Improving harmonic conversion efficiency via optimizing macroscopic properties of the gas medium

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Synopsis We study the effects of length and pressure of gas jet on the conversion efficiency of macroscopic harmonics. Our results show that an optimal flux for certain range of harmonics can be obtained by optimizing macroscopic properties of the gas jet.

High-order harmonic generation (HHG) has been considered as one of the best methods to obtain an ultra-short coherent light source in the extreme ultraviolet (XUV) and soft x-ray regions. It can also produce attosecond pulse, which provides a powerful tool to reveal ultrafast dynamics of the electron in the atoms and molecules.

However, for HHG applications, there are still some drawbacks[1]. One of the main disadvantages is its low conversion efficiency. In essence, the conversion efficiency depends not only on the parameters of laser field, but also on the macroscopic properties of the gas jet[2]. So the HHG conversion efficiency is not necessarily enhanced monotonously by increasing the pressure and the length of the gas jet.

In this paper, we want to find out whether there is a highest conversion efficiency for certain range of harmonics. Figures 1 and 2 show the conversion efficiency for harmonics of Ne atoms in the plateau region (H30-H45) and cut off region (H45-H55), respectively. It turns out that the conversion efficiency goes up as the pressure is increasing, but it goes down when it climb over the top as the pressure is getting higher for each length of the gas jet. For a fixed length of the gas jet, there is also optimal conversion efficiency for each gas jet pressure. Additionally, for the best conversion efficiency of different harmonic regions, the optimal pressure and length of the gas jet are different.

By means of removing the possible factor (for example, absorption and dispersion) terms in our theoretical model, we find out that the absorption of HHG is the most important factors under the condition of our simulation.

Our study indicates that the conversion efficiency of HHG for certain range can be improved by selecting proper pressure and length of the gas jet.

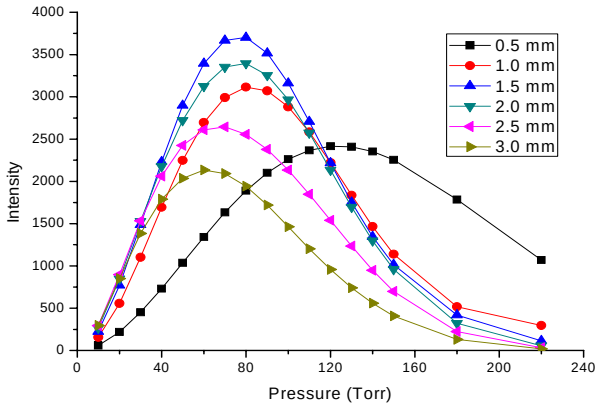

Figure 1. The conversion efficiency of harmonics H30-H45 as a function of the length and pressure of the gas jet.

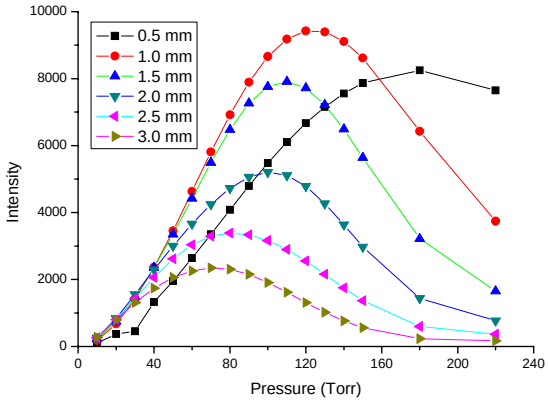

Figure 2. The conversion efficiency of H45-H55 as a function of the length and pressure of the gas jet.

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