Title
EXPERIMENTAL STUDIES OF ENHANCED EMITTANCE BY ZEEMAN SPLITTING OF A LOW-PRESSURE MERCURY/ARGON DISCHARGE

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Publication Date
1983-03-01

LBL-17394 c.2

Lawrence Berkeley Laboratory

UNIVERSITY OF CALIFORNIA

APPLIED SCIENCE DIVISION

Presented at the Third International Symposium on the Science and Technology of Light Sources, Toulouse, France, April 18-21, 1983

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Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

LBL-173 c.2

DISCLAIMER

LBL-17394
EEB-L-83-09
L-79

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This work was supported by the Assistant Secretary for Conservation and Renewable Energy, Office of Building Energy Research and Development, Buildings Equipment Division of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

Experimental Studies of Enhanced Emittance by Zeeman Splitting of a Low-Pressure Mercury/Argon Discharge

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Abstract

The Zeeman-effect experiment is designed to quantify the amount of mercury resonance radiation production at λ2537 at elevated (i.e. >42°C) cold-spot temperatures in a mercury discharge tube in the presence of an external magnetic field. A 24% enhancement is observed at a field value of approximately 700 gauss where the Zeeman splitting is comparable to the Doppler width. The value of the magnetic field of the maximum is in agreement with the Richardson-Berman theory.

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DESCRIPTION OF EXPERIMENT

The purpose of the experiemnt is to observe the effects of an external magnetic field on the emission of resonance radiation from a low-pressure mercury discharge tube.

Discharge tubes of 48 inches length and 1-1/4 inches diameter (48"l x 1-1/4"dia) were fabricated with fused silica center sections. Provision was made to control the temperature of a cold spot mercury reservoir, and hence, to control mercury number density in the discharge tube. The tube's walls were warmed by means of electrical heating tape and insulated with glass cloth tape.

The discharge current was held constant throughout the experiment. Filament power was supplied independent of the lamp arc power to enable monitoring of the lamp arc power and voltage, thus obtaining direct measurement of the discharge tube's effective impedance and resistance.

The external magnetic field was produced between a pair of electrically shielded short solenoids in a quasi-Helmholtz configuration, to minimize any Lorentz interaction between the arc current (which was coaxial with the solenoids) and the applied magnetic field.

The apparatus was assembled on a 1" x 54" x 8" aluminum slab to facilitate future ease in transportation to the location of a 3.4 meter optical spectrograph which was capable of resolving the components of the mercury hyperfine structure (hfs) at λ2537.

The experiment was mounted between a Jarrel-Ash 0.5 meter scanning monochromator set in the second order to the hfs lines at λ2537, and the large 3.4 meter instrument. This enabled the simultaneous acquisition of high resolution photographic data and a photoelectric signal proportional to the net hfs intensity, the latter being displayed on a recording millivoltmeter.

In a typical measurement situation a cold spot temperature would be selected and the discharge tube allowed to stabilize at that temperature with a fixed arc current. The arc current I, voltage V, and power P are then measured to characterize the lamp as an electrical load as follows:

The lamp's impedance is

$$Z_{lamp} = V/I,$$

and the lamp's power factor is

$$\text{Cos } \Theta = \frac{P}{VI} = \frac{VI \cos \Theta}{VI} .$$

The lamp's effective resistance is then

$$R = Z \cos \Theta$$

The axial magnetic field is applied to the lamp and increased in increments of about 25 gauss. The monochromator photoelectric signal, proportional to the emitted hfs, is recorded and the field value noted. As the field increases the hfs intensity initially increases. At some critical value of magnetic field the intensity is maximum and for larger field values, the intensity decreases. The value of magnetic field yielding peak intensity is thus observed. This is shown Figure 1.

During this exercise it was found that the Lorentz interaction between the applied magnetic field and the arc current density did not appreciably affect the arc electrical characteristics. Impedance increases due to the J x B interaction were only on the order of 0.3%. In a companion study in which the arc current density and applied magnetic field were at right angles it was found that for kilogauss fields, the effective lamp impedance increased by 200%.

