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High power 1123nm Nd:YAG laser longitudinally pumped by a 7W diode bar

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Abstract

We report efficient operation at 1123nm of a Nd:YAG laser end-pumped by a 7W diode-bar. Despite the low gain of this transition, an output power of 1.6W TEM_{00} has been obtained for 5.6W of incident pump power.

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Summary

Laser emission at 1123nm has a number of possible applications, the most notable being differential absorption water vapor LIDAR, to remotely sense concentrations of water vapor in the atmosphere. For this application use is made of two different wavelengths, one, at 1123.06nm, coincides with a weak absorption peak of water vapor, see figure 1, while the other at 1123.2nm, falls in a region of very low water absorption. Nd:YAG provides the possibility for laser emission at both of the required wavelengths, and has been recognised as a suitable laser source for such a system[1]. However the emission cross-section of Nd:YAG at 1123nm is very small, around one fifteenth that of the 1064nm line, hence resulting in very low gain. Thus to achieve efficient laser operation at 1123nm, a very bright pump source is required so that intense pumping can be achieved.

In this paper, we describe a diode-pumped Nd:YAG laser producing an output of 1.6W at 1123nm, in a linearly polarised, diffraction limited gaussian beam, around a five-fold increase on previous reports for this transition[2].

The diode used was a 7W diode-bar operating at 807nm, manufactured by the Opto-Power Corporation. The diode emission, which came from a 4.6mm wide region, was reshaped using the previously reported two mirror 'beam-shaping' technique[3]. The resulting beam had 5.6W of power, was approximately circular, and had M^2 values of ~20 and ~40. This was used to end-pump a 10mm long Nd:YAG rod, housed in a water cooled heat sink. To obtain intense pumping, the pump light was focused to a spot size of radius 130μm. The small spot-size results in a strong thermal lens in the laser rod, measured to have a focal length of ~55mm, but also being significantly aberrated. Careful design of the laser resonator was needed to achieve the combination of high efficiency and good beam quality. The resonator used is shown in figure [2]. A convex mirror (pump input mirror) adjacent to the rod gave partial compensation for the thermal lens. The output coupler, 2% transmission for 1123nm, had >90% transmission at 1064nm, to suppress lasing at this wavelength. These conditions gave a lasing threshold of 0.8W, and slope efficiency of 33% (both with respect to absorbed pump power), and at the maximum output power, 1.6W, a measured M^2 of ~1.1 was obtained.

These results suggest that efficient operation of a single frequency Q-switched ring laser on this transition should be possible, as required for an actual LIDAR system.

1 'A water vapor DIAL system using diode pumped Nd:YAG lasers', Stefan Lehmann and Jens Boesenberg, 18th INTERNATIONAL LASER RADAR CONFERENCE, Abstract book pg. 56

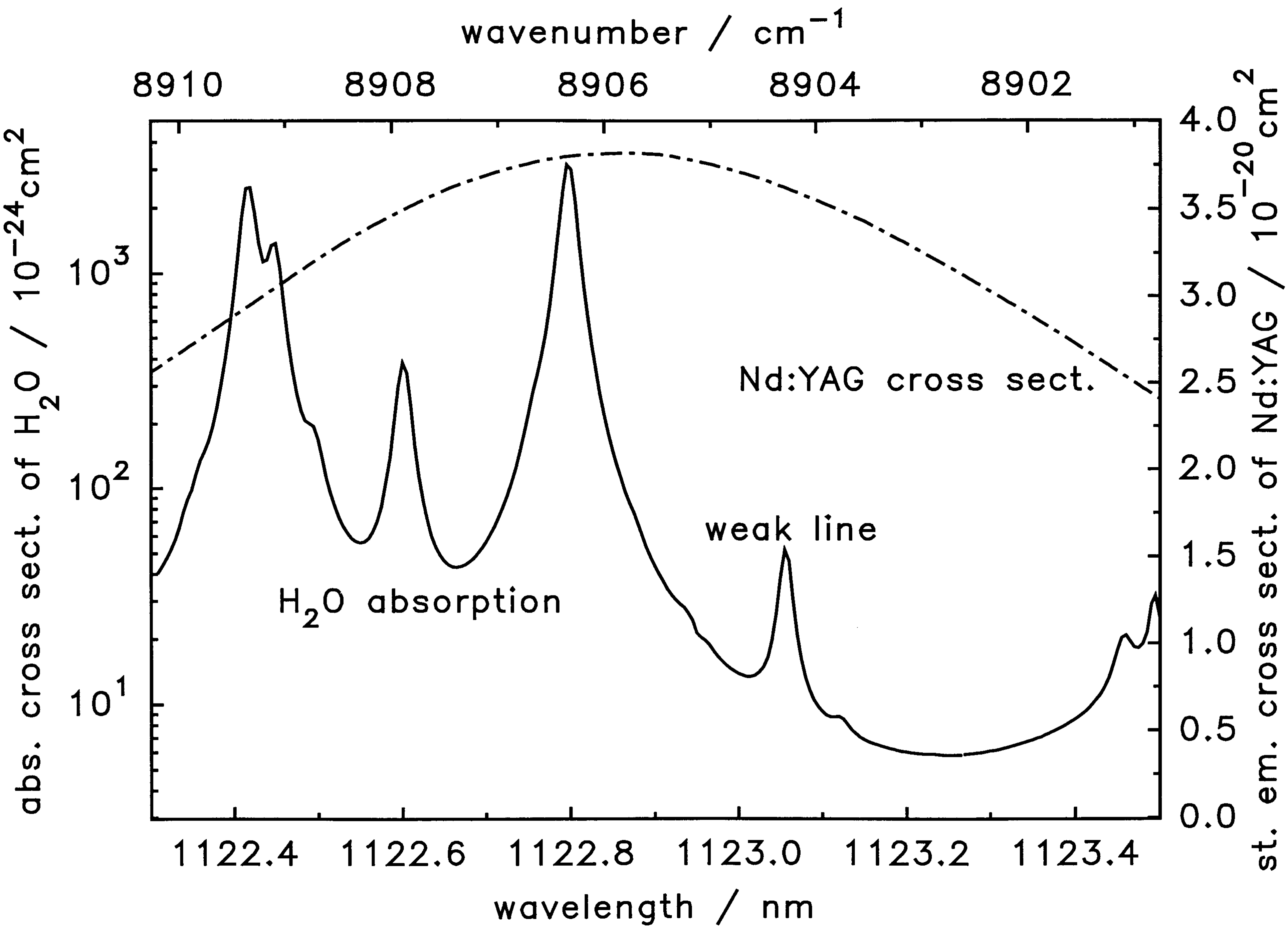
2 S. G.Grubb et al, ELECTRONICS LETTERS, vol. 28, No. 13, June 18 1992, p1243.

