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THE POSSIBILITY OF ENHANCED
 Hg^{202} AS A SOURCE OF
MONOCHROMATIC LIGHT

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THE POSSIBILITY OF ENHANCED Hg²⁰²
AS A SOURCE OF MONOCHROMATIC LIGHT

ABSTRACT

Electromagnetically enhanced Hg²⁰², as a source material for highly monochromatic radiation, is discussed briefly with relation to the effects of the isotopic impurities. A Fabry-Perot interferogram showing line purity in the 98.06 per cent Hg²⁰² is reproduced.

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Oak Ridge, Tennessee
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THE POSSIBILITY OF ENHANCED Hg^{202} AS A SOURCE OF MONOCHROMATIC LIGHT

In 1942, in discussing the possibility of a mercury isotope as a possible source of an improved wavelength standard, Meggers stated¹:

"If a single even isotope, say 202, which constitutes nearly 30 per cent of ordinary mercury, could be isolated it would solve the problem of the primary standard to the satisfaction of all. This appears to be too difficult, but the same end may be attained in another way."

This other way, through neutron irradiation of gold to produce Hg^{198} with Hg^{199} as a small impurity, has been shown by Meggers² to satisfactorily fulfill the requirements of a primary standard. The first successful transmutation of gold to mercury in quantities sufficient for spectroscopic purposes was carried out by Alvarez and Wiens³. As late as 1946 Wiens remarked⁴:

"Seven isotopes are present but since the isotope mass 202 is the most plentiful one might be inclined to try to use the mass spectrograph for separating this isotope from ordinary mercury. This and all other methods for separating the mercury isotopes in quantities large enough to produce a strong light source have until now been unsuccessful."

Availability of the isotopes of mercury, enhanced in the 202 isotope to 98.06 per cent, is concurrently reported⁵ in a recent letter to the Editor of the Physical Review. The expected relative intensities of the individual components in the 5461 Å transition of mercury (assuming no intensity anomalies) for the cases of natural mercury and the enhanced mercury are given in Table I, the notation being according to Schuler and Keyston⁶, the intensities being based on the natural abundances and the tables of White and Eliason⁷, and the relative positions being according to Burger and van Cittert⁸.

TABLE I

RELATIVE INTENSITIES OF 5461 HYPERFINE STRUCTURE COMPONENTS

<u>Isotope</u>	<u>Natural</u>	<u>Enhanced</u>	<u>Position</u>
196 I	0.15	< 0.02	-0.089 cm ⁻¹
198 II	10.1	0.09	-0.060
199 A	5.7	0.04	-0.320
199 B	10.2	0.07	0.000
199 C	1.1	0.01	0.756
200 III	23.3	0.78	-0.031
201 a	0.1	0.00	-0.751
201 b	1.2	0.03	-0.469
201 c	5.3	0.15	-0.089
201 d	0.2	0.01	-0.274
201 e	1.4	0.04	-0.089
201 f	2.8	0.08	0.194
201 g	1.1	0.03	0.124
201 h	1.1	0.03	0.304
202 IV	29.6	98.06	0.000
204 V	6.7	0.57	0.028

Although this is not the ultimate purity attainable through the electromagnetic process it is natural to inquire into the possibility of utilizing isotopic mercury of this purity to produce a monochromatic and reproducible wavelength. Limitations on discerning these weak components will arise from Doppler broadening and from instrumental background. Preliminary studies⁸ of these effects on a line having close-lying satellites, such as the 202 IV line and the 200 III or the 204 V component, indicate that, under ordinary conditions of observation, as much as 8.7 per cent satellite intensity could be tolerated without shifting the fringe maximum by more than one part in 50,000,000. It can also be shown that for a source at room temperature the contribution of Doppler broadening alone is simply to introduce very small wing effects due to the 0.78 per cent 200 III and the 0.57 per cent 204 V. Neither satellite maximum should be detectable in such a source.

The presence of extraneous weak maxima in an interference pattern may, however, be undesirable although they may have little or no effect on the intensity maximum of the main fringe. Thus, components other than the 200 III and the 204 V must be considered from another aspect since these can be separated more readily from the 202 IV main line by appropriate choice of interferometer path length. The next strongest line is the triplet, 201 c, 201 e and 196 I, having a total intensity less than 0.21 per cent. In order that this intensity be greater than the minimum background intensity between orders in the Fabry-Perot pattern one would require reflecting coefficients in excess of 90 per cent, a value in itself difficult to obtain. Consideration of the other components indicates that still more difficult experimental conditions must be met if the intensity of these other components is to be equal or greater than the background intensity (e.g., 198 II would require $r \geq 94$ per cent).

Figure 1 shows a 5461 A Fabry-Perot interference pattern taken using an electrodeless discharge tube containing the 98.06 per cent isotopic purity Hg^{202} . Preliminary over-exposed interferograms of this line at several etalon separations indicate no trace of satellite structure between fringe maxima.

The present status of the mercury enhancement indicates that Hg^{202} may be separated from the natural species in sufficient quantity and in sufficient purity to produce lamps having a monochromatic and reproducible wavelength, namely, the 5461 A line. The detailed investigation of this line and other lines of mercury based on present or future Hg^{202} purity is continuing.

Figure 1. Comparison of 5461 line structure in natural Hg(germinal lamp source) and enhanced Hg 202 (electrodeless discharge source). Etalon spacing 10 mm.

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