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# Numerical analysis of spatial evolution of the small signal gain in a chemical oxygen–iodine laser operating without primary buffer gas

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**Abstract**

A chemical oxygen–iodine laser (COIL) that operates without primary buffer gas has become a new way of facilitating the compact integration of laser systems. To clarify the properties of spatial gain distribution, three-dimensional (3-D) computational fluid dynamics (CFD) technology was used to study the mixing and reactive flow in a COIL nozzle with an interleaving jet configuration in the supersonic section. The results show that the molecular iodine fraction in the secondary flow has a notable effect on the spatial distribution of the small signal gain. The rich iodine condition produces some negative gain regions along the jet trajectory, while the lean iodine condition slows down the development of the gain in the streamwise direction. It is also found that the new configuration of an interleaving jet helps form a reasonable gain field under appropriate operation conditions.


*Keywords:* Chemical oxygen–iodine laser (COIL); Without buffer gas; Interleaved jet

## 1. Introduction

A chemical oxygen–iodine laser (COIL) is a short-wavelength, high-power chemical laser that operates on an atomic iodine laser transition. The ground-state iodine atom, I, is pumped into the excited state, I*, through a process of near-resonant energy transfer between metastable singlet oxygen, $O_2(^1\Delta)$, and I. The laser medium, I*, then radiates a photon with a wavelength of $\lambda = 1.315\,\mu m$, which can amplify the seed beam into a high-power infrared laser beam through the resonator. Research on COILs has recently accelerated due to the potential military and industrial applications that are dedicated to systematic integration of COILs into compact mobile platforms. To meet the requirements of such integration, we must reduce the enormous volumes and weights of COIL devices while maintain the original performance. In spite of the apparent difficulty of the task, it is an interesting research topic.

Recent research indicates that a COIL operating without primary buffer gas achieves higher efficiency and stability and more applicability for mobile integration [1–4]. In such a COIL system, the traditional pressure recovery device, which is driven by combustion gas injectors, is replaced with quiet cryosorption pumping equipment. However, one of the problems with this kind of COIL is that the injection orifices must be arranged downstream the nozzle throat due to the low character velocity, because this COIL device uses nitrogen rather than helium as the buffer gas [1–4]. Recently, at Ben-Gurion University [3–6], a series of experimental studies were completed with a special slit-nozzle supersonic COIL operating without primary buffer gas. Those studies concluded that the gain distribution is often inhomogeneous because of inefficient mixing [6]. Transverse jets in the transonic or supersonic section chock the nozzle flow or generically induce complicated flow discontinuities, which may in turn seriously affect the development of the mixing and chemical reaction flow.

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