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ELECTRIC FIELD INDUCED SHIFTING OF OPTICAL HOLES, FLUORESCENCE LINE NARROWING AND FREE INDUCTION DECAY IN RUBY

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Recently an elegant experimental technique for observing coherence effects in gases has been developed by Brewer and Shoemaker.[1] By Stark shifting molecules in and out of resonance with a CW laser, optical nutation, free induction decay and photon echoes are observed. The main advantage of this scheme over earlier methods in which the laser is pulsed is that the only transient observed is the desired coherent transient itself and secondly heterodyne detection is possible since the coherently radiated light propagates in the same direction as the laser beam and is shifted from it in frequency. In this paper we report the first extension of this technique to a solid, ruby. In view of the order of magnitude conflict of photon echo decay times measured by Liao and Hartmann[2] with earlier work, it seemed desirable to further study coherence effects in ruby using other approaches. In the process of this work a new technique for measuring optical hole shapes burnt into the inhomogeneously broadened R_1 line has been developed.

When an electric field is applied along the c axis of ruby, a pseudo Stark splitting of the R_1 line occurs. There are two chromium sites in ruby which are displaced in opposite directions from the mid point between the oxygen planes. The splitting occurs because of shifts, in opposite directions, of the R_1 frequency for the two sites. Measurements of the splitting using voltages up to 17 KV were reported earlier.[3] Such large voltages were necessary to observe a splitting of the inhomogeneously broadened lines of $\sim$ 5 GHz width. Using fluorescence line narrowing[4] (FLN)

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for which optical linewidths of ∿10 MHz are obtained, Stark shifts can easily be seen at 100 volts (produces ∿50 Mhz shift in our 2mm thick sample).

Measurements of the shape of the optical hole burnt into the R_1 line by a single frequency CW ruby laser will also be reported. When a step function field is applied to a ruby sample undergoing hole burning, a sudden change in the transmitted light is observed due to shifting of the hole out of resonance with the laser. By measuring the transmission change as a function of the step function voltage, a plot of the hole shape is obtained. Such a technique allows a higher resolution determination of the homogeneous width compared to FLN since a Fabry-Perot interferometer with its finite resolving power is not required. The resolution is determined only by the laser width. In agreement with photon echo and FLN results,[4] an order of magnitude decrease of homogeneous linewidth occurs when a magnetic field is applied along the c axis.

Finally optical free induction decay in ruby has been observed when a step function field is applied. The observed beat frequency is in excellent agreement with the predicted Stark shift and is seen to track the pulse voltage. Attempts are currently under way to observe photon echoes and optical nutation.

References

1. R.G. Brewer and R.L. Shoemaker, Phys. Rev. Letters 27, 631 (1971), and Phys. Rev. 6, 2001 (1972).
2. P.F. Liao and S.R. Hartmann, Optics Comm. 8, 310 (1973).
3. W. Kaiser, S. Sugano and P.L. Wood, Phys. Rev. Letters 6, 605 (1961).
4. A. Szabo, Phys. Rev. Letters 27, 323 (1971).