# 利用多色光超快脈衝產生氣態電漿誘發兆赫輻射之研究

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## 摘要

在本論文中，我們探討如何利用多色光超快雷射脈衝聚焦產生之空氣電漿誘發寬頻兆赫波輻射。這個現象可以用瞬時光電流模型來解釋，其中多色雷射脈衝之間的相位差、能量比例、以及脈衝總能量是影響兆赫波強度的重要因素。因為較為不對稱的電場分佈會得到較強的方向性瞬時電流，以雙色光激發兆赫波輻射時，相位差為 0.5π 時產生之兆赫波強度最強，而相位差為 0 時沒有兆赫波輸出。雙色光的最佳相位在不同的脈衝能量下變化不大。若以三色光誘發兆赫波輻射，其最佳相對相位差則會隨著脈衝能量變化，二階諧波與基頻光之最佳相位差落在 0.4π 至 0.5π 之間，而三階諧波與基頻光最佳相位差落在 0.7π 至 π 的範圍。

不同色光之脈衝能量比例會影響電場之不對稱性，並且產生兆赫波的最佳比例會隨著總脈衝能量而改變。實驗結果驗證了模擬中對二色光之能量比例與兆赫波輻射能量變化之趨勢的預測。此外，多色脈衝光之偏振態與兆赫波輻射強度以及偏振態的關係也在此工作中被探討。同時，模擬結果顯示以同旋光性之圓偏振二色光脈衝，可消除相對相位差對兆赫波輻射產生強度之影響，惟線性偏振之兆赫波之偏振角會隨著相對相位改變而旋轉。

# Investigation on Generation of terahertz radiation from a gas plasma excited by phase-controlled multi-color ultrafast pulses

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## Abstract

In this thesis, we investigate how to generate broadband terahertz (THz) emission by multi-color laser-induced filament in ambient air. The generation process of coherent THz wave from a gas plasma induced by multi-color ultrafast pulses can be well-described by transient photocurrent model. The relative phases, power ratios between multi-color laser fields and total pump power are important factors that will affect the yield of output THz signal. Simulation of THz emission based on the transient photocurrent model is carried out in this work. Because the directional transient current induced by the asymmetry of the synthesized electric field is stronger, the THz yield is strongest when one employs 2-color pulses pumping with their relative phase equals to $\pi/2$ while there is no output when the phase is 0. In 3-color pumping cases, the optimized relative phase changes with the power ratio between 3–color pulses and the total pump power, while it remains still in 2-color cases.

The relation of the THz power and the pumping power ratio has been investigated in 2-color pumping in both simulation and experiments. The experiment results are in general agreement with the prediction of the simulation outcome. We also considered the influence of polarizations of pumping pulses on THz emission. Meanwhile, using 2-color pulses pumping with both right or left circularly polarization, the relative phase does not affect the radiation power of the THz waves but the polarization angle of the linearly polarized THz field.