EL 9 Proposed $10^{14}\Delta\nu<\nu$ Laser Fluorescence Spectroscopy on Tl^+ Mono-Ion Oscillator III. D. WINELAND and H. DEHMELT, U. of Washington.--The pulsed $\lambda_2(^1S-^3P_1) \equiv c/\nu_2$ monitoring beam[1] of width $<<1/2\pi\tau_2 \simeq 6$ MHz also strongly cools the monoion oscillator (MIO) when slightly detuned to a side band[1] $\nu_2-n\nu_v$, e.g., $n = 1$, $\nu_v \equiv \omega/2\pi \simeq 3$ MHz. The Doppler effect will modulate the frequency of the λ_2 transition and strongly generate this side band for the value $v_m \simeq (\nu_v/\nu_2)c \equiv v_m{}^*$ of the maximum velocity of the oscillation parallel the λ_2 beam. Then the MIO predominantly absorbs $(\nu_2-\nu_v)$ photons. As it emits photons at all side band frequencies $\nu_2 + n\nu_v$, $|n|=0,1,2\cdots$, but of average energy $h\nu_2$ the balance $h\nu_v$ has to come from the oscillatory motion. The maximum cooling rate is $\sim h\nu_v/2\tau_2 \simeq .2$eV/s! This only drops off for $v_m<<v_m{}^*$, promissing oscillatory temperatures $h\nu_v/2k \simeq 10^{-4}$°K $\lesssim T_i<<Mv_m{}^{*2}/2k \simeq .004$°K, $-\delta_D<<7$mHz, $-\delta_S<<3$mHz and no Doppler side bands on the λ_o resonance! Directing the λ_2 beam along $(-\hat{i} + \hat{j} + \hat{k})$ makes the cooling 3-dimensional[1].--H.D. thanks H. Walter and coworkers for stiumlating discussions. We thank the National Science Foundation for it's generous support.

[1]Dehmelt, Bull. APS 18, 1521 (1973) & 20, 60 (1975).

EL 10 Anomalous Emission Effect and γ-ray Lasers.* J.P. HANNON and G.T. TRAMMELL, Rice Univ.--In previous papers we discussed the "anomalous emission effect" for Mossbauer optics which holds for Mossbauer emitters of multipolarity M1 or higher. This effect is potentially useful in the construction of γ-ray lasers as also has been recently pointed out by Kagan. The effective penetration depth for γ-rays in the Borrmann channels ℓ_B can be ≈200 times the off Bragg penetration depth ℓ_{OB}. As first pointed out by Baldwin, this will significantly decrease the critical population inversion necessary for lasing in these channels. However the reduction factor F is not simply ℓ_{OB}/ℓ_B as implied in ref.[2], but is considerably less because of a reduction in the coupling of the oscillators to such channels[1]. For M1 or E2 emitters, the reduction factor is $F = \ell_{OB}/[2\ell_B \sin^2(\theta/2)] = \langle x^2\rangle/\lambda\!\!\!^{-2}$, where x is the atomic displacement from equilibrium due to thermal and zero point motion. The reduction factor F is typically on the order of 1/15 - 1/4. These results and the results for higher order multipoles will be discussed.

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[1]J.P. Hannon, G.T. Trammell, Phys.Rev. 9 B, 2791 (1974).

[2]Yu. Kagan, JETP Lett 20, 11 (1974)

EL 11 Pulsed γ-Ray Laser.* G.T. TRAMMELL and J.P. HANNON, Rice Univ.--Following Schalow-Townes[1] Goldankii and Kagan[2] have given the lasing condition for a pulsed γ-ray laser in the form $R_o > \ell_{abs}^{-1}$, where ℓ_{abs} is the photoelectric absorption length in the laser and R_o is the stimulated emission gain coefficient,[1,2] $R_o = 2\pi\lambda\!\!\!^{-2} fg(1+\alpha)^{-1}(1+a)^{-1}(n_1-g_1n_2/g_2)$, where n_1 and n_2 are the population densities of the upper and lower lasing levels. This represents the lasing condition, however, only if (n_1-n_2) does not change substantially in a lifetime Γ_1^{-1} of the upper level. For the pulsed laser scheme, when the lower level is stable, and the initial population inversion persists for less than Γ_1^{-1}, we find that the lasing condition becomes $R_o \gtrsim 21\ \ell_{abs}^{-1}$. This would seem to prevent the lasing of the Ta^{181} Mössbauer level discussed in ref. (2). The possibility of a pulsed γ-ray Dicke superradiator will also be discussed.

