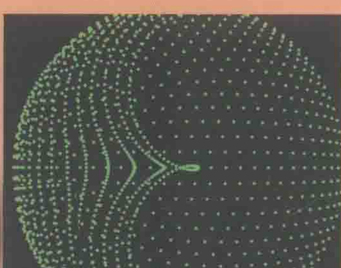
高等院校光电类专业系列规划教材

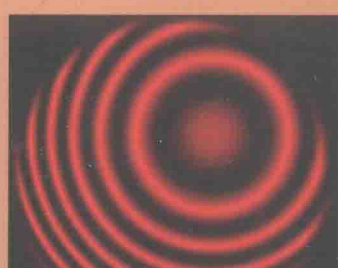
Simulations with VirtualLab in Physical Optics

物理光学

——VirtualLab虚拟仿真

付跃刚 张 磊 欧阳名钊 王 陆 编著





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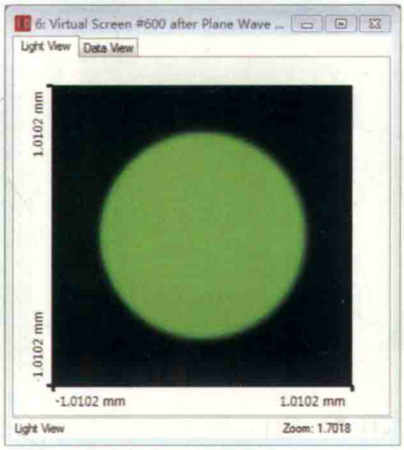
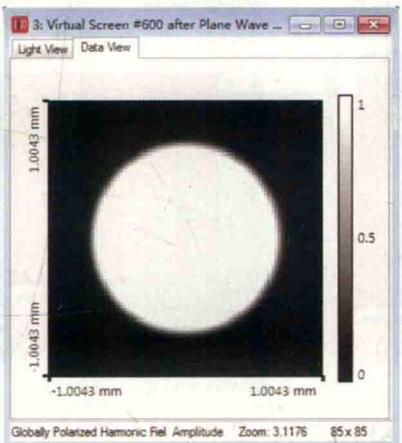
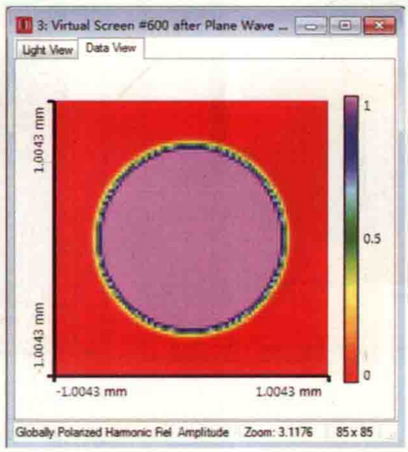


图1-10　人眼视图下的光场分布



(a)光强的灰度视图



(b)光强的伪彩色视图

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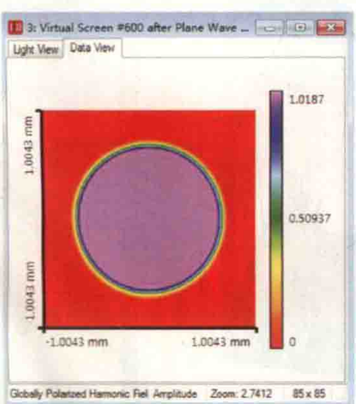
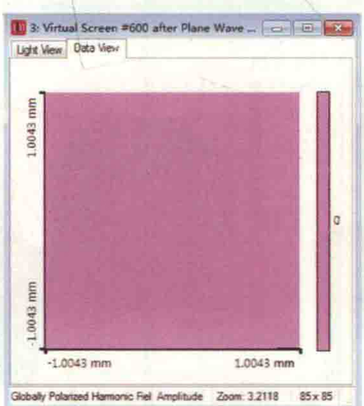
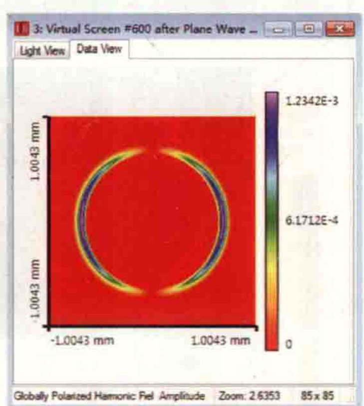


