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TITLE: SMALL-SIGNAL GAIN SPECTRUM OF AN 1800-TORR CO_2 AMPLIFIER

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Abstract

Prominent hot band effects have been observed in the 9.4 and 10.6 μm gain spectrum of an 1800 torr electron-beam-controlled-discharge CO_2 laser amplifier. Theoretical calculations agree well with data at 53 wavelengths.

This paper would be appropriate for the poster session.

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In current and planned CO_2 fusion laser amplifiers, parasitic oscillations are controlled by multicomponent gaseous saturable absorbers. However, detailed knowledge of the amplifier gain spectrum is required to prepare gas isolators which will reduce the net small-signal gain at all frequencies below the parasitic threshold while simultaneously allowing maximum transmission of the amplified short pulses.[1]

We have measured the small-signal gain coefficients on 53 laser lines in the P and R branches of the 9.4 and 10.6 μm bands of an electron-beam-controlled-discharge CO_2 amplifier. The probes for the gain measurements were two 20-torr, CO_2 lasers with chopped cw output beams propagating along the optical axis of a power amplifier in the HELIOS laser system.[2] The amplifier was operated with 1800 torr of a 3/0.25/1 gas mixture of $He/N_2/CO_2$, at pumping conditions yielding peak gains of about 0.035 cm^{-1} for the 10.6-μm P(20) line. The frequency of one of the low-pressure lasers was held constant to monitor shot-to-shot variations of the amplifier gain (typically 2-3%), while the frequency of the other laser was tuned throughout the 9.4 and 10.6 μm bands. These data, shown in Fig. 1, are the most complete measurements now available for this type of CO_2 laser. Gain was also measured for a few transitions at higher pump voltages.

The theoretical points and curves in the figure were obtained from a spectrum synthesis program[3] that used as input CO_2 vibrational temperatures calculated from a discharge kinetics code. The kinetics code used measured currents and voltages to compute the excitation temperatures at the center of the amplifier assuming a spatially homogeneous discharge and contained no adjustable parameters. The calculation includes hot-band and line-overlap effects[4] which can change the two-level gain coefficients of many of the lines by 10-20%.

The good agreement between the measured and calculated gain coefficients clearly shows the significance of the hot-band and line-overlap contributions to the amplifier gain for these highly excited molecules. Moreover, the calculations can be applied with confidence to other pumping regimes.

