as the sixth century B.C.

Today the study of the optical aurora is only one of many ways of acquiring information about a major phenomenon: the ejection of plasma from the sun, the interaction of this plasma with the geomagnetic field and the injection of fast particles into the earth's atmosphere. Hence, the separate treatment of the optical aurora is justified by the particular scientific approach: detection and interpretation of electromagnetic radiation, approximately in the 1000–100 000 Å region, produced through interaction between the auroral particles and the earth's atmosphere.

Other techniques, such as radio observations, X-ray observations, direct particle detections from rockets and satellites, studies of magnetic storms, and measurements of the magnetic field and plasma properties in the magnetosphere, are as important or more important than the classical way of studying the optical aurora. Nevertheless, it was felt worthwhile to treat the optical aurora in a separate book, perhaps mainly because today one author cannot master the whole subject with sufficient competence. This book is thus one volume in a series of books giving a more complete picture of physics and chemistry in space.

The study of the optical aurora has two distinctly different major purposes; first, to consider the optical radiation as one of several end results of a vast phenomenon extending between the sun and the earth. In this connection the earth's atmosphere may be considered as a scintillating screen, and the purpose of the study of auroras is to acquire information about the particle streams penetrating into the atmosphere and the fundamental processes which produced them. Second, to use the information concerning optical radiation to deduce the effects of primary particles on the ionosphere, and hence to study the perturbations of the ionosphere caused by these particles. These studies are important in regard to the propagation of radio waves and other radio phenomena.

Both aspects will receive due consideration in this book, although it is neither possible nor appropriate to keep them separate, chapter by chapter, or to present the book in two separate parts.

Many of the subjects treated in this book have been comprehensively dealt with in an excellent book by J. W. Chamberlain (1961)*. However, since 1960, when that book was written, many important publications have appeared, and the state of our knowledge has advanced considerably. Here we shall emphasize the progress made since then, rather than repeat general descriptions and knowledge which was available at that time. Hence the reader will, for many detailed discussions, be referred to that book.

No historical treatment will be given. Brief summaries of the history of the study of the aurora have been published by Chapman (1967, 1969). Further information may be found in the above mentioned book by Chamberlain (1961).

Blindern, Norway
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Anders Omholt

* For references, see under Chapter 1.

# Contents

Chapter 1

**The Occurrence and Cause of Auroras: a Short Introduction**



Chapter 2

**The Electron Aurora: Main Characteristics and Luminosity**

Chapter 3

## The Proton Aurora



Chapter 4

## The Optical Spectrum of Aurora

Chapter 5

**Physics of the Optical Emissions**



Chapter 6

**Temperature Determinations from Auroral Emissions**



Chapter 7

**Pulsing Aurora**

Chapter 8

## Optical Aurora and Radio Observations



Chapter 9

## Auroral X-Rays

# Frequently used Symbols

Standard spectroscopic nomenclature is used throughout.
Some symbols are occasionally used for other quantities, in agreement with current literature. This use should be clear from the text.

| | |
|---|---|
| $\alpha$ | recombination coefficient |
| $A_{nm}$ | transition probability |
| $\boldsymbol{B}, B$ | magnetic field (vector, scalar) |
| $e$ | electronic charge |
| $E$ | specific particle energy |
| $\boldsymbol{E}, E$ | electric field (vector, scalar) |
| $\Phi$ | geomagnetic latitude |
| $H$ | scale height |
| $H\alpha$, $H\beta$ | Balmer alpha, beta lines |
| $h$ | height |
| $I$ | surface brightness, integral invariant |
| $4\pi I$ | Auroral brightness |
| $L$ | McIlwain invariant parameter |
| $\Lambda_L$ | invariant geomagnetic latitude |
| $\lambda$ | wavelength |
| $m$ | particle mass |
| $\mu$ | magnetic moment |
| $\nu$ | frequency, collision frequncy |
| $\Omega$ | solid angle |
| $\omega$ | angular frequency, gyro frequency |
| $\Psi$ | wave function |
| $R$ | Rayleigh (photometric unit) |
| $R, r$ | radius, space coordinate |
| $\sigma$ | cross section (atomic or molecular) |
| $t$ | time |
| $T$ | universal time |
| $\tau$ | lifetime |
| $\Theta$ | pitch angle |
| $\boldsymbol{v}, v$ | particle velocity (vector, scalar) |
| $v', v''$ | vibrational quantum number |
| $W$ | kinetic energy |
| $\xi$ | penetrated air mass (STP) |
| $\zeta$ | penetrated air mass in number of particles |