*Supported in part by the National Science Foundation.

[1]A.L. Schalow and C. H. Townes, Phys. Rev. 112, 1940 (1958).

[2]V.I. Gol'danskii and Y. Kagan, Zh. Eksp. Teor. Fiz. 64, 90 (1973).

EL 12 Photon Statistics of a Tunable Dye Laser*, J.A. ABATE, H.J. KIMBLE and L. MANDEL, Univ. of Rochester.--The fluctuation and correlation properties of a single-mode dye laser have been measured by a photon counting technique both above and in the neighborhood of threshold. The dye laser is optically pumped by a single line argon laser, and single-mode operation is achieved by insertion of several glass etalons into the cavity. A feedback arrangement holds the light intensity constant to within a fraction of 1% in the course of the measurement. Results for operation at several different optical wavelengths and comparison with conventional laser theory will be presented.

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EL 13 Two-Photon Spectroscopy of Stark Effects in Sodium.* K.C. HARVEY, R.T. HAWKINS, G. MEISEL† and A.L. SCHAWLOW, Stanford University.--The quadratic Stark shift of the 3s-5s transition, and both shift and splittings of the 3s-4d transition, in sodium atoms have been measured by Doppler-free two-photon spectroscopy. By this method, the signs, as well as the magnitudes, of both the scalar and tensor polarizabilities are measured.

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EL 14 Two-Photon Spectroscopy of Hydrogen 1S-2S.* T. W. HÄNSCH,† S. A. LEE, R. WALLENSTEIN,+ and C. WIEMAN,++ Stanford University.--The intervals 1S-2S and 2S,P-4S,P,D in atomic hydrogen and deuterium have been compared with high precision. The 1S-2S transition was observed by Doppler-free two-photon spectroscopy with a pulsed frequency doubled dye laser at 2430Å, and the Hβ line was simultaneously observed in absorption with the fundamental laser output at 4860Å. An accuracy of 2 parts in 10^8 is expected from ongoing experiments, using saturation spectroscopy of Hβ. Future experiments should permit a comparison within 2 parts in 10^{13} or better, if the 2S-4S transition is observed by two-photon spectroscopy.

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+NATO Postdoctoral Fellow.

++Hertz Foundation Predoctoral Fellow.

EL 15. Longitudinally Excited N_2 Laser. ERNEST E. BERGMANN, Lehigh U. -- We have constructed a novel N_2 laser operating at 3371Å that is longitudinally excited in 3.5 cm segments, thus reducing the HV required for excitation. The device is 25 cm long, 1 mm ID and filled with pure N_2 at 15-20 Torr. The pulsed electrical excitation is accomplished by individually capacitively coupling alternate electrodes to the two sides of a larger storage capacitance. When the charge in the capacitance (which is charged to 20-25 kV) is suddenly reversed by the action of the spark gap, a considerable voltage transient is applied to the electrodes. The device lases strongly with an aluminized plane mirror at one end.

SUPPLEMENTARY PROGRAM

EL 16 Phase-Matched Second Harmonic Generation in GaAs Optical Waveguides by Focused Laser Beams. J. P. VAN DER ZIEL, R. C. MILLER, R. A. LOGAN, and W. A. NORDLAND, JR, Bell Laboratories, Murray Hill, N. J.--We have observed second-harmonic generation in $Al_{0.5}Ga_{0.5}$As-GaAs-$Al_{0.5}Ga_{0.5}$As double heterostructure waveguides.[1] Using a tunable parametric oscillator operating near 2 μm as a source, we have matched the guide wave vectors of the TE (m=0) fundamental and the TM (m=2) harmonic in a guide 0.92 μm thick. The radiation is end coupled into and out of the guide by 21X microscope objectives. Astigmatic focusing is used to focus the fundamental radiation