3 W. A. Clarkson and D. C. Hanna, OPTICS LETTERS, vol. 21, No. 6, March 15, 1996, p375.

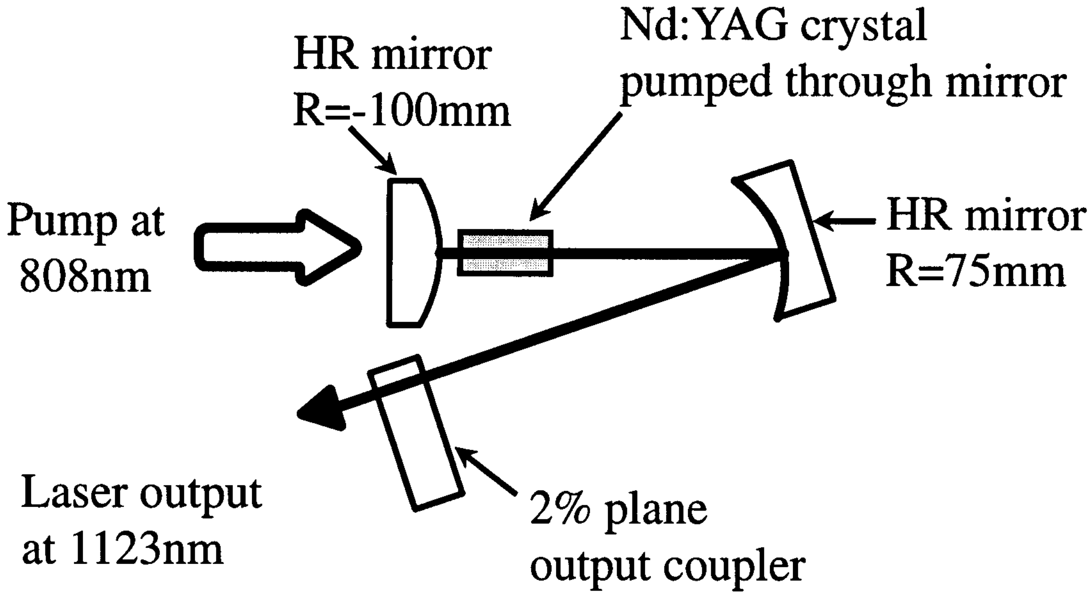
Figure captions:

figure 1 Absorption cross section of H_2O and emission cross section of Nd:YAG around 1123nm

figure 2 Laser resonator design



wavenumber / cm^{-1}
8910
8908
8906
8904
8902
abs. cross sect. of H_2O / 10^{-24}cm^2
10^3
10^2
10^1
st. em. cross sect. of Nd:YAG / 10^{-20}cm^2
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Nd:YAG cross sect.
weak line
H_2O absorption
1122.4
1122.6
1122.8
1123.0
1123.2
1123.4
wavelength / nm


HR mirror
R=-100mm
Nd:YAG crystal
pumped through mirror
Pump at
808nm
HR mirror
R=75mm
Laser output
at 1123nm
2% plane
output coupler