(a)E_x

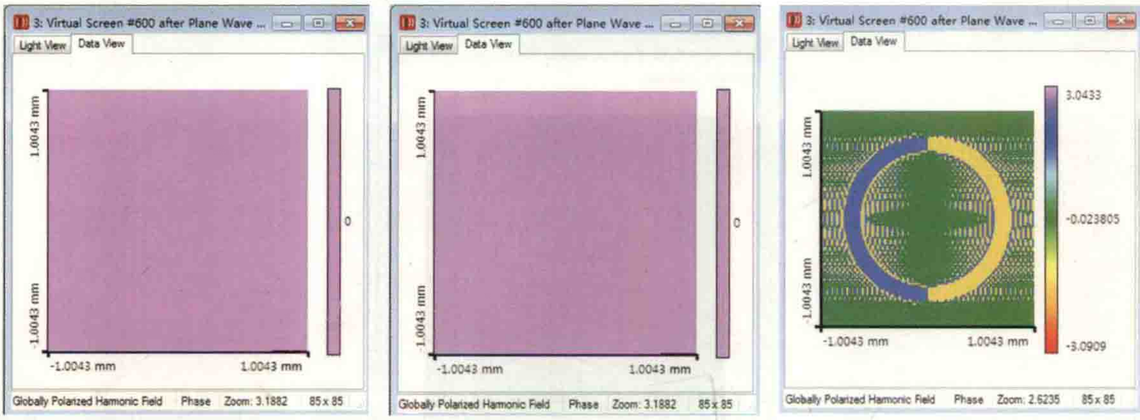


(b)E_y



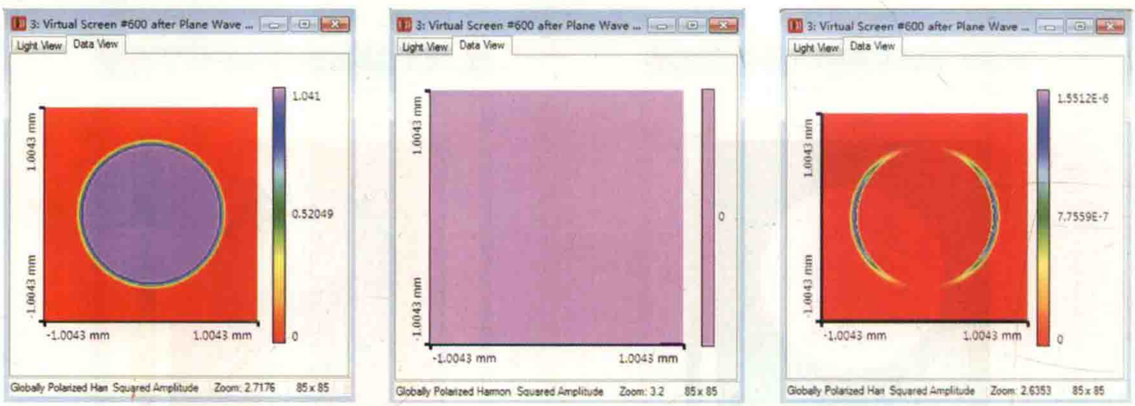
(c)E_z

图1-12　平面波电场振幅的伪彩色视图



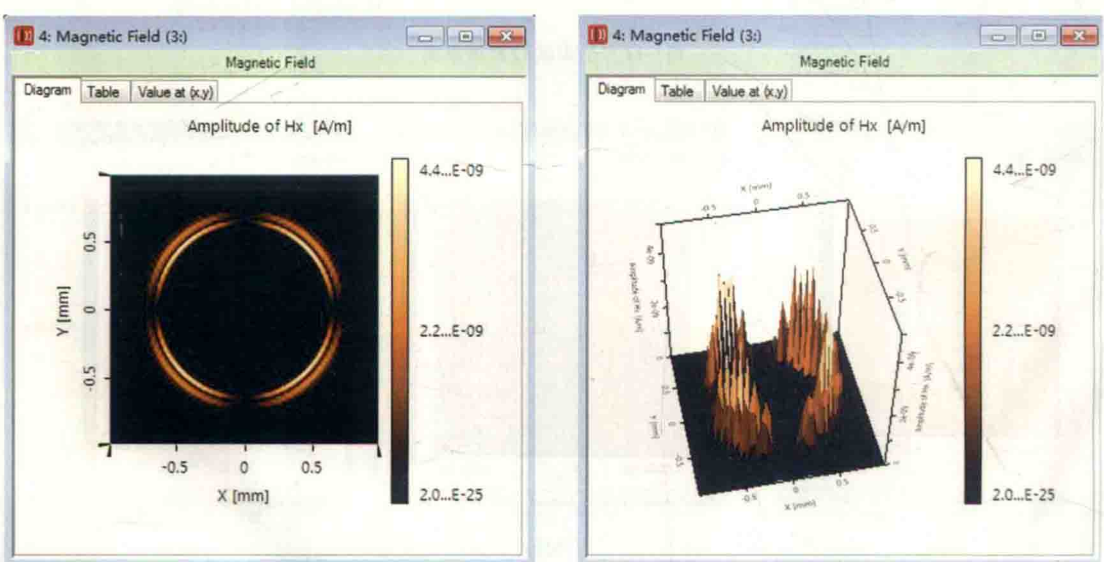
(a)E_x^2　　(b)E_y^2　　(c)E_z^2

图1-13　平面波相位的伪彩色视图



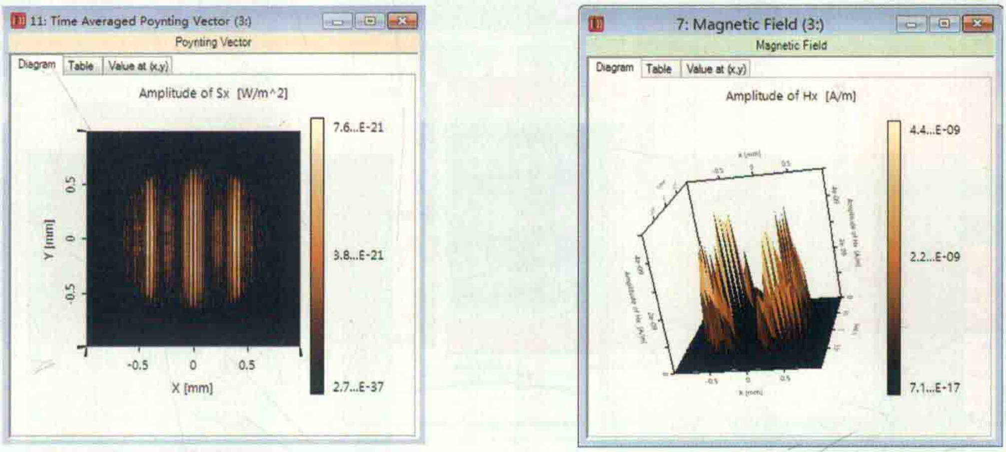
(a)　　(b)　　(c)