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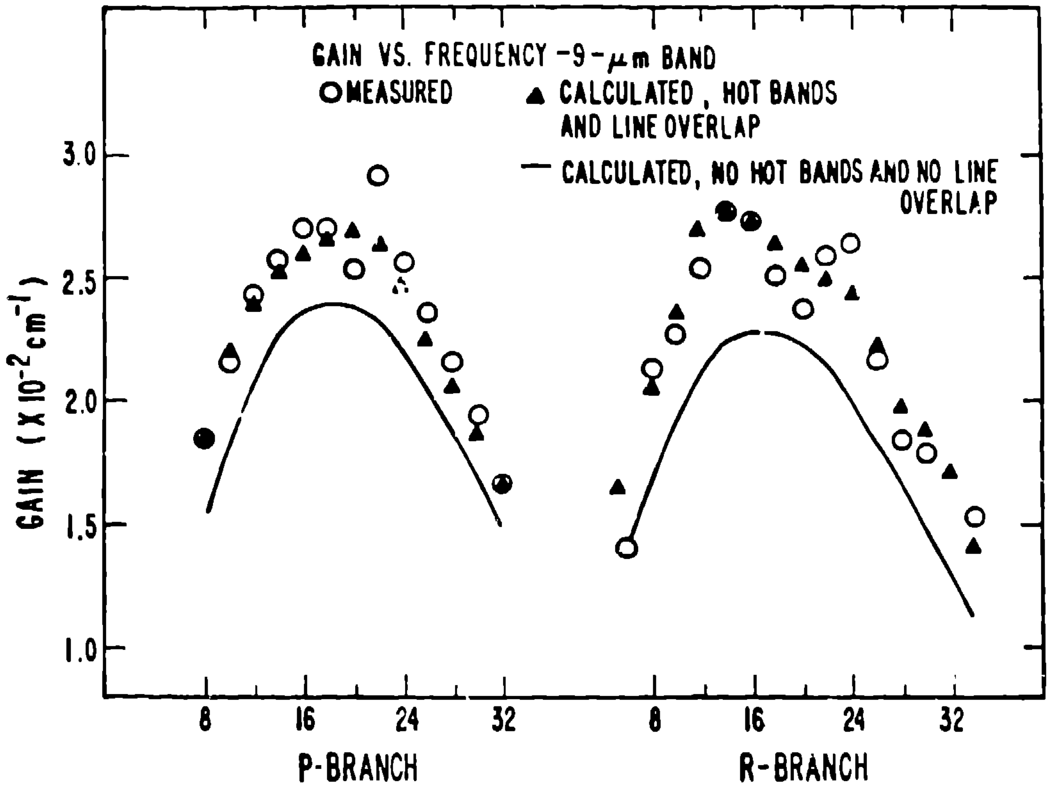
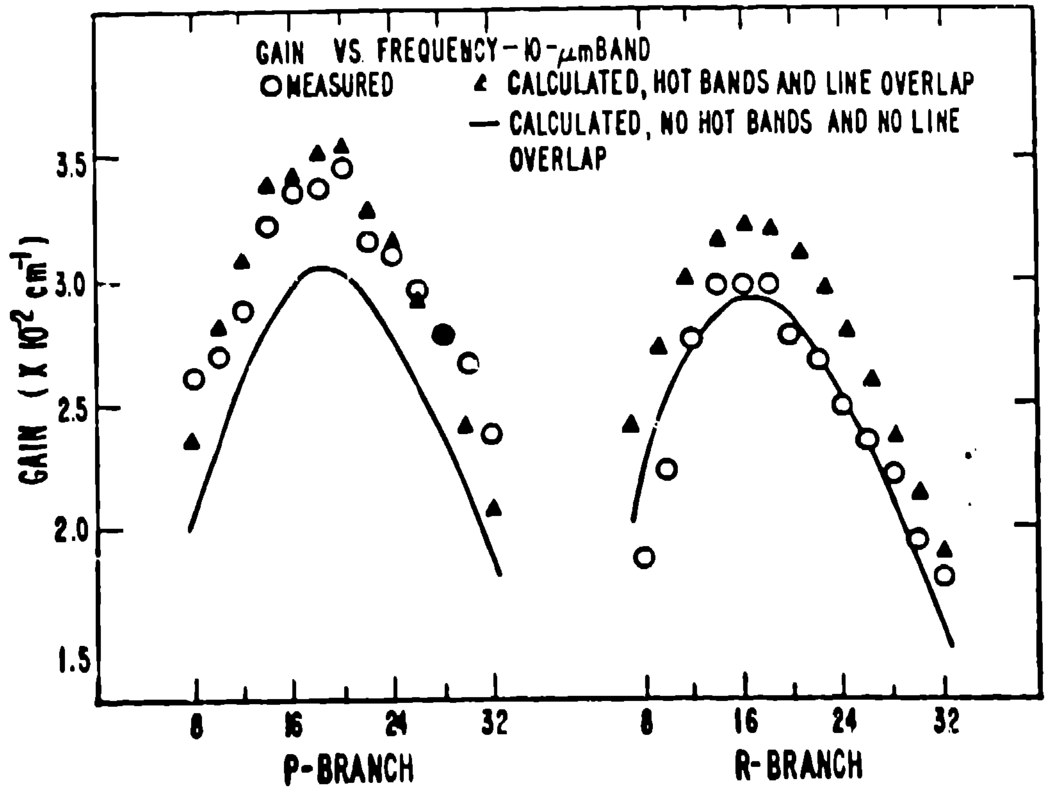
Figure Caption

Small-signal gain coefficient vs line number for an 1800 torr CO_2 laser amplifier. The solid curves are theoretical calculations which do not include hot-band, sequence-band or line-overlap contributions to the gain.


GAIN VS. FREQUENCY -9-μm BAND
MEASURED
CALCULATED, HOT BANDS AND LINE OVERLAP
CALCULATED, NO HOT BANDS AND NO LINE OVERLAP
GAIN (X 10^-2 cm^-1)
3.0
2.5
2.0
1.5
1.0
8
16
24
32
P-BRANCH
R-BRANCH


GAIN VS. FREQUENCY - 10-μm BAND
MEASURED
CALCULATED, HOT BANDS AND LINE OVERLAP
CALCULATED, NO HOT BANDS AND NO LINE OVERLAP
GAIN (X 10^-2 cm^-1)
3.5
3.0
2.5
2.0
1.5
8
16
24
32
P-BRANCH
R-BRANCH