VUV emissive properties of the regenerative soot

by

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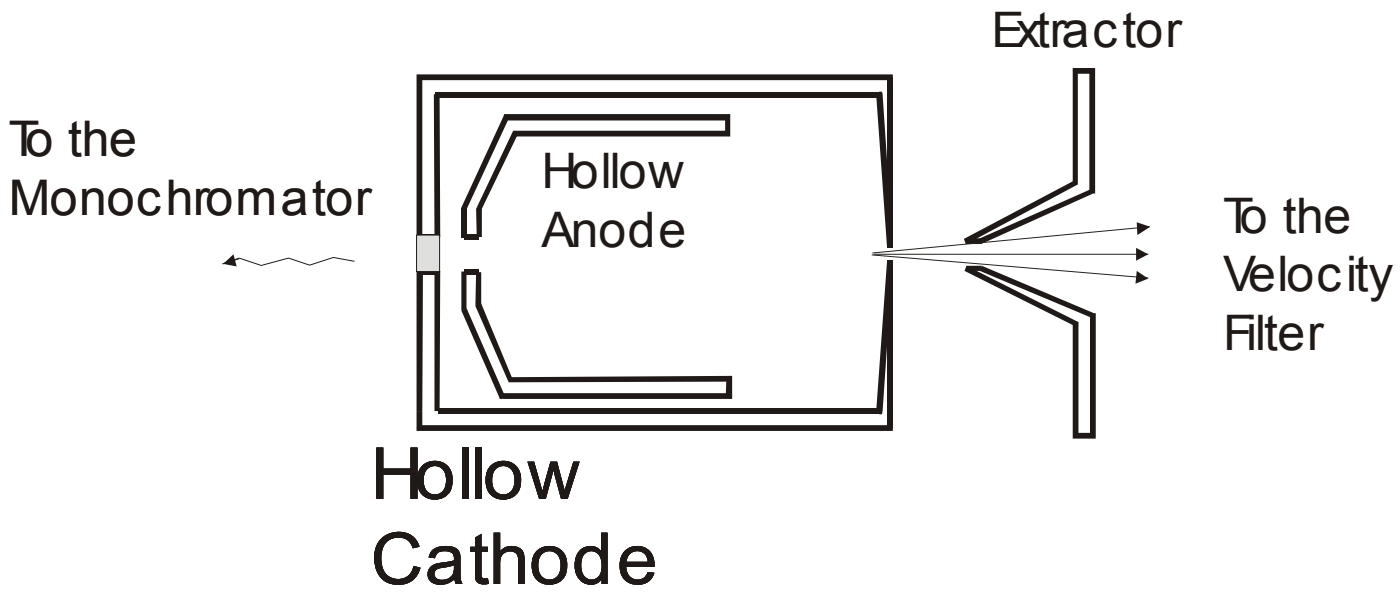
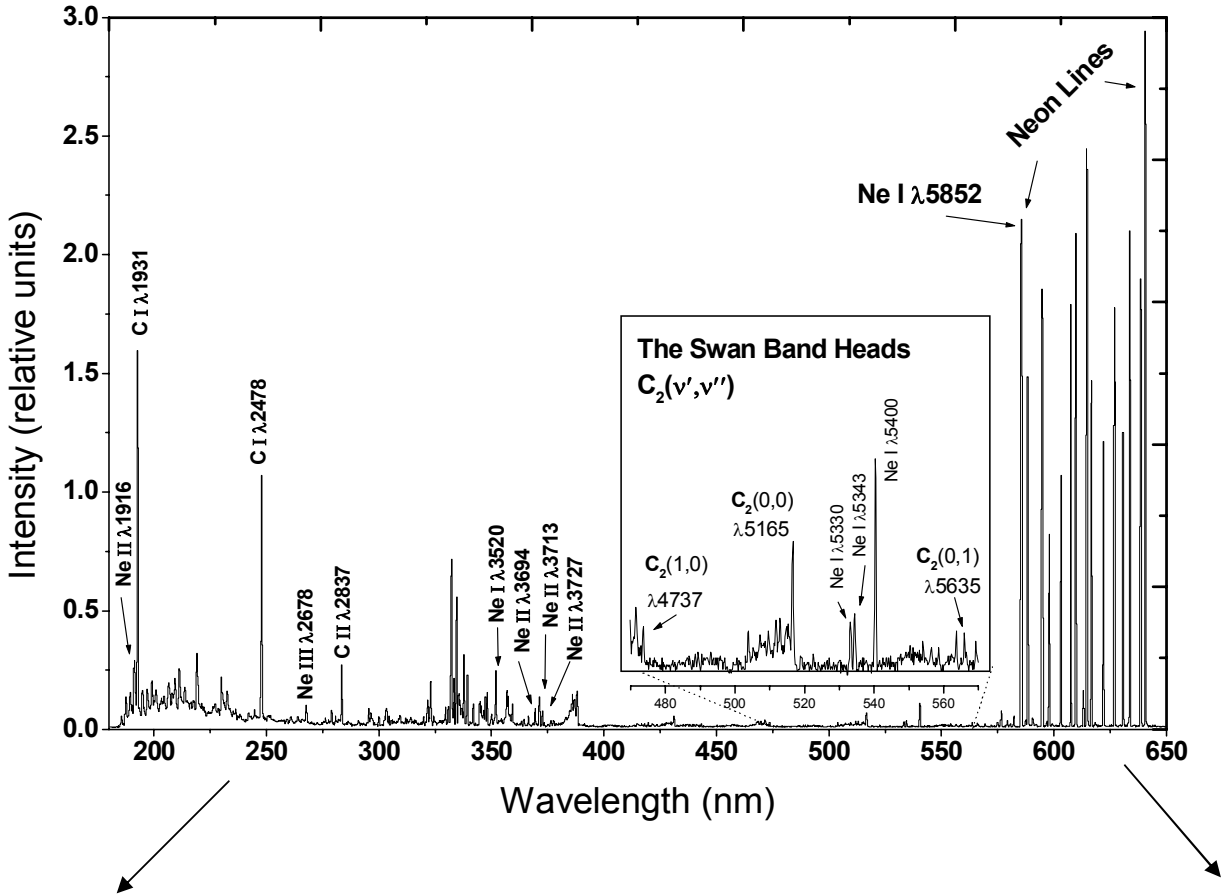
Formation of the Carbonaceous Plasma