图1-14　平面波的各方向上的A^2场分布



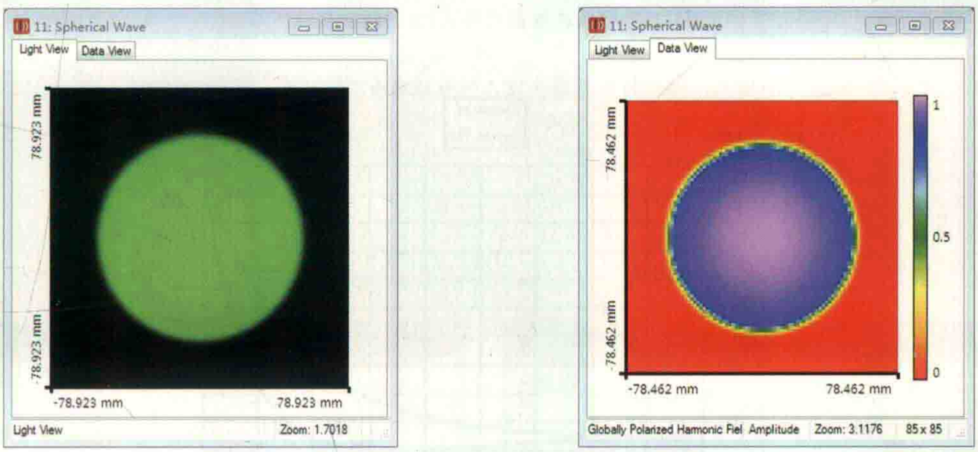
(a)2D模式　　(b)3D模式

图1-15　平面波的磁场振幅x方向分量



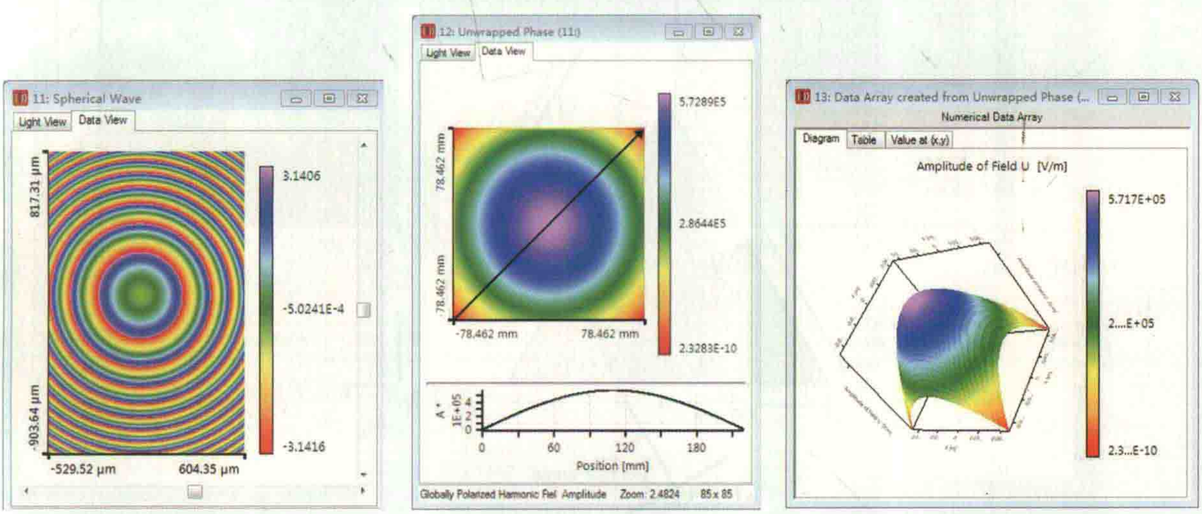
(a)2D模式　　(b)3D模式

图1-16　平面波的坡印廷矢量的x方向分量



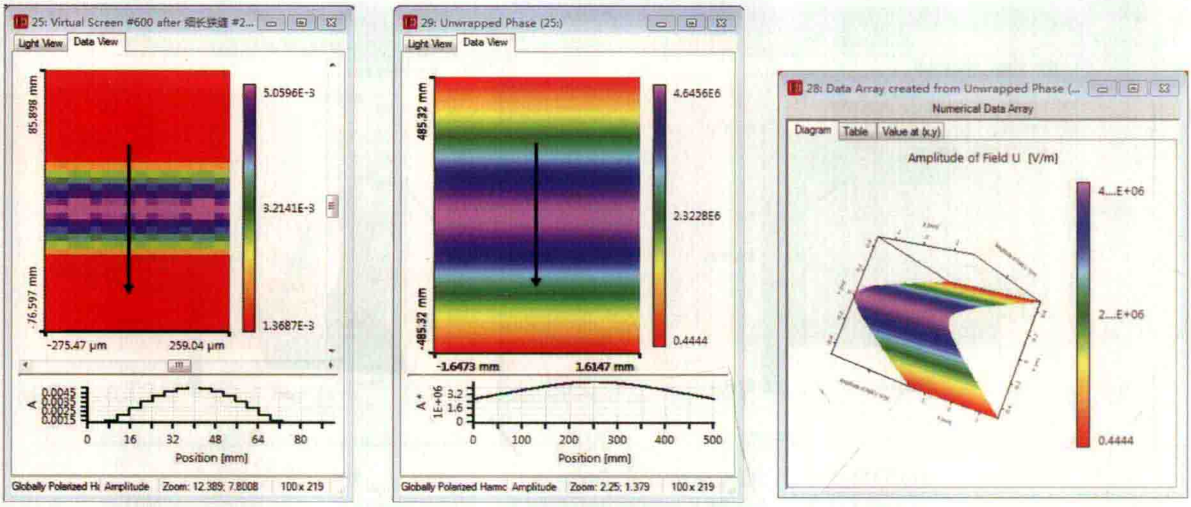
(a)人眼视图　　(b)数据视图（球面波x方向振幅的伪彩色视图）

图1-19　球面波



(a)相位分布的伪彩色视图　　(b)相位分布的2D模式显示　　(c)相位分布的3D模式显示

图1-20　球面波输出光场在x方向的相位分布



(a)振幅分布的伪彩色视图　　(b)相位分布的2D模式显示　　(c)相位分布的3D模式显示