In Figure 2 is shown the Zeeman effect enhancement of resonance radiation as a function of cold spot temperature for both the natural mercury isotope distribution and the single isotope ^{202}Hg.

AUGMENTATION OF RESONANCE RADIATION
AS A FUNCTION OF APPLIED MAGNETIC FIELD

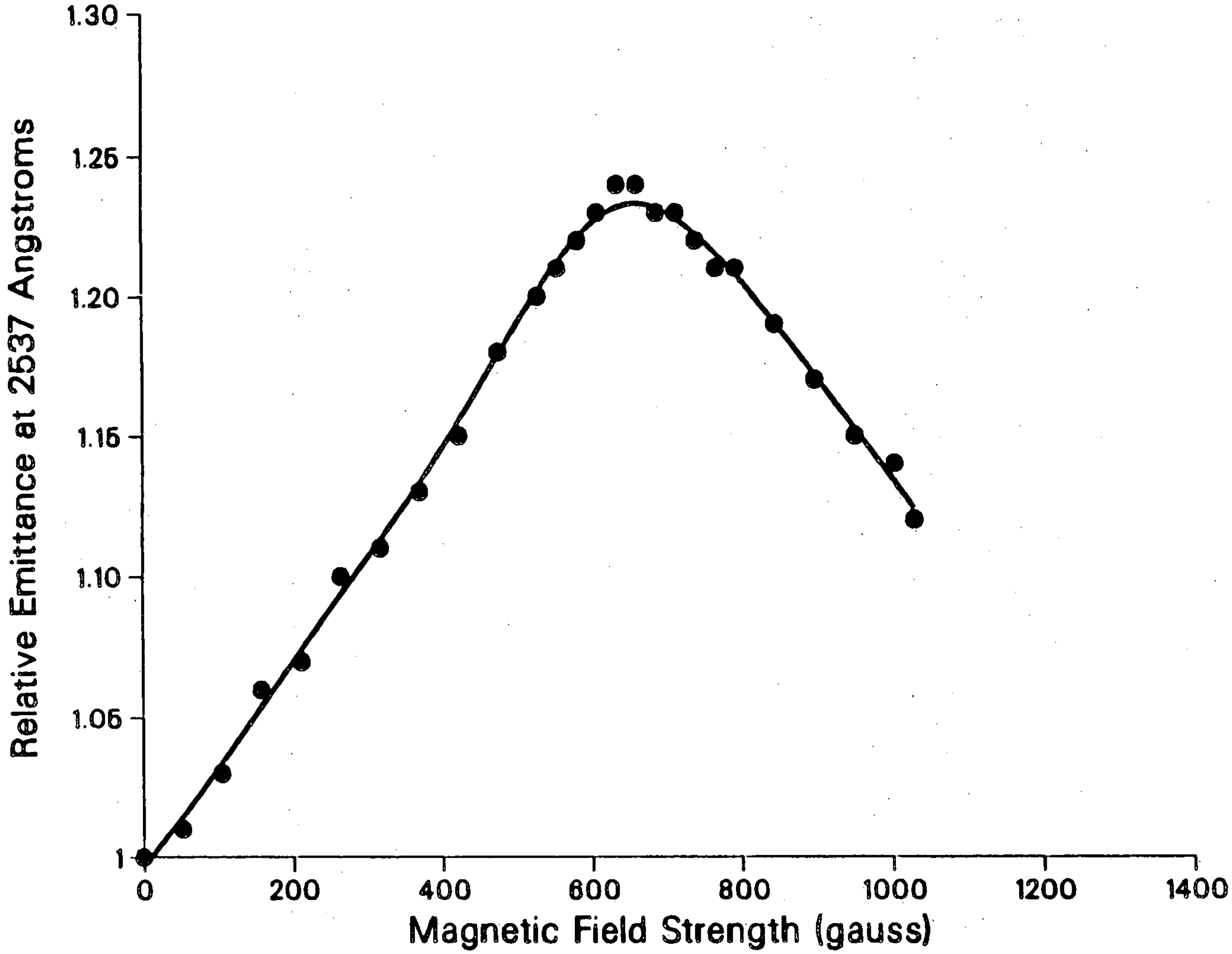

FIGURE 1

RELATIVE RESONANCE RADIATION PRODUCTION OF NATURAL MERCURY AND 202 HG ISOTOPE AS AUGMENTED BY THE ZEEMAN EFFECT

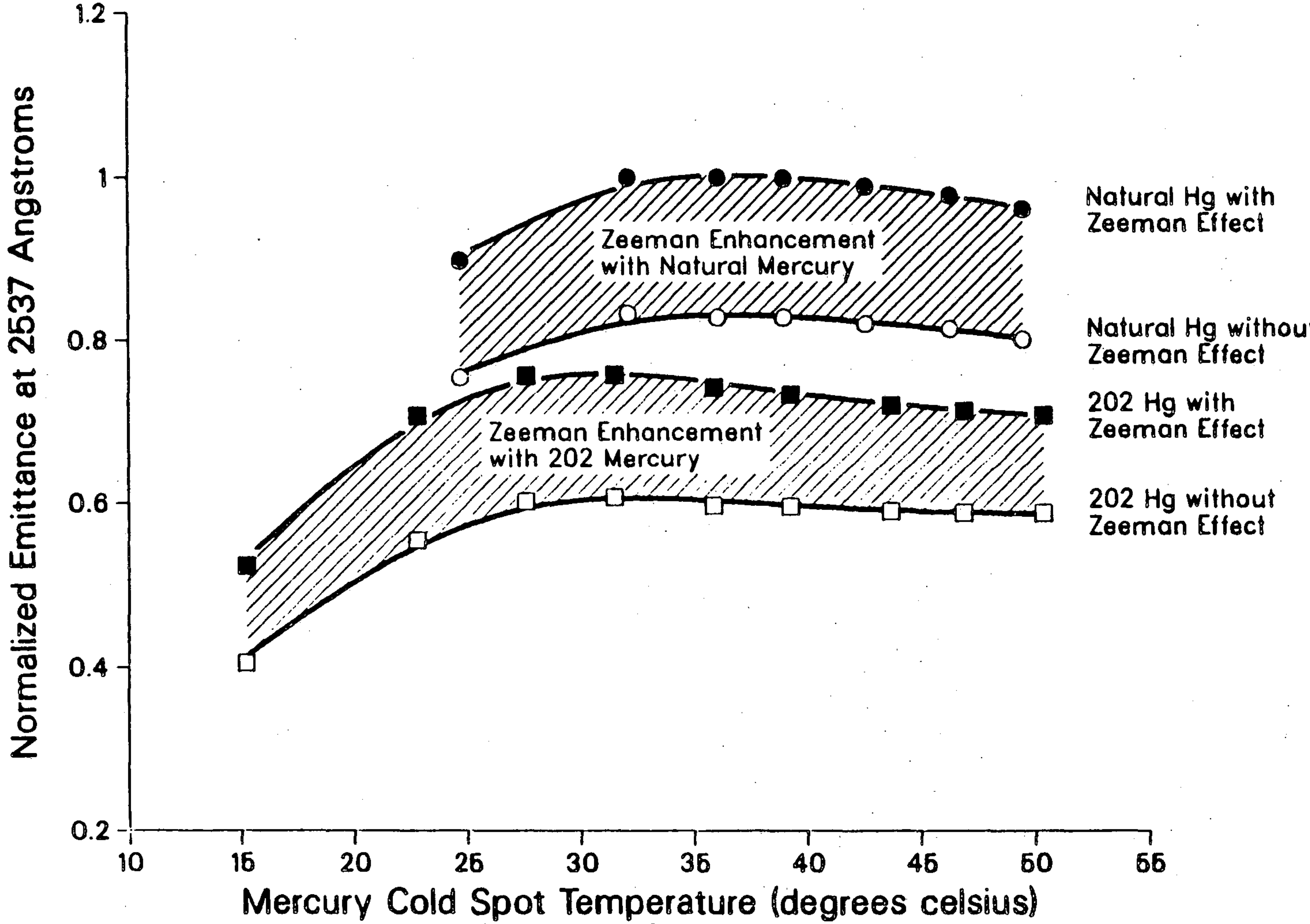

FIGURE 2

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