Structure of Iridium Lines

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(Received August 21, 1939)

The isotopic constitution of iridium was for the first time determined by Venkatesachar and Sibaiya from a study of the hyperfine structure of its arc line λ3513.67A. It was shown that iridium consists of two odd isotopes of mass numbers 191 and 193, the isotope 193 being twice as abundant as the isotope 191. This result was afterwards corroborated by Dempster's mass-spectrograph analysis. With the view of determining the ratio of the nuclear magnetic moments of the two isotopes, the hyperfine structure, arising from the nuclear spin moments of $(\frac{1}{2})(h/2\pi)$ and $(\frac{3}{2})(h/2\pi)$ of the isotopes 191 and 193, respectively, has been investigated for a few more iridium lines using an aluminized Fabry-Perot etalon. From the results obtained for the hyperfine level separations of the isotopes, it is concluded that the ratio of the nuclear magnetic moments of Ir (191) and (193) is −0.92.

IN an attempt to determine the isotopic constitution and nuclear spin of iridium, the hyperfine structure of some iridium lines has been previously investigated.[1] With a water-cooled hollow cathode source[2] and a quartz Lummer-Gehrcke plate 20 cm long and 3.45 mm thick, the structure of the Ir I 3513.67A revealed the existence of two odd isotopes in iridium with mass numbers 191 and 193. It was further inferred that their nuclear spin moments were $(1/2)(h/2\pi)$ and $(3/2)(h/2\pi)$, respectively. From estimates of the intensities of the components, Ir (193) was concluded to be nearly twice as abundant as Ir (191). These conclusions in regard to the isotopes and their abundance in iridium have been corroborated by Dempster[3] from a study of its mass spectrum. The wave number separation of the extreme satellites of λ3513.67 was found to be 0.217 cm^{-1}, which corresponds to 0.027A width. Some of the other lines that exhibited a similar structure could not be resolved by the Lummer plate employed. Thus the separation of the extreme satellites of these lines was less than that of λ3513.67. The present work was undertaken with a view of studying the hyperfine structure of other significant lines of iridium.

In the spectral region under observation silver films exhibit an absorption band, in consequence of which a silvered Fabry-Perot etalon could not be employed. For the study of lines in this region of the ultraviolet other investigators have used a coating of Hoch-heim alloy on the interferometer plates. As this alloy was not available, the etalon plates have been aluminized; these films also do not exhibit any absorption in the spectral region under study. The structure of the lines has been investigated with Invar distance-pieces of thickness 10, 15, 17.5, 20 and 23 mm between the etalon plates. The resulting increase in resolving power with increase of air-gap between the plates has enabled the determination of the hyperfine structure of some more iridium lines. The source

[1] B. Venkatesachar and L. Sibaiya, Nature **136**, 437 (1935); and Proc. Ind. Acad. Sci. **2**, 203 (1935).
[2] B. Venkatesachar and L. Sibaiya, Proc. Ind. Acad. Sci. **1**, 955 (1935).
[3] A. J. Dempster, Nature **136**, 909 (1935).

TABLE I. *Comparison of the structure of λλ3800.10 and 2924.81 with the structure of λ3513.67.*

LINE (A)	STRUCTURE (cm^{-1})					REMARKS
	Wing	*Wing*				
3513.67	+0.072	—	+0.000	−0.073	−0.145	Previous values
	(7)		(22)	(13)	(9)	
	+0.072	+0.032	0.000	−0.080	−0.151	New values
3800.10	+0.066	—	0.000	−0.053	−0.098	
2924.81	+0.060	—	0.000	−0.065	−0.118	
2849.74	0.082 (1)			0.000 (2)		Probably an isotope displacement
2639.70	0.083 (1)			0.000 (2)		

TABLE II. *Level separations.*

LEVEL[1]	Ir (191) ($\frac{1}{2}$)	Ir (193) ($1\frac{1}{2}$)
$A\ ^4F_{4\frac{1}{2}}$	-0.150 cm^{-1}	0.162 cm^{-1}
$1°\ ^4F°_{4\frac{1}{2}}$?	-0.052	0.056
$2°\ ^4G°_{5\frac{1}{2}}$?	~-0.005	$\sim$0.006
$10°_{4\frac{1}{2}}$?	-0.032	0.036

[1] W. Albertson, Phys. Rev. **42**, 443 (1932).

employed was the same water-cooled hollow cathode previously described. The light from the source is focused on the Fabry-Perot etalon and a quartz achromat focuses the pattern on the slit of a Hilger E_1 spectrograph with quartz train.

