

Terahertz Spectroscopy and Imaging

Theory and Applications

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Preface

There is no commonly agreed definition of the upper and lower frequency limits of terahertz (THz) radiation. Its spectral range overlaps with the far-infrared at the higher frequency end and the microwave region at lower frequencies. Some authors refer to the range of 0.1–1.0 mm in wavelength as terahertz radiation while others extend this range to wavelengths as short as 30 μm .¹ The term thus refers to a relatively narrow part of the electromagnetic spectrum. Despite this narrowness, which it shares, for example, with visible light, terahertz radiation is of great importance in terms of fundamental research as well as in technology and the life sciences. And yet, while nobody would question the importance of research involving radiation such as visible light, until recently research into terahertz radiation has been relatively obscure.

There can be no doubt that the main reasons for the surge in interest in performing spectroscopy at terahertz frequencies were the development of ultrafast lasers and the discovery of the Auston switch in the 1970s. These led to a new generation of spectrometers in the early 1990s that were able to generate and detect pulses of coherent terahertz radiation with previously unprecedented ease and sensitivity. Today, most of the research in terahertz spectroscopy and imaging is carried out using such time-domain spectrometers. Terahertz time-domain spectroscopy (THz-TDS), therefore, is the main focus in this book; though of course other technologies, such as far infrared spectroscopy, remain of great importance and are discussed or referred to where appropriate. The book is structured into roughly three areas. In the first seven chapters, the technology and fundamental physics of terahertz spectroscopy are introduced. The following 13 chapters give a detailed overview of how terahertz radiation can be used to study a wide range of materials. The final three chapters provide a fascinating glimpse into

¹ Brüdermann, Hübers, and Kimmitt recently presented an introduction to the history of terahertz research as part of their monograph on terahertz techniques. Their book is an excellent general introduction with a lot of background information regarding the underlying technology. E. Brüdermann, H.-W. Hübers, and M. F. Kimmitt, *Terahertz Techniques* (Springer, Heidelberg, 2011), pp. 394.

future developments in the field, including physics at terahertz frequencies. Due to space constraints, it has been decided to omit from the present volume in-depth discussions of gas spectroscopy or applications in astronomy and astrophysics.

We are very fortunate in that we have been able to secure some of the leading experts in the field as contributors of chapters to this book. Our aim is to provide a representative, though by no means exhaustive, overview of the current state of research in terahertz spectroscopy and imaging. Terahertz spectroscopy has developed into a very active research community and we hope that this book will provide a go-to source of assistance for its new researchers as well as a reference for its more experienced members.

Joensuu, Cambridge and Tokyo

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