INJECTION SEEDING FOR SINGLE-MODE OPERATION IN AN OPTICALLY PUMPED HIGH-POWER D_2O LASER


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Abstract

Spectrally narrow, pulsed outputs consisting of almost a single mode have been obtained from an optically-pumped high-power (200kW) D_2O laser by adopting the injection seeding method, where single-mode radiation (seed pulse) from a low-power, compact D_2O laser has been injected into the main D_2O laser. Spectrally narrow outputs with high power having spectral widths as narrow as 5 MHz have been obtained, when the seed pulses with frequency tuned to one longitudinal mode of the main D_2O laser have been injected at a time sufficiently before the lasing of the main laser took place. The experimental results have been compared with those of numerical simulation modified to include the injection field with varying injection times.

Keywords: injection seeding, spectral narrowing, optically pumped D_2O laser, high power, numerical simulation, semiclassical theory
1 Introduction

Spectral narrowing of optically-pumped high-power far-infrared (FIR) lasers has been of great importance since many applications of FIR lasers require the emission frequency to be spectrally pure. For instance, the ion temperature measurement of high-temperature fusion plasmas by collective scattering of FIR laser radiation requires a high-power narrow-bandwidth D$_2$O laser [1], since the broadband emission from the D$_2$O laser induces spurious broadening of the scattered radiation, resulting in excessive evaluation of the ion temperature [2]. The multimode D$_2$O laser is applicable for the ion temperature measurement if the spectrum of the D$_2$O laser emission is measured simultaneously with the scattered radiation [2]; however, this method requires an expensive extra receiver to measure the spectral distribution of the D$_2$O laser radiation with a high frequency resolution.

We have recently developed an oscillator-amplifier system for spectral narrowing of a high-power D$_2$O laser, in which a low-power single-mode output from a compact D$_2$O laser is amplified by a high-power D$_2$O amplifier [3]. As a result, spectrally narrow outputs of approximately 10 MHz in full width at half maximum (FWHM) were obtained from the amplifier successfully. However, the output power of the oscillator-amplifier system was about one half the value obtainable with our conventional D$_2$O laser system [4], in which the D$_2$O amplifier in the oscillator-amplifier system was operated as a laser oscillator with an unstable resonator. In addition, spectrally narrow radiation is obtained only in the central region of the amplifier cross section, unless the beam diameter from the compact D$_2$O laser is expanded [3]. The above two items are drawbacks of the oscillator-amplifier system; the weak output power is an especially serious problem since high power is an indispensable requirement when we apply the D$_2$O laser system to ion Thomson scattering measurements.

In this paper, we adopt the injection seeding method for spectral narrowing of a high-power D$_2$O laser. Injection seeding is a popular method for spectral narrowing (single-mode operation) in other broadband lasers such as TEA CO$_2$ lasers and dye lasers [5]. In this method, a low-power, monochromatic radiation from a master laser is injected into the cavity resonator of the high-power broad-