图1-23　柱面波输出光场在x方向的相位分布

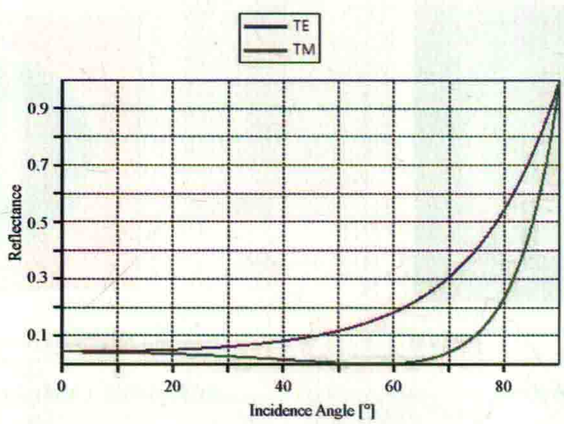


图1-26　TE和TM反射率随入射角的变化曲线

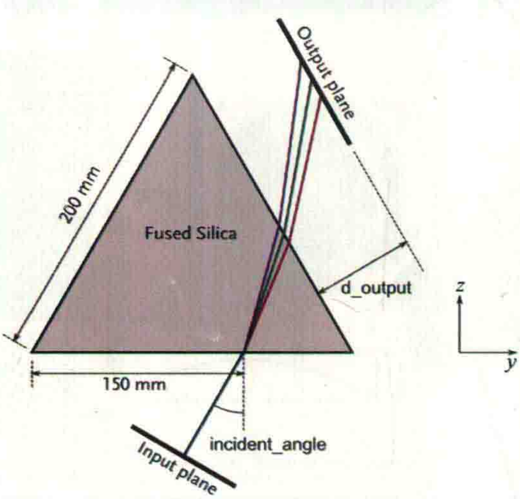
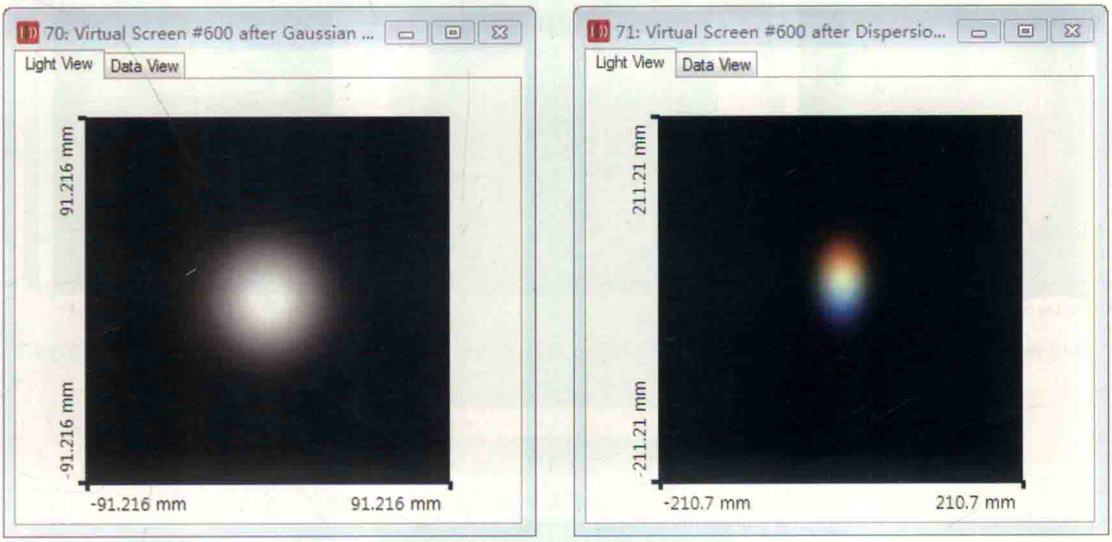


图1-37　色散棱镜模型



(a)入射光场　　(b)出射光场

图1-38　色散棱镜的入射光场与出射光场

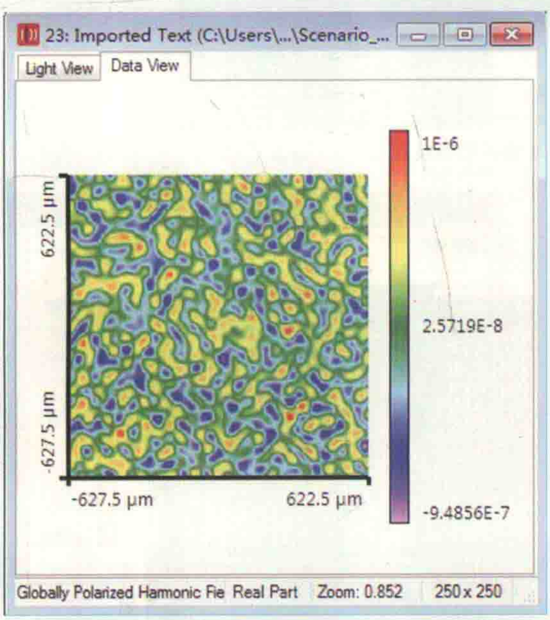


图1-40　粗糙表面的二维分布

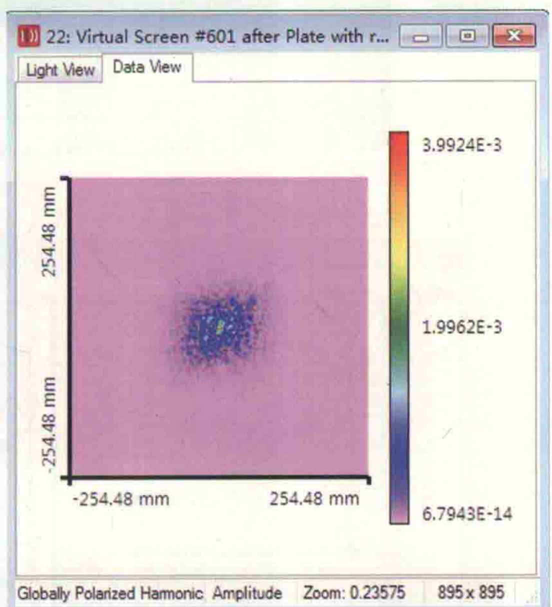
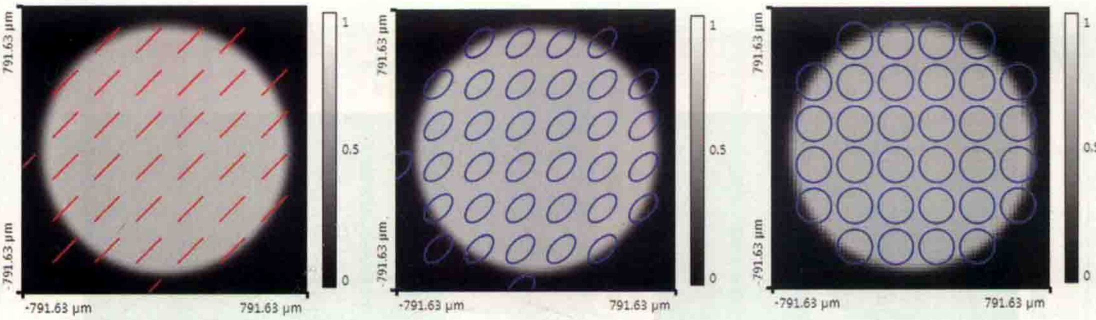


