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Hyperfine structure measurements of neutral atomic iodine (^{127}I) in near infrared and visible regions

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ABSTRACT

Hyperfine structure (*hfs*) investigations were performed on neutral atomic iodine (II) in the near-infrared and visible spectral regions. Fourier transform spectroscopy to investigate the emission spectrum of a microwave driven electrodeless discharge lamp operated in a mixture of iodine vapor and Ne gas. In the present investigations, the observation of 240 hyperfine resolved spectral lines were reported. *Hfs* analysis was carried out on 128 spectral lines for the first time and repeated on 49 spectral lines. The magnetic dipole constant (A) and electric quadrupole constant (B) were derived for 100 energy levels. Among the 100 energy levels, A and B constants for 18 levels were presented for the first time.

1. Introduction

Atomic Iodine (II) has electronic configuration [Kr] $4d^{10}5s^25p^5$ with 53 electrons. II has the nuclear spin I = 5/2, nuclear magnetic dipole moment (μ) + 2.81327(8) μ_N [1] and electric quadrupole (Q) moments −0.696(12) barn [2].

The spectroscopic investigations on II were performed by many groups in the past. Tolansky [3] had examined the spark spectrum of iodine to determine the nuclear spin as 5/2. Corliss et al. [4] had observed the emission spectra and reported 900 lines in the spectral region 23,070–1195 Å. Arc and spark spectrum of iodine were photographed by McLeod [5] using a vacuum grating spectrograph in the spectral region 800–1900 Å. Spectral positions and intensities were assigned for 31 lines, in the infrared region (0.8–2.2 μm) by Eshbach and Fisher [6]. Humphreys and Edward Paul [7,8] had reported the first spectra of several halogens in the spectral region 1.8–4 µm.

Jaccarino et al. [9] had reported the *hfs* of the $^2P_{3/2}$ ground state by considering a magnetic octupole moment term along with magnetic dipole and electric quadrupole moment terms using the atomic beam magnetic resonance method. The majority of iodine *hfs* data in the Infrared (3000–11,500 cm^{-1}) region was carried out by Luc-Koenig et al. [10]. These authors presented 130 spectral lines along with the derivation of A and B constants for 37 even as well as 42 odd levels using a Fourier transform spectrometer. Deng et al. [11] had reported a list of *hfs* constants A and B of 18 even and 28 odd levels by analyzing 45 spectral transitions in the Near Infrared region (11,300–13,000 cm^{-1}) using optical heterodyne concentration modulation spectroscopy with a tunable single-mode CW Ti: Sapphire laser. Recently, this group presented further *hfs* investigations [12]. In our previous studies [13], we have reported *hfs* splitting of 183 spectral lines in the emission spectrum of II using FTS in the spectral range of 6000–10,000 cm^{-1}, and have also calculated the *hfs* constants A and B values for 25 even parity and 26 odd parity energy levels.

In the present investigations, we are extending our previous work [13] to Near Infrared and Visible regions (10,000–25,000 cm^{-1}). We report a large number of previously unknown spectral lines, together with their classification. From the observed *hfs* patterns, we determined the *hfs* constants of the involved energy levels.

2. Experimental details

We have used the same experimental setup as used in our previous work [13]. A mixture of iodine vapor and Ne was excited in an Electrodeless Discharge Lamps (EDL) driven by a surfatron [14] microwave cavity. The emitted light was focused to a high resolution Fourier transform spectrometer (IFS 125 HR). The instru-

