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High resolution optogalvanic spectrum of N_2-rotational structure of (11, 7) band in the first positive system

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Abstract. High resolution optogalvanic spectrum of the (11, 7) band in the first positive system of nitrogen molecule has been recorded from 17179 to 17376 cm^{-1}. Assignment of 432 rotational lines belonging to the 27 branches of this band has been carried out.

Keywords. Optogalvanic spectroscopy; nitrogen molecule

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1. Introduction

Optogalvanic spectroscopy (OGS) using tunable lasers has proven to be a highly useful and sensitive method for detecting transitions of excited states of atoms and molecules [1, 2]. In OGS, when the incident laser radiation is resonant with a transition of some species present in the gaseous discharge, a change in impedance of the plasma can occur. This change in impedance of the discharge is monitored as a function of the irradiating laser wavelength. Such laser-induced impedance changes manifest as current changes and can be detected as a signal voltage across a suitable ballast resistance connected in series with the discharge cell.

First positive system ($B^3\Pi_g$–$A^3\Sigma_u^+$) of nitrogen molecule is the most prominent band system and has been the subject of many detailed investigations [3, 4]. OGS has been successfully applied to investigate transitions of N_2 with low as well as high resolution techniques. OG spectrum of the first positive system of nitrogen molecule in the wavelength region of 560–600 nm under low resolution has been studied by many researchers [2, 5]. Certain results of the investigations on rotational structure of various band systems of N_2 by using this technique have also been reported [6–8]. This paper reports the recording of well resolved rotational lines in the 17179–17376 cm^{-1} region of the (11, 7) band of the $B^3\Pi_g$–$A^3\Sigma_u^+$ system using high resolution optogalvanic spectroscopy.

2. Experimental

The experimental set up employed to record Doppler-limited high resolution OG spectrum is reported earlier [6]. In brief, a positive column N_2 discharge was maintained at a current of 2·8($\pm$ 0·1) mA and a pressure of 0·8 mbar. Modulated beam from a frequency stabilized single mode ring dye laser (Spectra Physic 380D), at about 225($\pm$ 15) mW power, was axially passed through the cell without allowing to

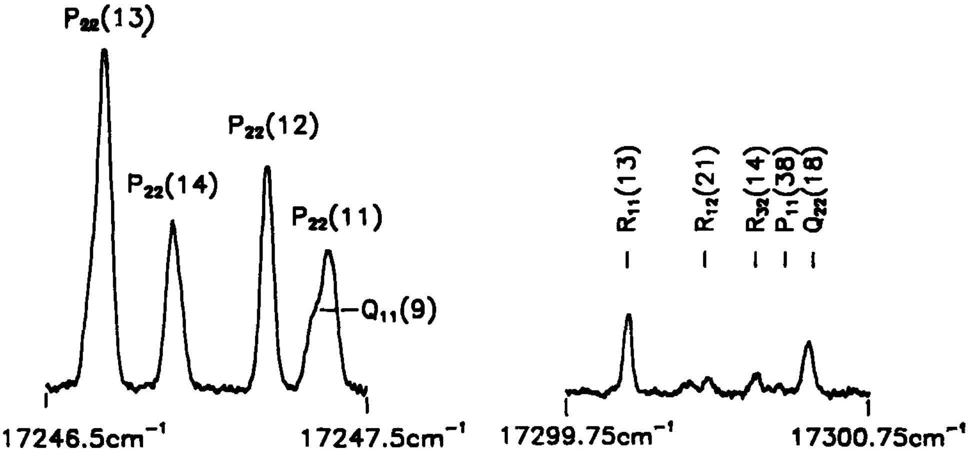

Figure 1. High resolution OG spectrum of some main and satellite lines.

fall on the electrodes. The laser was scanned in steps of 30 GHz, and the OG signal generated was detected using a lock-in amplifier which is interfaced with a computer for data acquisition. Figure 1 shows such a spectrum obtained in a single scan. Effect of variation in intensity of the dye laser on scanning was eliminated by normalizing the OG signal intensity with the photo diode output of the dye laser. The wavelength was measured using a commercial wave meter and the frequency of the measured lines is accurate to $\pm 0{\cdot}06\,\mathrm{cm}^{-1}$.

3. Analysis of the OG spectrum

The digitized OG spectrum, which is obtained by joining a number of 30 GHz spectra, and the Fortrat parabola of all branches are shown in figure 2. The first positive system of nitrogen molecule, which corresponds to the transition $B^3\Pi_g$–$A^3\Sigma_u^+$, consists of three subsystems namely $^3\Pi_0(F_1)$–$A^3\Sigma_u^+$, $^3\Pi_1(F_2)$–$A^3\Sigma_u^+$ and $^3\Pi_2(F_3)$–$A^3\Sigma_u^+$. These transitions are composed of 27 branches with three main and six satellite branches in each of the subsystems. Details of the energy level diagram and the rotational analysis are discussed in literature [9]. About 648 rotational lines have been observed and 432 of these have been identified as members of the (11, 7) band belonging to all of the 27 branches of the $B^3\Pi_g$–$A^3\Sigma_u^+$ system. These are listed in table 1. A few transitions belonging to the (12, 8) band are also observed in this region. The correctness of the J number assignment of rotational line is tested by a number of standard combination relations [9].