图1-41　输出光场的伪彩色视图



(a)y偏振相对x偏振分量延迟为0　(b)y偏振相对x偏振分量延迟为1　(c)y偏振相对x偏振分量延迟为$\pi/2$

图2-48　y偏振相对x偏振分量延迟量变化对叠加光场偏振状态的影响

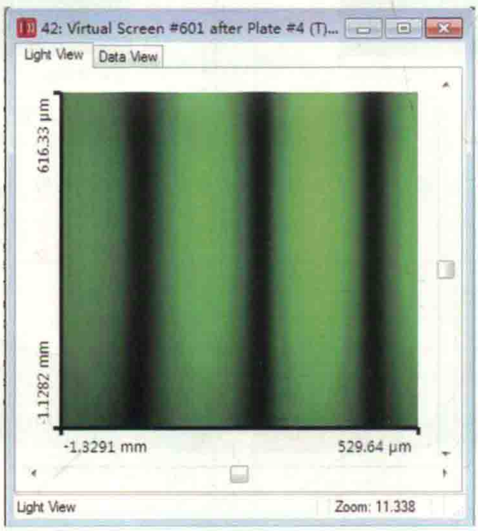
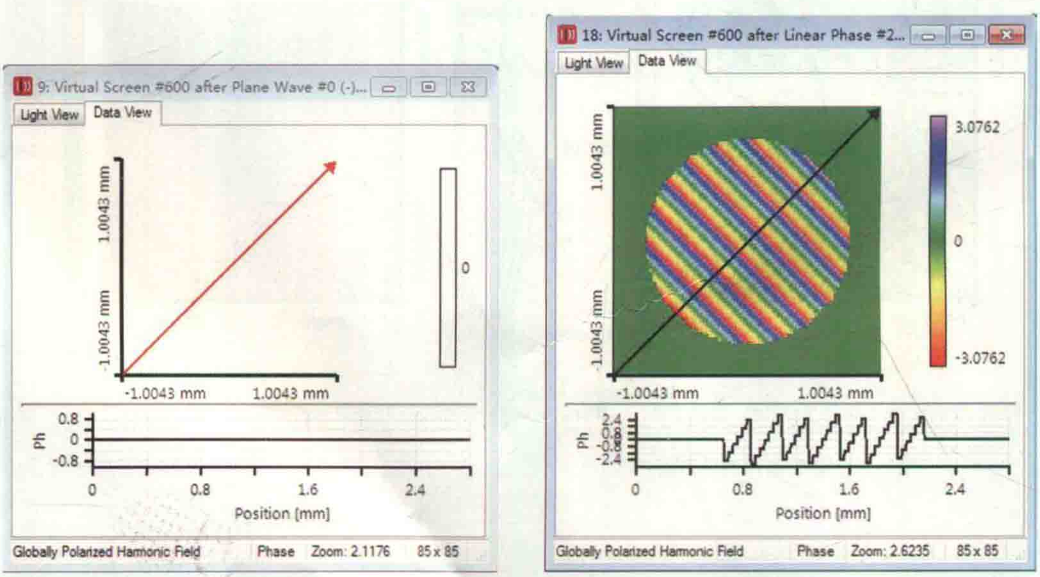


图2-65　杨氏干涉出射光场的人眼视图



(a)　　(b)

