OPTICAL MIXING*

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The presence of small quadratic terms in the optical polarizability of transparent piezoelectric materials has made possible the production of the optical second harmonic of the intense red light from a ruby laser.[1] These nonlinear terms should also permit the mixing of light from two different sources of different frequencies. The present Letter reports the observation of the sum frequency in the near ultraviolet of two ruby laser beams of different frequencies coincident simultaneously upon such a crystal.

In the experiment, the sources were Trion Instruments, Inc., pulsed ruby lasers—one operated at room temperature, the other at liquid nitrogen temperature. Abella and Cummins[2] have reported that there is a difference of about 10 A between the wavelengths emitted by ruby lasers at these two temperatures. The flash lamps of both units were triggered by the same voltage pulse, and it was observed that the start of laser action in one ruby was rarely delayed by as much as 100 μsec with respect to the other, as compared to a duration of laser action of about 500 μsec in each. The two laser beams were superimposed by means of a half-silvered mirror and the resultant beam was focussed by a 16-mm $f/1$ lens onto the front surface of a crystal of triglycine sulfate[3] about 3 mm thick. This crystal was placed at the entrance slit of a Hilger quartz prism spectrograph. The slit was set at approximately 25 microns in order to achieve the necessary resolution in the ultraviolet. It should be noted that this particular arrangement requires precise optical alignment: The primary beams must be coplanar, they must focus to the same spot on the crystal, and this focus must lie directly in front of the entrance slit of the spectrometer.

A magnified reproduction of the 3470A region of the most successful plate exposed to nine synchronized pulses from the two lasers is shown in Fig. 1. The line on the right is the second harmonic of the cold laser, the one on the left is the second harmonic of the warm one, and the middle one is the sum frequency of the two. The separation of the lines is 2.5 A, which is consistent with an original difference in the red of 10 A. The cold second harmonic is distinctly more intense than the warm one in accord with the primary intensities; the intensity of the sum frequency lies between these two. The "staggering" of the three lines in Fig. 1 is due to inevitable small departures from the alignment conditions noted above. Many repeated exposures with just one laser have yielded only a single line in the ultraviolet corresponding to its second harmonic.

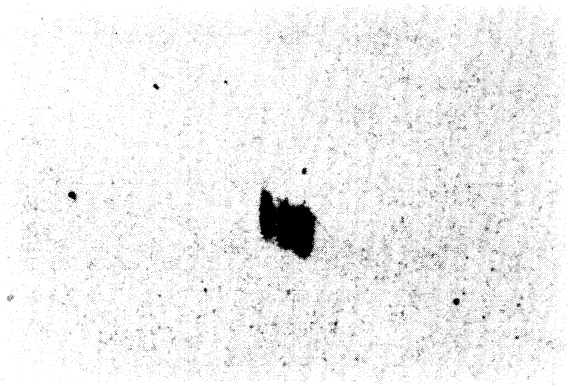

FIG. 1. Magnified spectrum in the 3470A region made by nine successive synchronized shots of the warm and cold ruby lasers focussed on a triglycine sulfate crystal. The second harmonic of the cold laser is to the right, the second harmonic of the warm laser to the left, and the sum frequency between them. The distance between the lines on the plate is 0.004 inch, corresponding to 2.5 A.

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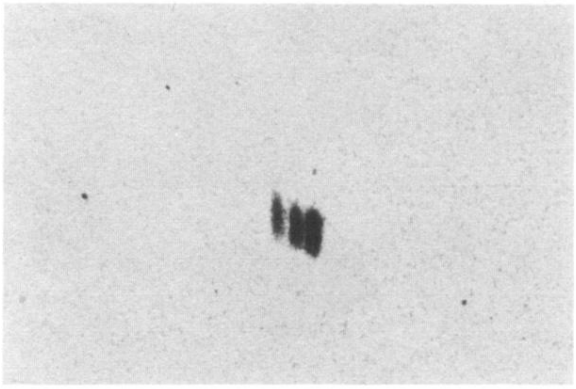
[1] P. A. Franken, A. E. Hill, C. W. Peters, and G. Weinreich, Phys. Rev. Letters 7, 118 (1961).

[2] I. D. Abella and H. Z. Cummins, J. Appl. Phys. 32, 1177 (1961).

[3] Triglycine sulfate was used because in our apparatus it has appeared to be more effective than many other crystals for the production of optical harmonics. It is interesting to note that this crystal does not yield the second harmonic when it is at a temperature above its Curie point (~50°C), due to the change in its crystal symmetry at the Curie point as reported by S. Hoshino, Y. Okaya, and R. Pepinsky, Phys. Rev. 115, 323 (1959).



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