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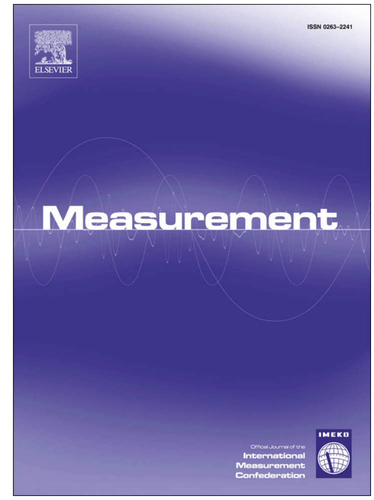

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Wenbo Wan, Dengxin Hua, Jing Le, Tingyao He, Zhe Yan, Chunyan Zhou

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Study of Laser-Induced Chlorophyll Fluorescence Lifetime Measurement and its Correction

Wenbo Wan, Dengxin Hua *, Jing Le, Tingyao He, Zhe Yan, Chunyan Zhou
(*School of Mechanical and Precision Instrument Engineering, Xi'an University of Technology, Xi'an 710048, PR China*)

Abstract A novel method for laser-induced fluorescence lifetime measurement and correction are presented to improve precision of chlorophyll fluorescence lifetime measurement. Laser was used as excitation source for exciting chlorophyll fluorescence. According to the measured signals characteristics, the fluorescence and background signals were detected respectively by photomultiplier. The chlorophyll fluorescence lifetime can be estimated from deconvolution of the fluorescence and background signals. Based on a number of retrieved results from simulations, a rule of inherent error with deconvolution was found. Therefore, the calibration formula was obtained through the comparison of ideal fluorescence lifetimes and retrieved ones. In actual measurements, the intrinsic fluorescence decay can be separated from the measured signals by deconvolution, and thus, the retrieved fluorescence lifetimes were substituted into a calibration formula to calculate the corrected values. Both simulations and experiments show that the method is a high precision and real-time measurement technique for chlorophyll fluorescence lifetime.

Keywords: Fluorescence lifetime, Laser-induced fluorescence, Correction technique, Deconvolution, Fluorescence LiDAR

1. Introduction

With the increasing industrialization and urbanization, ecological environment has become a global issue. Human environment has a serious effect on the plant growth variations. If a tiny variation within plant can be detected before visual observation, the variation of plant growth could be predicted. The light energy, which is absorbed by plant chlorophyll, is useful for photosynthesis. Some of the surplus energy is lost as fluorescence-emission [1-3]. Theoretically, the plant information can be obtained by measuring chlorophyll fluorescence. Although chlorophyll fluorescence is fainter compared to the reflected radiation, it is now possible to be detected using accurate equipments with high spectral resolution. The optical measurement technique, which is widely used to detect chlorophyll fluorescence for the plant growth status, has become a focus of the laser remote sensing.

Fluorescence Light Detection and Ranging (LiDAR), as a powerful type of laser remote sensing technology, with high temporal-spatial resolution and measurement accuracy, has been widely applied in environment monitor. The first global map of plant fluorescence had been published by NASA in 2011, in which distributions of global plant were shown. At present, the plant Fluorescence Explorer (FLEX) programme feasibility of European Space Agency (ESA) has been studied with the uncertain date of LiDAR launching. As the intrinsic parameter of fluorescence signal, fluorescence lifetime is unsusceptible to ambient light, divergence angle of fluorescence and chlorophyll photolysis, etc. Therefore, chlorophyll fluorescence lifetime measurement can provide high stability and precision [4,5]. However, because of the extremely short chlorophyll fluorescence decay time, the fluorescence lifetime measurement is a challenge, which can not be achieved by the traditional instruments and measured methods. In this work, a novel method is presented to correct the inherent error from fluorescence lifetime measurement.

* Corresponding author. Tel./fax: +86 029 82312441.
E-mail address: dengxinhua@xaut.edu.cn (D. Hua).