图2-69　平面波经线性位相调制对比

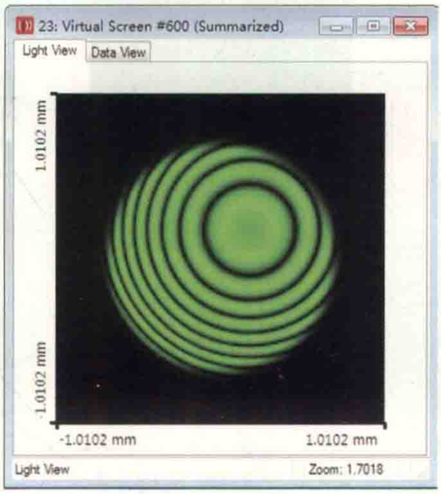


图2-71　经调制后的平面波和球面波的干涉光场

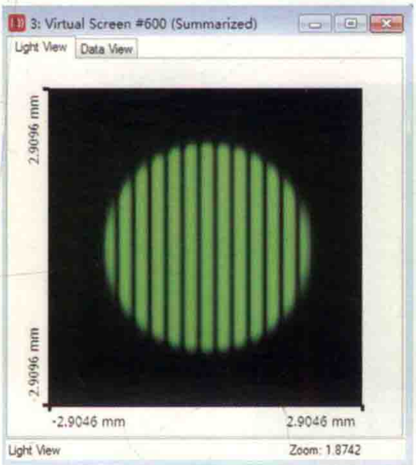


图2-84　迈克尔逊干涉输出光场

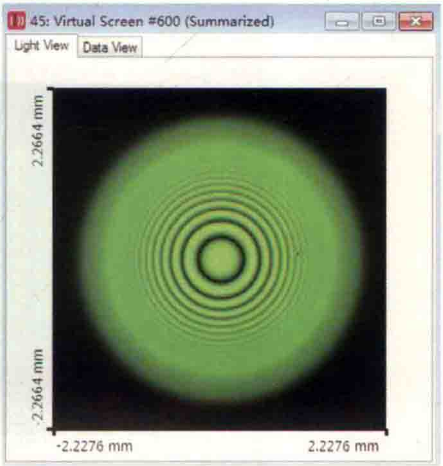
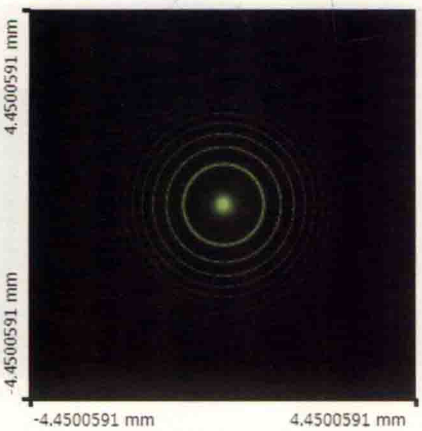
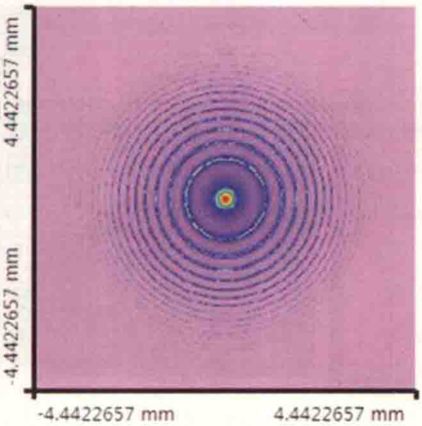


图2-90　马赫–曾德干涉仪输出光场

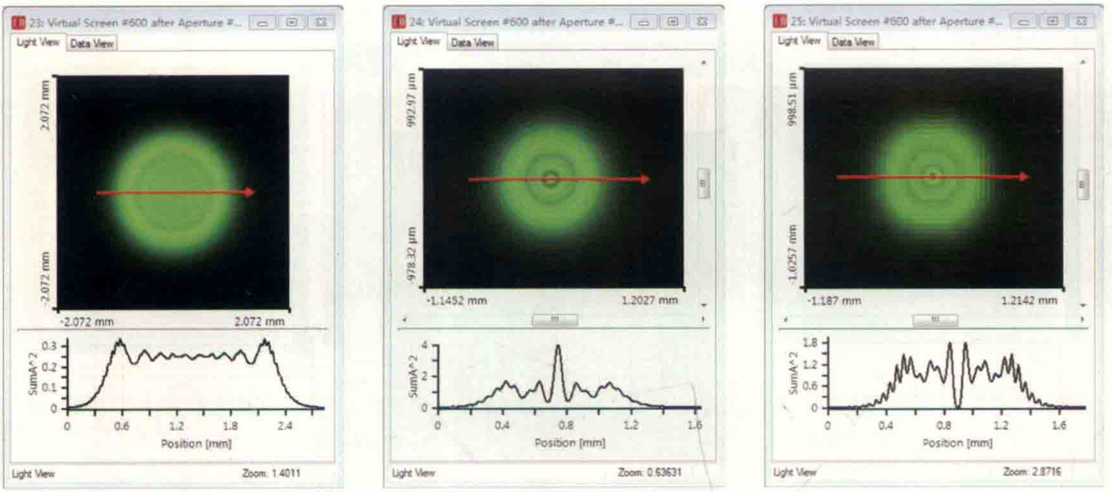


(a)人眼观察效果



(b)伪彩色视图

图2-105　F-P干涉仪单波长干涉图样



(a)球面波光源　(b)平面波光源，光阑孔径为5个半波带　(c)平面波光源，光阑孔径为6个半波带

图3-21　虚拟屏上的光场显示

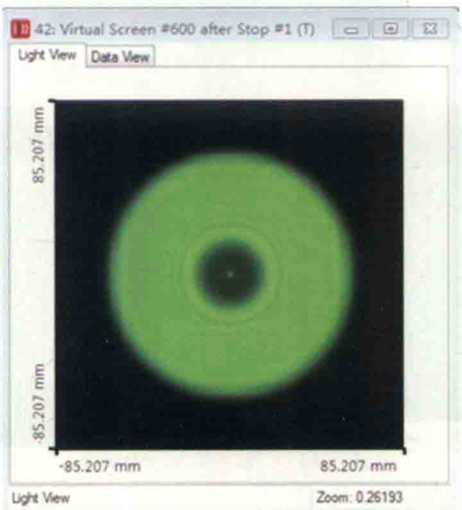
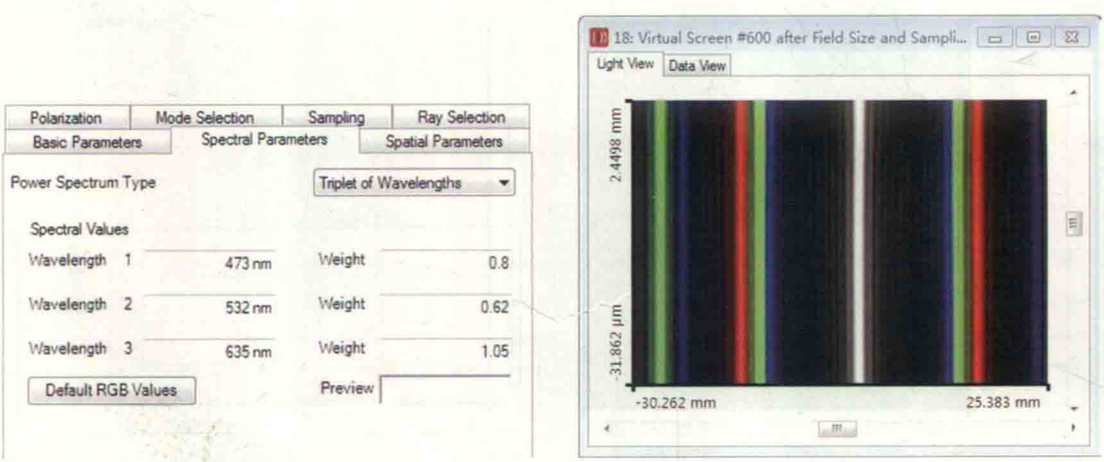
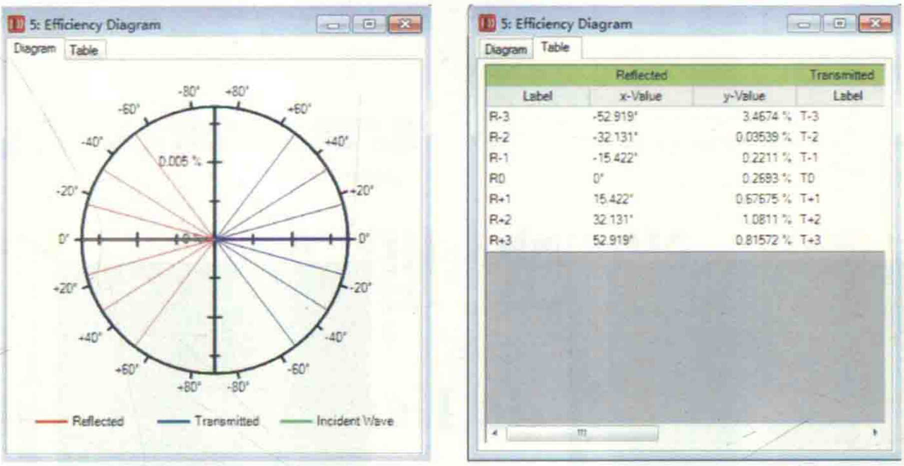


