1 Introduction

Development of diffraction spectrometers has a special place in optical design because the main element of the diffraction spectrometer is a diffraction grating. The diffraction grating is not a native object; it is an artificially made structure. However, the properties of this structure are so complex that the diffraction grating can be considered not only as a part of the optical instrument but also as a subject of scientific research. That is why very often an engineering problem of the optical design of a spectrometer leads to scientific research.[1–3]

Ray tracing and optimization programs were developed simultaneously with diffraction grating fabrication technology. Initially, these programs were focused on lens design. Later, new features, such as mirror systems and diffraction spectrometer designs, were gradually added to these programs. However, the developers of these programs were not always familiar with all of the specific features and limitations of diffraction grating fabrication technology. That is why the details of diffraction grating modeling are missing from many manuals. The instructors giving lectures to the users of these programs are not able to answer the questions about the modeling of the most complicated types of diffraction gratings in many cases.

The author of this book was lucky to work in both optical design and diffraction grating fabrication. The purpose of the book is to connect these two topics, focusing mainly on surface relief reflection gratings for spectroscopy. The considered gratings are made by using two fabrication technologies: using a ruling engine and holographic recording in photoresist. Since the description of a diffraction grating by polynomial phase (binary) coefficients is, in general, common for most optical design programs, the work is not specifically focused on users of a specific program's code. Historically, some equations were developed in CODE V, and they can be easily transformed into the terms used in any other program by simple weight coefficients. Since some of the programs also have specific surface types which can be used to model a grating (without direct use of phase coefficients), these surface types are briefly discussed.

This book consists of 10 sections. Section 1 is the introduction defining the purpose of the book. Section 2 is a brief history of the diffraction grating and its fabrication. Section 3 shows how the description of the diffraction grating by a two-dimensional polynomial commonly used in optical design programs can be understood in terms of the geometric theory of the grating and how the phase coefficients can be associated with the main aberrations. Section 4 shows that for both ruled and holographic gratings, most of the polynomial coefficients are not independent. The equations connecting the polynomial coefficients with the technological parameters are presented. The importance of these equations is the possibility to use them as user-defined constraints in the merit function for optimization. The constraints prevent the optimization from achieving results that are not producible.