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现代应用光学

旋转粗糙圆柱的激光散射功率谱分析

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摘要： 建立了圆柱旋转激光散斑功率谱的理论模型以实现粗糙目标光学无损测量的方法。首先,根据粗糙面激光散射特征,研究了平行光束照射匀速旋转的圆柱表面时其反射空间形成的动态散斑特性,给出了接收场散斑强度起伏互相关函数及其功率谱密度函数的理论模型,以及动态散斑场的相干长度和接收信号带宽。接着,分析了旋转引起的散斑平移和散斑沸腾对接收信号带宽的影响。最后,测量了旋转圆柱准镜向及漫射部分的散斑图像。结果显示:当0.633 μm入射光波照射半径为1 mm的圆柱时,频率为10 Hz的旋转圆柱自相关函数的相关时间约为4 ms,而20 Hz的旋转圆柱自相关函数对应的相关时间为2 ms左右。结果表明,在动态散斑场中,多普勒效应和散斑平移效应引起的带宽约为同一个量级,而散斑沸腾效应可以忽略。

关键词： 激光散射 动态散斑 旋转圆柱 粗糙目标 功率谱 带宽

Analysis of power spectra for laser scattering intensity on rotating cylinder targets

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Abstract: A mathematical model for the power spectrum density function of dynamic speckles was established to complete the nondestructive measurement of a diffuse target. First, the dynamic speckle characteristics formed by the reflection space of a rotating cylinder at an immobile angular velocity were discussed when it was fully illuminated by a collimated light beam. The theoretical model on the cross-correlation function and the power spectrum density function of dynamic speckle intensity fluctuation was given and the coherent length and receiving signal bandwidth of the dynamic speckle field were described. Then, the impacts of speckle translation and speckle boiling caused by rotation cylinder on the received signal bandwidth were analyzed. Finally, the near-specula of the cylinder and the diffuse speckle patterns were measured. Obtained results indicate that when the wavelength of 0.633 μm is shone on the cylinder with a diameter of 1 mm, the correlation time of autocorrelation function is 4 ms for a 10 Hz rotating cylinder and 2.0 ms for a 20 Hz rotating cylinder. In conclusion, the Doppler effects and speckle translation effects in the speckle dynamic field can produce the bandwidth with the same order of magnitude, and the speckle boiling effect can be negligible.

Keywords: laser scattering dynamic speckle rotating cylinder roughness target power spectrum bandwidth

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参考文献：

[1] 陈辉. 粗糙物体高斯波束散射及在激光一维距离成像中的应用. 西安:西安电子科技大学学位论文, 2004. CHEN H. *Scattering of Gaussian beam by object with rough surface and its application on laser one dimensional range profile*.Xi'an:Xi Dian University. (in Chinese) [2] BANKMAN I. Analytical model of Doppler spectra of coherent light backscattered from rotating cones and cylinders [J].*J. Opt. Soc. Am. A*,2000,17(3):465-476. [3] MINDEN M L, KOST A, BRUESSEBACH H W. A range resolved Doppler imaging sensor based on fiber laser [J]. *IEEE*, 1997, 3(4):1080-1086. [4] 王广君, 田金文, 柳健. 激光成像雷达前视成像仿真及障碍物识别方法研究[J]. 红外与激光工程, 2001,30(6):462-465. WANG G J, TIAN J W, LIU J. The front view imaging simulation of imaging laser radar and the obstacles identification approach [J]. *Infrared and Laser Engineering*, 2001,30(6):462-465. (in Chinese) [5] 郭冠军, 邵芸. 激光散斑效应对激光雷达探测性能的影响[J]. 物理学报, 2004, 53(7):2089-2093. GUO G J, SHAO Y. Rough surfaces induced speckle effects on detection performance of pulsed laser radar [J]. *Acta Physica Sinica*, 2004, 53(7):2089-2093. (in Chinese) [6] BRIERS J D. Laser Doppler and time varying speckle: reconciliation [J]. *J. Opt. Soc. Am. A*, 1996, 13(2):345-350. [7] 程传福, 宋洪胜, 刘春香,等. 基于电磁场积分方程数值求解法的光学近场散斑及其一阶统计特性[J]. 中国科学(G), 2004,34(1):15-28. CHENG CH F, SONG H SH, LIU CH X, *et al*.. The optical near field speckles and their first order statistics on the basis of the integral equations of electromagnetic field [J]. *Science in China,Ser* (G), 2004,34(1):15-28. (in Chinese) [8] YURA H T, HANSON S G, LADING L. Laser Doppler velocimetry: analytical solution to the optical system including the effects of partial coherence of the target [J]. *J. Opt. Soc. Am. A*, 1995, 12(9):2040-2407. [9] WANG J Y. Lidar signal fluctuations caused by beam translation and scan[J].