图3-24　菲涅耳圆屏衍射场



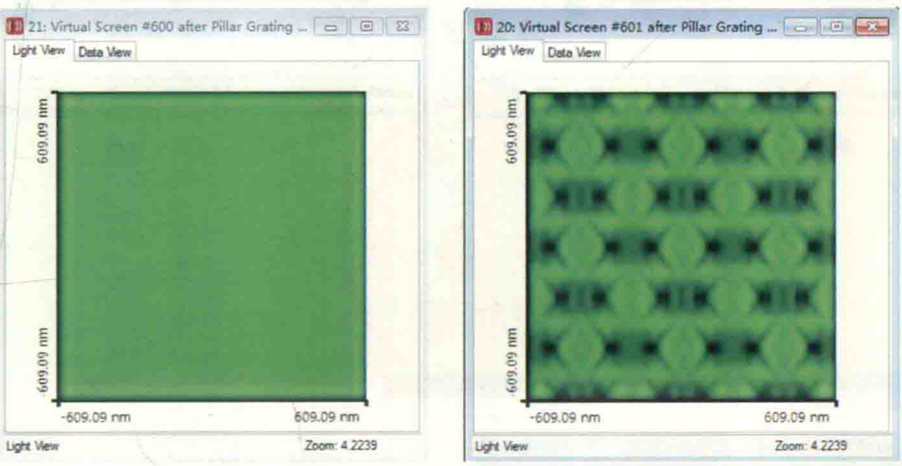
(a)光源设置　(b)衍射输出场

图3-41　衍射光栅实验二



(a)圆形表示　　(b)列表表示

3-51　闪耀光栅各级次的衍射效率



(a)透射输出场　　(b)反射输出场

图3-56　柱形3D光栅透射和反射输出场

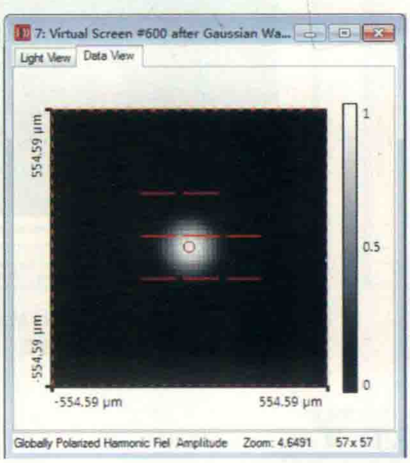


图4-20　偏振方向为x方向的线偏振高斯光

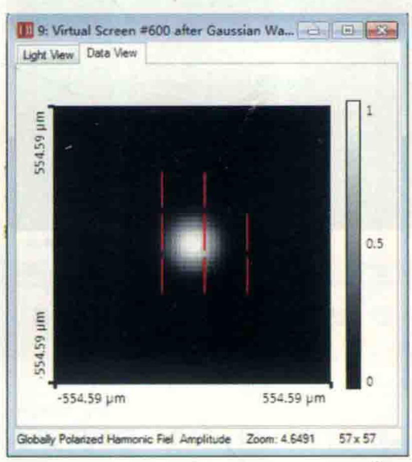


图4-21　偏振方向为y方向的线偏振高斯光

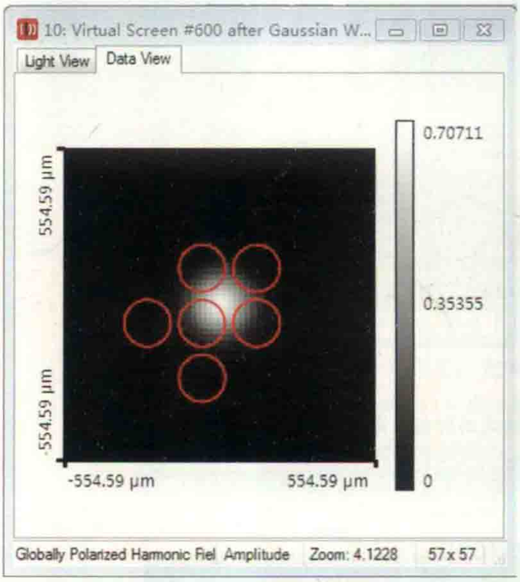


图4-22　右旋圆偏振高斯光

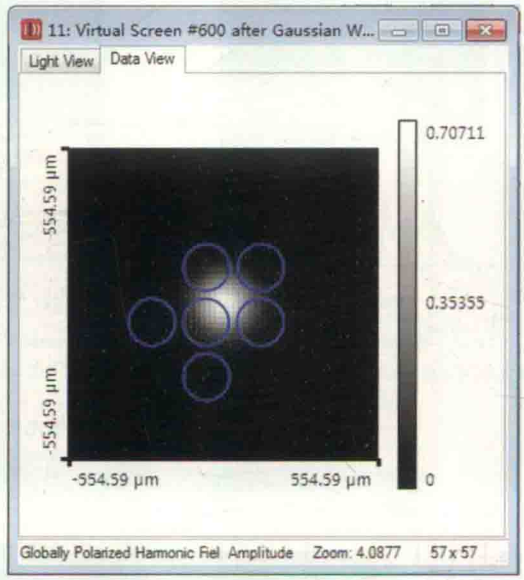


图4-23　左旋圆偏振高斯光

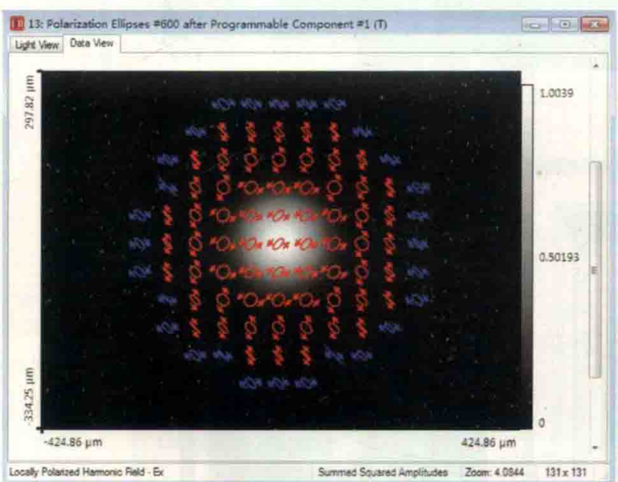


图4-27　径向双折射输出光场的偏振椭圆

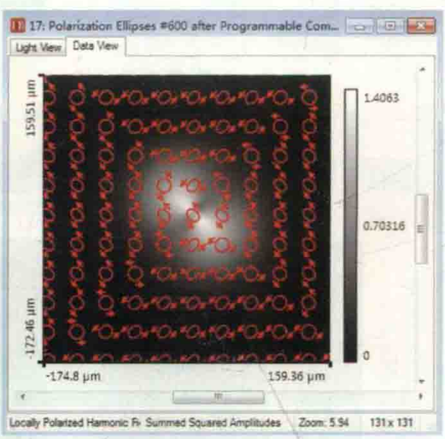


图4-30　有方位角的双折射晶体输出光场的偏振椭圆

高等院校光电类专业规划教材编委会

Preface

Optics and photonics have developed to an essential enabling technology in commercial and industrial applications. Optical technologies play an important role in an ever-increasing number of products and fabrication processes. Any nation with advanced ambitions in high technology must have a high standard and advanced expertise and skills in optics and photonics, which requires a well-established education in optical technologies on a high and modern level. Consequently, the development of optical technologies is of increasing concern in universities, institutes and industry of China. This book will be a contribution to the support of a modern optics education in China.

Optical modeling and design is still dominated by the well-established geometrical optics approach in form of ray tracing methods. However, its limitations also become more obvious by introducing light sources like CW lasers, ultrashort laser sources, partial coherent X-ray sources, LED's, and laser diodes to mention some of them. Moreover, optical components come in a much larger variety including micro optical components, lens arrays, gratings, diffractive optical elements, diffusers, freeform surfaces, and waveguides. Finally, besides imaging nowadays much more general manipulation and control of light gain momentum. This interest in non-imaging occurs for instance in form of laser beam shaping, general light transformations, lighting, light pattern generation, scattering, wavefront engineering, polarization and coherence control. All these developments demand for an optical modeling and design approach which is not restricted to ray tracing but includes geometrical optics as one technique among others. Wave-optical modeling techniques must be embedded in a modern optical modeling concept as well. A unification of optical modeling and design is highly required.