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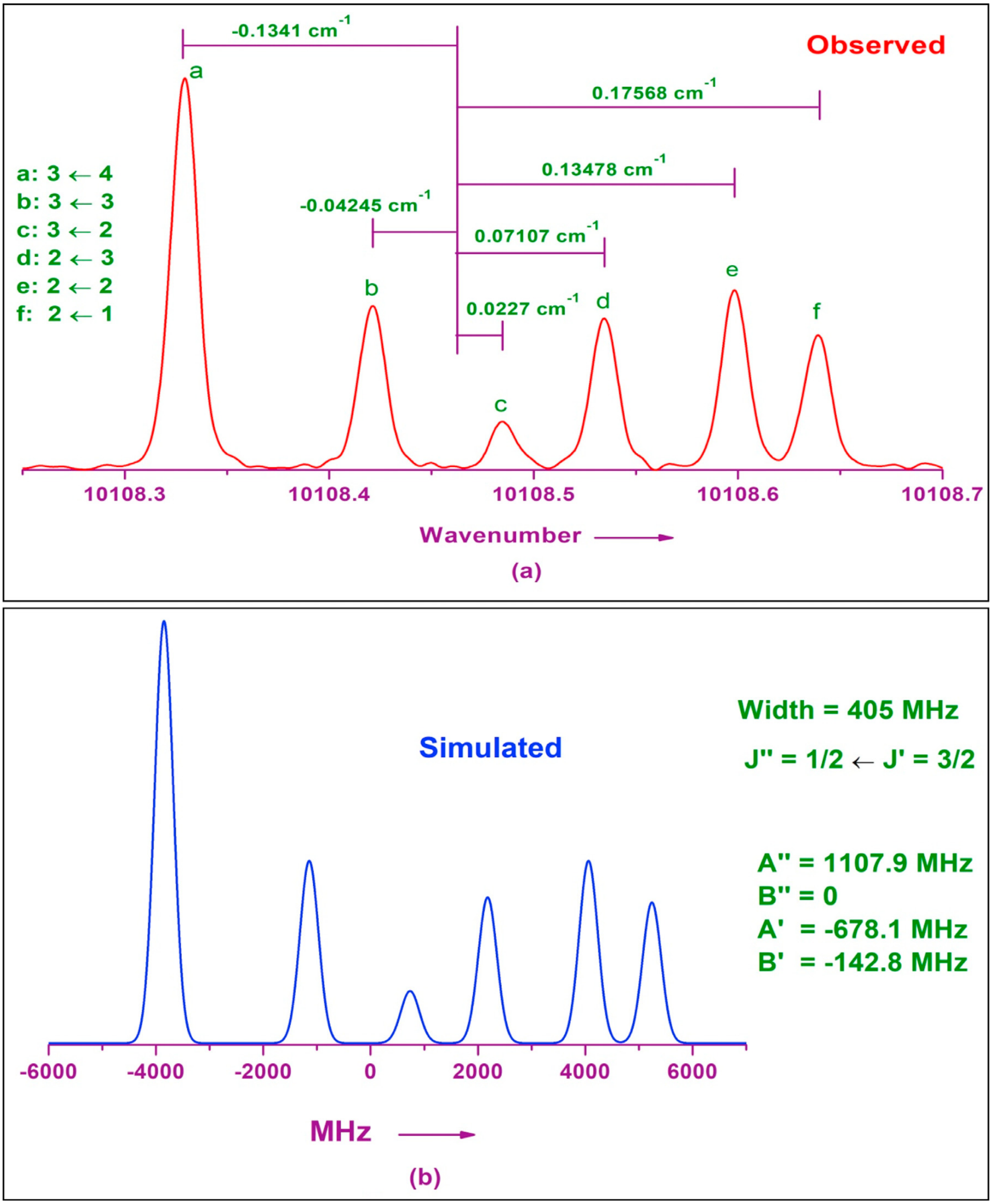

Fig. 1. (a) Assigned F″- F′ transitions, and shift values of the *hfs* components from the center of gravity in the observed spectrum (b) simulated spectrum, width and A and B values of both upper and lower levels as determined from the experimental recording.

ment was equipped with various beam splitters (CaF_2 in the infrared / Quartz in the visible region) and appropriate detectors (Si diode / Photomultiplier Tube) to observe the spectra in the near infrared and visible spectral regions. Various instrumental resolutions 0.04, 0.02, 0.018, 0.012, 0.01, 0.008 and 0.006 cm^{-1} were applied to identify weak as well as strong lines. Multiple band pass filters (band width: 10, 25 and 50 nm) were used in the spectral region above 12,000 cm^{-1} to enhance the S/N. On an average, 50 to 150 scans were co-added depending upon the resolution and S/N.

To minimize power and Doppler broadening effects on spectral lines, the EDL was operated under low microwave power along with reduced temperature. Surfatron cavity and EDL were cooled with nitrogen gas which has passed through a LN_2 bath [13]. Consequently, the full width half maximum (FWHM) of the spectral lines drastically reduced and well resolved *hfs* patterns were observed. A detailed experimental setup was discussed in our previous report [13].