Even with the highest resolving power employed, a complete resolution of some of the lines has not been possible. The structure of λλ3800.10 and 2924.81 are compared with the structure of λ3513.67 in Table I.

The lines λ2664.77 and λ2824.44, though they appear to be single even with the 23 mm etalon, are much wider than the lines λ2694.22 and λ2797.72; it must therefore be concluded that, at least in the former case, the resolving power is insufficient to resolve the structure of the lines. Consistent with the previous explanation of the structure of λ3513.67A, the values for the other level separations are given in Table II.

If H is the magnetic field at the nucleus arising from the optical electron and μ the magnetic moment of the nucleus of spin moment I, the distance between the extreme F levels of any gross structure term characterized by the quantum number J is given by

$$\Delta W=\mu H(2J+1)/J, \quad \text{when} \quad J\geqslant I,$$

and

$$\Delta W=\mu H(2I+1)/I, \quad \text{when} \quad I\geqslant J.$$

The nuclear spins of iridium isotopes 191 and 193 are $\frac{1}{2}$ and $1\frac{1}{2}$, respectively, the sign of the former being negative; and hence for the iridium terms, whose total splittings have been computed above, $J>I$. It therefore follows that in these cases

$$\mu_{191}/\mu_{193}=\Delta W_{191}/\Delta W_{193}.$$

The values for the total widths of the hyperfine levels of the various terms lead to the conclusion that the ratio of the magnetic moments of Ir (191) and Ir (193) is -0.92. The ratio of the magnetic moments thus obtained for iridium is of the same order as that of μ_{199}/μ_{201} for mercury, *viz.*, -0.90; again in the case of xenon also μ_{131}/μ_{129} is -0.90.

OCTOBER 15, 1939 PHYSICAL REVIEW VOLUME 56

A $^1\Sigma\rightarrow{}^1\Sigma$ Transition of the C_2 Molecule

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(Received August 29, 1939)

The λ2300 "band" of the carbon arc, previously noticed by Bloomenthal and other investigators and measured by Hori, who attributed it to a C_3 molecule, has been accurately measured and analyzed, using photographs taken on the 30-foot, 30,000-line grating spectrograph. The analysis shows definitely that the structure consists of superposed (0,0), (1,1), (2,2), and (3,3) headless bands of a $\Sigma\rightarrow\Sigma$ transition of C_2 (or possibly C_2^+), in agreement with the earlier diagnosis of Mulliken and Dieke. Alternate lines are missing in each series, as expected in view of the zero spin of the carbon nucleus. Most probably the transition is $^1\Sigma_u^+\rightarrow{}^1\Sigma_g^+$ of C_2. The molecular constants are very nearly equal for the upper and lower electronic states. They correspond rather closely to the average values of the same constants for other known states of C_2. The following values were obtained for the more important constants: $B_e'=1.8334$ cm^{-1}, $B_e''=1.8223$ cm^{-1}, $\alpha'=0.0204$, $\alpha''=0.0195$, $r_e'=1.2382$ A, $r_e''=1.2419$ A, $\omega_e'=1748$ cm^{-1}, $\omega_e''=1774$ cm^{-1}, $\nu_0^{0,0}=43{,}227.25$ cm^{-1}. The ω_e values were obtained indirectly from the B and D values, since only one sequence of bands could be analyzed.

INTRODUCTION

BECAUSE of its importance in the study of molecular structure in general and in particular in the study of problems that arise in organic chemistry, the electronic transitions of the diatomic carbon molecule and the determination of related constants have been of considerable interest to the physicist and the