ACCURATE CO\textsubscript{2} LASER FREQUENCIES AND MOLECULAR
CONSTANTS OF REGULAR AND NEW HOT-BAND LINES\textsuperscript{*}

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Abstract

A new, high-resolution, highly
efficient, cw, CO\textsubscript{2} laser oscillating on more
than 250 lines including over 40 lines in the
new 9 \textmu{}m hot band has been built at NIST,
Boulder. The frequencies of the 9 and 10 \textmu{}m
hot band lines and high J (to J=66) regular
band lines of 12\textsuperscript{C}\textsuperscript{16}O\textsubscript{2}, which now fill the gap
between the 9 and 10 \textmu{}m regions, have been
locked to saturated fluorescence signals in
CO\textsubscript{2}, and measured. New molecular constants
and more accurate frequencies of the four
common isotopes of CO\textsubscript{2} have been obtained.

A CO\textsubscript{2} laser oscillating on more than 3
times as many lines as the standard CO\textsubscript{2} laser
has been built. A regular CO\textsubscript{2} laser oscillates
on 75 to 80 lines; this laser oscillates on more
than 250 lines. It exhibits such high resolution
and efficiency that a whole new band system
which had not previously been observed has
been discovered. The new system is the 9
\textmu{}m hot band (01\textsuperscript{1}1-[1\textsuperscript{1}1\textsuperscript{0},03\textsuperscript{0}]\textsubscript{0}) a partner to
the well known 10 \textmu{}m hot band (01\textsuperscript{1}1-
[1\textsuperscript{1}1\textsuperscript{0},03\textsuperscript{0}]\textsubscript{0}). More than 40 lines have been
observed in this band, the strongest emitting

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more than 8 W cw. The laser has higher
resolution and more efficiency than other CO\textsubscript{2}
lasers; this has been brought about by the use
of a multi-ribbed discharge tube and zero-order
coupling from a high reflectance, ruled-in-gold
grating. The grating end of the laser, 1.5 m
long and 13.5 mm id, is shown in Fig.1. The
ribs are spaced about 10 mm apart and are

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Figure 1. Grating end of zero-order multi-
ribbed CO\textsubscript{2} laser.

1.5 mm high (they are simply molded into the
16 mm id Pyrex tube). Their main function is
to block the waveguide (wall-bounce) modes
from oscillating; this increases the resolution
about a factor of three compared with a
non-ribbed tube, and permits the weaker lines,
such as the sequence and hot band lines, to
oscillate. A portion of the scan of laser output versus grating angle is shown in Fig. 2.

The laser oscillates on higher-J lines, permitting accurate frequency measurements of these lines for the first time. An analysis of these frequencies produces more accurate molecular constants on the transitions in the regular bands of this laser and these lines serve as both frequency and wavelength standards from 27 to 33 THz (11.1 to 9.1 μm).

Both high J (to J=66) regular lines and 9 and 10 μm hot-band lines were stabilized on the saturated fluorescence in CO₂ and frequency measured with respect to ¹²CO₂ and ¹³CO₂. A least-squares analysis of the frequencies that includes the present measurements, recent new absolute frequency measurements (1), and earlier relative and absolute frequency measurements (2) of the laser transitions has been made. This analysis has resulted in an improved set of rovibrational constants and new values for the laser transition frequencies and their uncertainties for the regular bands of ¹²C₁₆O₂, ¹³C₁₈O₂, ¹₂C₁₄O₂, and ¹₃C₁₄O₂; and for the 9 and 10 μm hot-band transitions of ¹²C₁₆O₂.