In conclusion, optogalvanic spectrum of (11, 7) band of the $B^3\Pi_g$–$A^3\Sigma_u^+$ system of N_2 is recorded and J values of rotational lines were assigned in the spectral region from 17179 to $17376\,\mathrm{cm}^{-1}$.

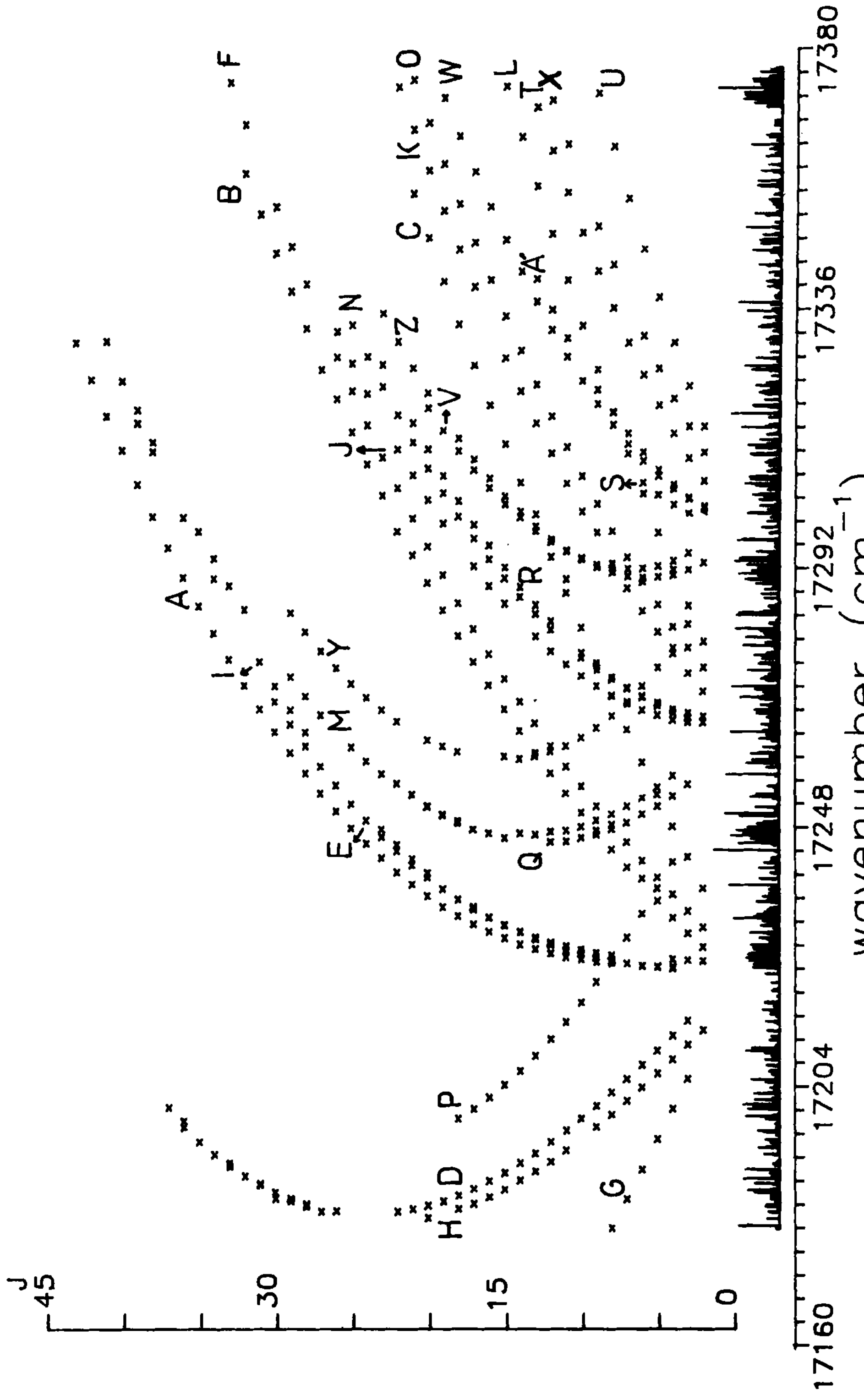

Figure 2. Optogalvanic spectrum along with Fortrat diagram of the (11, 7) band in the $B^3\Pi_g - A^3\Sigma_u^+$ transition of N_2 from 17179 to 17376 cm^{-1}.
(27 branches namely $P_{11}, Q_{11}, \ldots Q_{33}$ and R_{33} are indicated as by A, B, … Z and A′ respectively.)

