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现代应用光学

CO_2探测仪光学系统设计

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摘要： 设计并架构了CO_2探测仪的光学系统。通过对比国外典型大气温室气体探测仪采用的光学系统,总结了光栅与傅里叶变换两种分光方法的优缺点,确定设计的CO_2探测仪采用大面积光栅色散光谱仪系统,该光学系统包括前置光学系统和三通道光栅光谱仪系统两部分。前置光学系统由无焦双离轴抛物面系统、2个分束器和3个聚焦透镜组组成,采用了多种消杂光措施,有效抑制了杂散光。光栅光谱仪的3个通道采用相同的结构,工作在相同的偏离角下;根据光栅方程推导了固定偏离角下光栅参数的计算方程,确定了3个通道的光栅参数;透镜采用低膨胀熔石英材料;大面积光栅工作在大入射角、大衍射角状态,工作波段内的光栅衍射效率可达90%以上。对光学系统的分析测试显示:通过在光谱仪系统放置0级光陷阱等消杂光措施,可将杂散光控制在10^{-5}以下,空间方向的MTF大于0.9,光谱分辨率达到0.035 nm(@760 nm),实现了20点同步观测。由于相对孔径较大(*F*1.8),提高了集光能力。结果表明,设计的光学系统满足温室气体探测的技术指标要求。

关键词： 温室气体探测 CO_2探测仪 大面积光栅 光谱仪 光学设计

Optical system design of CO_2 sounder

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Abstract: An optical system for CO_2 sounder is designed and implemented. The advantages and disadvantages of two dispersive methods, grating and Fourier transfer, are summarized by the contrast of optical systems from different greenhouse gas spectrometers, and the optical system with a large area diffractive grating as a dispersive element is selected for the CO_2 sounder. The total optical system includes a fore-optics and a tri-channel grating spectrometer. The fore-optics consist of a non-focal system with double off-axial parabolic mirrors, two dichotic splitters and three focal lenses, in which several measures are taken to reduce stray light. Each channel in the tri-channel grating spectrometer has the same mechanics, and three gratings have the same deviation angle to ensure the high mechanic stability. On the basis of grating equation, a computational formula is derived to calculate the grating parameters at the fixed deviation angle and to determine the parameters of three large area gratings. The lens material is fused silica with a low coefficient of expansion. The diffractive efficiency of the large area grating can be over 90% when it works at a large entrance angle and a large diffractive angle without other order diffractive lights except 0 order and +1 order diffractive lights at selected wavebands. Analysis and experiments on the system show that the system can detect 20 footprints at same time. By setting a 0 order light trap and other stray light removal methods, the stray light in the system has decreased to 10^{-5}, its spatial MTF is more than 0.9(@1.4 lp/mm), and the spectral resolution of the spectrometer exceeds 0.035 nm(@760 nm). Moreover, the large relative aperture(*F*1.8) increases the ability to collect light. The design results indicate that the optical system can satisfy the technical requirements of CO_2 sounders.

Keywords: greenhouse gas sounding CO_2 sounder large area grating spectrometer optical design

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