Applied Optics, 1986,25(17):2878-2885. [10] GOODMAN J W. *Statistical Optics*[M]. New York:John Wiley & Sons, Inc., 1985:1-28. [11] ERDMAN, JOACHIM C. Speckle field of curved, rotating surfaces of Gaussian roughness illuminated by a laser spot [J]. *J. Opt. Soc. Am.A*, 1976,66(11):1194-1204. [12] LYNM J, SMITH. Far-field speckle and Doppler shifts for rough laser-illuminated rotating cylinders [J]. *Applied Optics*, 1979,18(6):755-756.

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1．袁建国, 李好, 何清萍.光转换单元中锁相环带宽的优化[J]. 光学精密工程, 2011,19(8): 1937-1943

2．王国良, 刘金国.基于粒子滤波的多自由度运动目标跟踪[J]. 光学精密工程, 2011,19(4): 864-869

3．朱猛, 黄战华, 王小军, 蔡怀宇.显微动态散斑法测量压电陶瓷位移特征曲线[J]. 光学精密工程, 2011,19(4): 844-849

4．苏学军, 高劲松, 朱华新, 赵晶丽, 冯晓国.窄通带高透过频率选择表面[J]. 光学精密工程, 2011,19(3): 561-566

5．杨林, 郑贤良, 陈波.基于反射镜表面粗糙度计算极紫外望远镜分辨率[J]. 光学精密工程, 2011,19(11): 2565-2572

6．杨 晖, 郑 刚, 王雅静.用动态光散射现代谱估计法测量纳米颗粒[J]. 光学精密工程, 2010,18(9): 1996-2001

7．张宁;沈湘衡;杨亮;谢明明,.利用动态靶标谐波特性评价光电经纬仪的跟踪性能[J]. 光学精密工程, 2010,18(6): 1286-1294

8．周斌, 王军政, 沈伟.基于组合带宽均值迁移的快速目标跟踪[J]. 光学精密工程, 2010,18(10): 2297-2305

9．刘超, 胡立发, 穆全全, 曹召良, 高峰, 王永伟, 宣丽.校正水平湍流波面的自适应光学系统的带宽需求[J]. 光学精密工程, 2010,18(10): 2137-2142

10．章宝歌, 李碧琦, 鲁彦.非对称马赫-曾德尔干涉仪型不等带宽光学梳状滤波器[J]. 光学精密工程, 2010,18(10): 2150-2155

11．吴保军.四极质谱检测中复合放大器的低噪声高带宽设计[J]. 光学精密工程, 2008,16(9): 1767-1772

12．杨先辉[1];张秋华[2];于永森[3];孙圣和[1].可调谐F-P腔进行锥形光栅 反射带宽解调的应力测量方法[J]. 光学精密工程, 2007,15(5): 651-655

13．李文军;陈 涛.光电跟踪系统噪声分析及其抑制[J]. 光学精密工程, 2007,15(2): 254-260

14．李小秋[1,2];高劲松[1].Y环单元FSS结构参数对频率特性的影响[J]. 光学精密工程, 2006,14(6): 1070-1075

15．肖 凯;刘 颖;付绍军.振幅矢量叠加法分析X射线波带片 加工误差对效率的影响[J]. 光学精密工程, 2005,13(6): 643-649