Table 1. Identification of the OG resonances with the rotational transitions of the (11, 7) band of N_2: $B^3\Pi_g$–$A^3\Sigma_u^+$ system.

J	P_{11}	Q_{11}	R_{11}
2		17227·64	17237·57
3		17229·97	17242·95
4	17224·25	17232·65	17248·07
5	17224·32	17235·50	17253·48
6	17224·47	17239·29	17258·96
7		17241·17	17264·50
8	17224·86	17244·18	17270·15
9	17225·14	17247·34	17275·85
10	17225·59	17250·40	17281·72
11	17225·89	17253·66	17287·63
12	17226·52	17257·06	17293·72
13	17227·32	17260·56	17299·96
14	17228·09	17264·27	17306·33
15	17229·20	17267·98	17312·89
16	17230·24	17271·98	17319·50
17	17231·51	17276·03	17326·32
18	17232·90	17280·31	17333·26
19	17234·48	17284·72	17340·44
20	17236·31	17289·32	17347·84
21	17238·27	17294·02	17355·24
22	17240·35	17298·02	
23	17242·74	17304·11	
24	17245·19	17309·48	
25	17247·78	17314·93	
26	17250·71	17320·58	
27	17253·66	17325·53	
28	17257·06	17332·47	
29	17260·56	17338·72	
30	17264·10	17345·16	
31	17267·93	17351·77	
32	17271·98	17358·62	
33	17276·40		
34	17280·76		
35	17285·38		
36	17290·18		
37	17295·25		
38	17300·49		
39	17305·99		
40	17311·77		
41	17317·62		
42	17323·82		
43	17330·05		

J	P_{12}	Q_{12}	R_{12}
2		17225·24	17230·98
3	17215·13	17225·38	17233·72
4	17212·63	17225·59	17236·59
5	17210·08		17239·41
6	17207·66		17242·27
7	17205·24		17245·38
8	17202·94	17226·19	17248·36
9	17200·67	17226·62	17251·49
10	17198·55	17227·19	17254·86
11	17196·52	17227·78	17258·24
12	17194·58	17228·39	17261·70
13	17192·60	17229·25	17265·57
14	17191·00	17230·24	17269·21
15	17189·34	17231·36	17273·13
16	17187·92	17232·65	17277·31
17	17186·64	17234·10	17281·51
18	17185·49	17235·74	17285·91
19	17184·53	17237·50	17290·66
20	17183·76	17239·41	17295·45
21	17183·19	17241·51	17300·23
22	17182·74	17243·93	17305·41
23		17246·29	17310·60
24		17249·07	17316·13
25		17251·85	17321·88
26	17182·85	17255·08	17327·68
27		17258·24	
28	17184·04	17261·70	17339·96
29	17185·00	17265·38	17346·25
30	17186·08	17269·21	17352·97
31	17187·33		
32	17188·86		17366·89
33	17190·47		17374·03
34	17192·49		
35	17194·58		
36	17197·09		
37	17200·42		

J	P_{13}	Q_{13}	R_{13}
2		17213·55	
3	17205·24	17211·08	
4	17200·21	17208·60	17224·01
5	17195·05	17206·20	17224·25

J	P_{21}	Q_{21}	R_{21}
2		17271·00	17279·47
3	17265·78	17274·08	17285·51
4	17266·16	17277·41	17291·55
5	17266·95	17281·00	17297·90

Continued

Table 1. *Continued*

J	P_{13}	Q_{13}	R_{13}
6	17189·92	17203·83	17224·47
7	17184·83	17201·52	17224·86
8	17179·85	17199·23	17225·24
9		17197·09	17225·89
10			17226·52
11		17193·13	17227·09
12		17191·22	17228·09
13		17189·59	17229·02
14		17187·99	17230·18
15		17186·48	17231·36
16		17185·20	17232·65
17		17184·12	17234·48
18		17183·19	
19			
20		17181·65	17240·22
21			17242·58
22			17244·99
23			17247·57
24			
25			
26			
27		17182·74	
28		17183·70	17264·05
29		17184·53	17267·79
30		17185·00	17271·88
31		17187·47	17276·03
32			
33		17191·00	
34			17290·01
35			
36		17198·14	17300·39
37			
38			17311·49
39			17316·45
40			17323·56

