Abstract Title

Monitoring of the plant growth using statistical interferometry under the influence of air pollution

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Abstract body

1. INTRODUCTION

Recently, rapid advancement in the human activities, especially in the industry, has led to serious problems of environmental pollution. Therefore, demands to establish new techniques that can estimate the level of the damage to the plants has been on the rise. In this study, we have developed an optical method to monitor the condition of plant such as biological activity or growth with an aim to assess the environmental conditions. For this purpose, a statistical interferometry proposed by the authors[1-3] has been applied to measure the growth of the plant. In the experiments, the growth rates of the plant were measured under ozone exposure, which is the main substance of photo-chemical smog.

2. EXPERIMENTAL SYSTEM AND METHOD

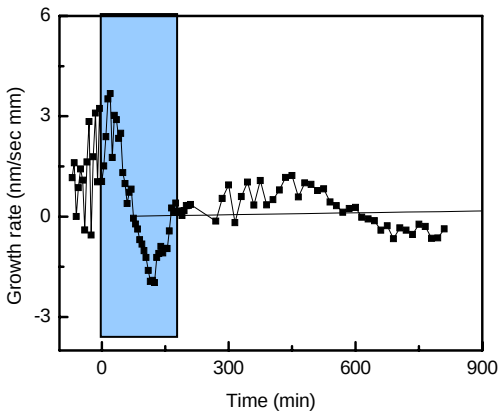
The object phase Ψ is derived according to the algorithm of the statistical interferometry. In contrast to the conventional and deterministic interferometric techniques such as the phase shifting interferometry (PSI), heterodyne interferometry etc., we have taken a reversed approach to achieve a technique with high accuracy and have adopted the complete randomness of the interfering fields as a standard of phase in a statistical sense. The fully developed speckle field has a completely randomized wavefront which takes a uniform probability density distribution over $-\pi$ to π[4]. In our previous study, we pointed out that this randomness of the fully developed speckle field can be a standard for phase. This method has the advantage of its simple optical system to achieve measurements with an extremely high accuracy. It was found from computer simulations that an accuracy of $2\pi/1000$ is attainable with about speckle intensity data samples N=30000.

3. EXPERIMENT

The speckle interference patterns were acquired every half a second over several seconds, and the phase changes due to the growth of the plant were analyzed according to the algorithm of statistical interferometry. Several experiments were carried out to demonstrate the validity of the present method to investigate the behaviors of plants under pollutant exposure, ozone. We used Liriope platyphylla as a sample. The experiments were

done with d=3mm, and the growth rate is indicated as expansion per 1mm on the leaf.

In the figure, the results are shown for the ozone concentrations of 0.12 ppm for 3 hours. Ozone concentration of 0.12 ppm is the level where photo-chemical smog advisory is issued. It can be clearly seen that the average growth rate before exposure, 1.3nm/sec, rapidly decreases in a short period. Negatiave growth rate means that the leaf has started to shrink. Moreover, the most significant and interesting point would be that the growth rate of the plant is never constant that can be seen typically for time<0, on the contrary to our common understanding for the behavior of plant. When the biological activity is reduced due to toxic ozone exposure, the fluctuation in the growth rate also becomes smaller to be 18% of that in normal condition. It was also found that the reduction in the growth rate fluctuation depends on the ozone concentration.



Dependence of growth rate of plant under exposure of 0.12ppm ozone.

4. CONCLUSION

In this study, we have applied statistical interferometry to monitor the condition of plant, i.e., biological activity or growth aiming to monitor the influence of air pollutant, ozone. With the potential of our technique for its high sensitivity of nm scale measurement and high temporal resolution of second scale, we found that exposure of ozone retards plant growth. Further, under normal conditions, the plant growth rate has some inherent fluctuations and these fluctuations have been found to be reduced too under ozone exposure. These inherent fluctuations in growth rate are not known before as there are no methods to investigate in such fine scale and were also confirmed in other species of plant. We are expecting such behavior is reflecting a very fundamental aspect of plant activity.

Keywords

Statistical interferometry, Environmental pollution, Ozone, Plant growth

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