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OBSERVATION OF IKEDA INSTABILITIES AND OPTICAL BISTABILITY IN AN ALL-OPTICAL RESONATOR CONTAINING NH_3 GAS

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INTRODUCTION

Substantial effort over the last few years on optically bistable systems has more recently been extended to considerations of period-doubling cascades to chaotic behaviour[1,2] in such systems. Passive all-optical systems are particularly interesting here, as basically simple arrangements capable of exhibiting oscillation[3,4] and turbulence, but also because they can be fully quantised. Ikeda[5] showed in 1979 that an optically-bistable ring resonator containing a two-level system can show a period-doubling cascade, a sufficiently strong c.w. input beam yielding an output oscillating at twice the resonator round trip time t_R. On further increasing the input field the output period doubles to chaos. Since then, observations of these phenomena have been made in various optical systems, such as a hybrid bistable device[6] and lasers[7,8], but the nearest approach to Ikeda's system has been a recent demonstration[9] in fibre-optic resonator, using mode-locked excitation to avoid stimulated scattering. None of these systems are particularly simple, nor do they lend themselves to quantisation.

We believe that molecular gases, excited close to resonance by a CO_2 laser have unique advantages in this field, and here we report observations of $2t_R$ oscillation (with some indications of $4t_R$) in an all-optical system very similar to Ikeda's original proposal. A passive ring resonator was pumped by a TEA CO_2 laser pulse (10R(14) transition, $\lambda = 10.3$ μm). This line lies 1.23 GHz above the aR(11)[10] transition of the NH_3 gas contained in a 1 m intra-cavity cell at pressures of 9-15 torr, where it acts as a homogeneously-broadened two-level system. Our results, which