J	P_{21}	Q_{21}	R_{21}
6	17267·79	17284·59	17304·46
7	17268·88	17288·43	17311·27
8	17270·30	17292·55	17318·26
9	17271·88	17297·90	17325·53
10	17273·58	17301·40	17332·97
11	17275·59	17306·23	17340·69
12	17277·76	17311·27	17348·54
13	17280·23	17316·45	17356·63
14		17321·88	17364·98
15	17285·82	17327·55	17373·52
16	17288·79		
17	17292·17	17339·56	
18		17345·91	
19	17299·43	17352·42	
20	17303·39	17359·20	
21	17307·58	17366·17	
22	17311·97	17373·39	
23			
24	17321·50		
25	17326·59		
26	17331·98		

J	P_{22}	Q_{22}	R_{22}
2		17266·75	17275·06
3		17267·31	17278·41
4	17256·74	17267·98	17281·89
5	17254·73	17269·08	17285·68
6	17252·95	17270·15	17289·52
7	17251·49	17271·46	17293·68
8	17250·13	17272·96	17298·09
9	17249·07	17274·73	17302·67
10	17248·03	17276·74	17307·42
11	17247·39		17312·41
12	17247·19	17281·40	17317·58

J	P_{23}	Q_{23}	R_{23}
2			17265·68
3		17255·22	17266·54
4	17242·05	17253·24	17267·41
5	17237·57	17251·49	17268·59
6	17233·31	17250·13	17270·01
7	17229·25	17248·68	17271·60
8	17225·38	17247·57	17273·41
9	17221·71	17246·69	17275·30
10	17218·23	17246·10	17277·57
11	17214·93	17245·54	17279·99
12	17211·99	17245·38	17282·80

Continued

Table 1. *Continued*

J	P_{22}	Q_{22}	R_{22}
13	17246·69	17284·08	17323·06
14	17246·89	17286·92	17328·73
15		17290·11	17334·62
16		17293·30	17340·73
17		17296·83	17347·07
18	17248·99	17300·59	17353·61
19	17250·01	17304·56	17360·34
20	17251·43	17308·75	17367·37
21		17313·17	17374·56
22		17317·80	
23	17256·98	17322·65	
24	17259·14	17327·75	
25	17261·50	17333·05	
26			
27	17266·95		
28	17270·15		
29	17273·41		
30			
31			
32	17284·83		
33	17288·79		
34	17293·40		
35	17298·02		
36			
37			
38	17313·17		
39	17318·66		
40			
41	17330·29		

J	P_{23}	Q_{23}	R_{23}
13	17209·22		17285·59
14	17206·59		17288·61
15	17204·26	17246·10	17291·98
16	17202·11	17246·89	17295·62
17	17200·21	17247·57	17299·21
18	17198·55	17248·68	17303·21
19		17250·13	17307·49
20		17251·49	17311·97
21		17253·48	17316·45
22		17255·35	
23			17326·38

J	P_{31}	Q_{31}	R_{31}
2		17306·67	17315·91
3	17301·31	17310·51	17322·77
4	17302·58	17314·72	17330·10
5	17304·25	17319·50	17337·82
6	17306·33	17324·66	17345·93
7		17330·10	17354·43
8		17335·98	17363·23
9		17342·16	17372·35
10		17348·71	
11		17355·52	
12		17362·59	
13		17369·98	

J	P_{32}	Q_{32}	R_{32}
2		17302·31	17311·49
3	17294·39	17303·60	17315·91
4	17293·08	17305·32	17320·62
5	17292·17	17307·49	17325·74
6	17291·81	17309·99	17331·28
7	17291·69	17312·89	
8	17291·81	17316·13	17343·28
9	17292·45	17319·67	17349·80
10	17293·50	17323·56	
11	17294·64	17327·75	17363·75
12	17296·22	17332·27	17371·17
13	17298·09	17337·10	
14	17300·39	17342·16	
15	17302·67	17347·50	
16	17305·41	17353·12	
17	17308·47	17359·01	
18	17311·71	17365·11	
19	17315·19	17371·56	
20	17318·99		

Table 1. *Continued*

J	P_{33}	Q_{33}	R_{33}
2		17292·76	17301·99
3	17282·33	17291·55	17303·79
4	17278·41	17290·66	17305·97
5	17275·06	17290·35	17308·47
6	17271·88	17290·18	17311·49
7	17269·21	17290·45	17314·72
8	17266·82	17291·08	17318·26
9	17264·82	17291·98	17322·15
10	17263·13	17293·30	
11	17261·70	17294·80	17330·89
12	17260·73	17296·71	17335·69
13	17260·00	17298·93	17340·90
14	17259·50	17301·40	
15	17260·00	17304·04	
16		17307·07	
17		17310·31	
18	17260·73	17313·85	
19	17261·70		
20	17262·74	17321·59	
21		17325·80	
22	17265·88	17330·29	
23	17267·79	17335·03	
24	17269·93		
25	17272·23		
26	17274·97		
27	17277·76		
28	17281·00		
29	17284·22		

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