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SELF FOCUSSING OF CO_2 LASER RADIATION IN NH_3 GAS

I.A. AL-SAIDI, D.J. BISWAS [1], C.A. EMSHARY [2] and R.G. HARRISON
Physics Department, Heriot-Watt University, Edinburgh EH14 4AS, UK

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Self focussing of CO_2 laser radiation in ammonia gas is reported for a number of laser emissions in near coincidence with NH_3 absorption lines. Detailed results for the aR(11) NH_3 transition are in excellent accord with theory accounting for intensity dependent saturation of both absorption and the associated anomalous dispersion responsible for nonlinear refraction n_2, giving a value for n_2 of 2.375×10^{-11} esu $torr^{-1}$.

Self focussing in resonantly absorbing media was first predicted by Javan and Kelly in 1966 [1] and subsequently observed in the molecular gases SF_6 and BCl_3 [2], as well as iodine [3] and sodium vapour [4]. The nonlinear refractive index mechanism responsible for this effect is ascribed to intensity dependent saturation of anomalous dispersion. More recently nonlinear optical resonators based on this mechanism have attracted great interest in the area of optical bistability [5] and in regard to transitions to chaos in such systems [6]. For such applications self focussing provides a useful independent method for identifying media with suitably high nonlinear susceptibility. Furthermore, for simple systems such as two level media results are readily quantified and nonlinear coefficients determined. In particular molecular gases, although largely unexplored are potentially excellent candidates in this field.

In this communication we report on first observations of self focussing of pulsed CO_2 laser radiation in ammonia gas for various laser emissions in near resonance with NH_3 absorption lines. Here we concentrate on the 10R(14) CO_2 line ($\lambda = 10.3\ \mu m$), pumping the aR(11) NH_3 transition 1.23 GHz above line centre [7]. Over most of the pressure range the system acts as an off resonantly pumped, homogeneously broadened two-level system, the pressure-broadened full width at half maximum (FWHM) being 27 MHz $torr^{-1}$ [8]. Our results are shown to be in good accord with predicted behaviour; this to our knowledge being the first report quantifying self focussing behaviour in saturable absorbing media.

The experimental arrangement comprised an NH_3 gas cell 1 metre in length and internal diameter 2.5 cm sealed at both ends by KBr windows at Brewster's angle. A conventional line tunable TEA CO_2 laser operating on the lowest order transverse mode to give a gaussian spatial distribution was used as the signal. Suitably apertured to a beam diameter of ~7.5 mm the collimated input signal to the NH_3 cell had a peak power of ~1 MW and pulse duration ~100 ns in the gain switched spike. Signal strengths were monitored throughout using photon drag detectors together with joulemeters and displayed on a Tektronix 7104 oscilloscope. A slit aperture (width ~1 mm) provided with lateral translation placed just beyond the exit window of the cell sampled the transmitted signal. The beam width and intensity distribution of the transmitted signal were monitored over a range of pressure (0 to 30 torr) for a fixed input signal (~1 MW) by step translation of the slit.

Experimental results are shown in fig. 1 for the 10R(14) CO_2 line at 10.3 μm, and are typical of those obtained for other lines in near coincidence and to the blue side of various absorption features in NH_3. These include the 10R(8), 10R(10), 10R(16), 9P(40), 9P(20) and 9P(30) laser emissions from CO_2.

[1] D.J.B. is currently on leave from Bhabha Atomic Research Centre, Bombay-85, India.

[2] C.A.E. has returned to Basrah University, Physics Department, Iraq.