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硕士学位论文

激光自混合干涉测量系统的研究与应用

Research and Application of Measurement System Base on Laser Self-Mixing Interference

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摘　要

激光自混合干涉效应是指由于外部物体反射或者散射，而导致光反馈回激光腔内引起光功率波动的现象。该技术不仅保证了传统干涉的测量精度，还具备单光路、结构紧凑、易准直等优点，解决了传统干涉中存在的问题，因此受到了研究人员的关注，被广泛应用于速度、位移和振动、生物医学等领域的测量。

本文介绍了激光自混合干涉效应的发展历程和研究现状。通过三种不同的数学模型，详细阐述了自混合效应的机理，并对自混合干涉系统进行数值仿真，进而分析研究了系统模型中各参数对自混合干涉信号的影响。在此基础上，搭建半导体激光器自混合干涉测量系统，通过观察和研究实验现象，验证了理论仿真的结果。此外，本文还根据自混合基本数学模型，研究了特征点分析、波形拟合、频谱分析三种参数测量方案，并对比了它们的优劣。

在理论研究和基础实验的基础上，本文分析讨论了自混合干涉技术在阻尼、折射率、脉搏波方面的测量应用：（1）研究了阻尼振动的基本理论，基于搭建的自混合干涉测量系统实现阻尼测量，并利用波形计数方案还原阻尼振动曲线；（2）基于自混合原理提出一种简易的折射率测量方案，分析测量方案中摆放误差对结果精度的影响，从中得出优化系统角度可以降低甚至消除该误差的结论；（3）研究心血管的基本理论，基于搭建的自混合干涉测量系统实现脉搏波测量，实验结果验证了该方案的可行性。

关键词：自混合干涉;参数测量

Abstract

As a new laser technique called, self-mixing interference (SMI), which is based on the interaction of cavity field with the field backscatter from the remote target, has increasingly garnered intense attention. The SMI has advantages of simple and compact system structure and easy collimated light path. Therefore, the applications of the SMI have been popularized in many fields, including metrology, laser parameters, velocimeter, and biomedical signals sensing.

In this article, we introduce the development history and the current research issues of SMI. Base on three different mathematical models, we analyze the mechanism of self-mixing effect, and the influence on SMI signals of various model parameters. On this basis, we build the SMI measurement system of semiconductor laser. According to the base experimental phenomena, we verify the correctness of the theoretical simulation results. In addition, we also research three methods of measuring system model parameters of SMI, which include research the feature point analysis method, waveform fitting method, frequency-spectrum analysis method, then compare their advantages and disadvantages. Finally, we discusses the measurement applications, such as damping vibration, refractive index and pulse wave, based on SMI: (1) studying the mechanism and characteristics of damping vibration, using the wave counting obtaining damping vibration curve by building SMI measurement system; (2) demonstrating a new method based on SMI for refractive index measurement, obtaining conclusion that the setting error of the proposed system can be effectively decreased by modifying the incidence angle; (3) researching the basic theory of cardiovascular, obtaining the pulse wave by building SMI measurement system, the experimental results verify the feasibility of the scheme.

Keywords: Self-mixing Interfer;Parameter Measuremen

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