In my teams at Friedrich Schiller University and the companies LightTrans and Wyrowski Photonics, all situated in Jena, Germany, we have developed a unified optical modeling approach, which we call field tracing. It consequently uses an electromagnetic representation of light and by that, it allows the combination of any physical optics modeling technique with geometrical optics. That enables fast modeling with high accuracy, which includes diffraction, interference, polarization and coherence effects. It does not replace geometrical optics but allows its combination with wave-optical methods for modeling optical systems.

We have developed the optical modeling and design software VirtualLab based on unified optical modeling by field tracing. Hence, it provides ray tracing, geometrical optics field tracing and numerous wave-optical modeling techniques in an interdisciplinary optical modeling platform. Ray tracing and wave optics are typically considered as opposite poles in optical modeling and design, However, VirtualLab combines the best of both worlds and establishes a fast, accurate, and unified optical design experience.

In this book, the authors discuss along the typical curriculum of optics education at Chinese universities the highly beneficial use of VirtualLab in education. With various examples, the use of VirtualLab is demonstrated. Though the potential of VirtualLab is much higher than it is possible to present in such an education-related book, it gives a very good first insight into the concepts of modeling with VirtualLab with an emphasis on wave optics. We support the use of VirtualLab in the optics education in China, because we are firmly convinced that it offers the most attractive and sophisticated way to add simulation experiments to optics education. In this context, I'd like to thank Mrs. Zhu from Infotek for her steady effort with the VirtualLab Teaching Plan, which is attracting a growing number of Chinese universities.

I wish this book a wide distribution in China and I am convinced that it will have a very positive impact on a high-level optics education in China.

Prof. Dr. Frank Wyrowski
Jena, Germany
March 6, 2015