demonstrates conclusively that the nucleus of this galaxy can recover from and repeat an energy release of $\sim 10^{55}$ erg after a few million years.

K. J. Wellington
G. K. Miley
H. van der Laan

Sterrewacht, Leiden

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Absolute Frequency Measurement of the R(12) Transition of CO_2 at 9.3 μm

The frequency of a CO_2 laser stabilized to the R(12) transition of CO_2 has been measured with an accuracy better than one part in 10^9. This is part of an experiment at the National Physical Laboratory to determine the speed of light to the full accuracy of the krypton-86 length standard[1].

Our result for the frequency of the CO_2 R(12) transition is

$$\nu = 32{,}176{,}079{,}482 \pm 28 \text{ kHz}$$

The provisional error comprises a random error of 4.2 kHz and possible systematic effects amounting to 27.5 kHz combined as the root sum of squares throughout. Further studies of these effects may reduce the error, which will be discussed in more detail elsewhere.

Comparison of the CO_2 laser frequency with the caesium standard at 9 GHz is achieved by harmonic generation and mixing of radiation from microwave, submillimetre wave and infrared sources, using point contact devices. The apparatus is an extension of that recently described for measurement of a stabilized H_2O laser frequency at 28 μm (ref. 2). The CO_2 laser was stabilized to a saturated absorption dip observed using the 4.3 μm fluorescence[3] from an external CO_2 gas cell. The following three frequencies were measured concurrently. (i) The beat frequency between the CO_2 laser and the 3rd harmonic of a free-running 10.7 THz (28 μm) H_2O laser; (ii) the beat frequency between the H_2O laser and the 12th harmonic of a free-running 891 GHz (337 μm) HCN laser; and (iii) the HCN laser frequency via a klystron phase locked to the laser by fiftieth harmonic mixing in a Josephson junction.

A total of 480 readings in forty-eight sets of ten were obtained on five different days over a period of two months. Apart from the initial day (forty measurements) there were about 100 measurements per day with a standard deviation of a single reading near 60 kHz. Each set of ten was averaged and the standard deviation of the mean of these forty-eight averages was 4.2 kHz. The means of the four principal days were consistent to ±4 kHz.

The chief causes of systematic error were: (a) possible asymmetry in the HCN laser spectrum causing a difference between time-averaged counting and the centre of the beat spectrum as observed and measured on a spectrum analyser; (b) uncertainties in the offsets produced by the servo-control system which locked the CO_2 laser to the dip in the saturated absorption signal from the CO_2 gas cell; (c) thermal drift of the HCN laser frequency during the period of measurement (of the order of 1 s); (d) uncertainties in the relation of the local working frequency standard to the caesium standard.

After completion of our measurements and the foregoing analysis the result for the frequency of the CO_2 R(12) transition was communicated to the meeting of the Comité Consultatif pour la Définition du Mètre (June 14), and a comparison was made with the R(10) transition frequency measurement of K. M. Evenson *et al.*[4] using a value for the R(12)–R(10) difference frequency recently determined at the National Bureau of Standards, Boulder. The agreement was within 3 parts in 10^{10}, and thus confirms one part of the frequency measurement by Evenson *et al.* in their determination of the speed of light[5].

T. G. Blaney
C. C. Bradley

Division of Electrical Science,

G. J. Edwards
D. J. E. Knight
P. T. Woods
B. W. Jolliffe

Division of Quantum Metrology,
National Physical Laboratory,
Teddington, Middlesex

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Observation of Electron Swarms produced by Laser Light

Observation of the displacement current caused by the motion of charge carriers in a discharge gap can yield quantitative information on many basic processes[1], such as ionization, electron attachment and charge carrier mobilities. A relatively large number of charge carriers is, however, required to produce a signal which exceeds the high inherent noise level of any wideband detection system by a sufficient margin. Hitherto, it was necessary, except in one or two special cases, to rely on gas amplification to raise the electron current to an observable level; this is only possible, however, when ionization dominates attachment of electrons to neutral molecules. The number of initial electrons required is particularly high when measurements in electronegative gases (high voltage insulants such as SF_6 and air) are to be made over the technically important range of low ratios of field strength to pressure for which the electron loss by attachment is at least as probable as the production of additional electrons by ionization.

In order to apply relatively simple methods of electron current pulse shape evaluation, the primary electrons must be released from the cathode within a very short time; on the other hand, a high light intensity is required to produce a reasonable number of primary electrons. Attempts have been made to produce such a large number of primary electrons by ultraviolet light flashes (ref. 2 and references in ref. 1). With spark light sources, however, those two requirements contradict each other. Higher energy input tends to lead to a longer duration of the light emission; in particular, the light emission frequently shows a very long "luminosity tail" of lower intensity which can be troublesome in gas discharge studies. Attempts have been made