- *He, Ne* discharges
- Sooting discharges
- Regeneartive soot

•Ahmad & Riffat NIM B **152,** 506 (1999)

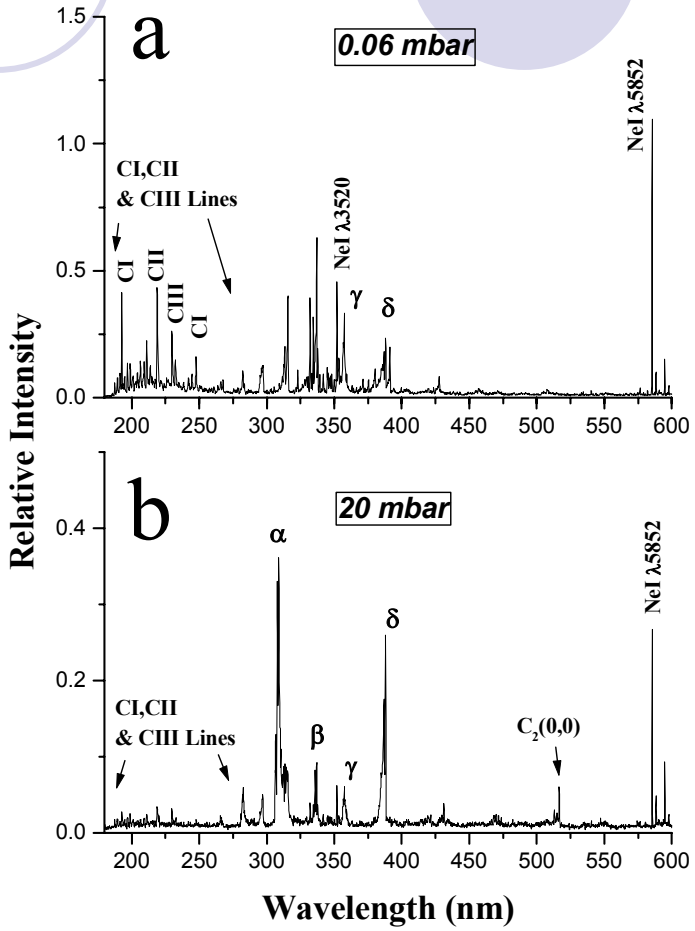


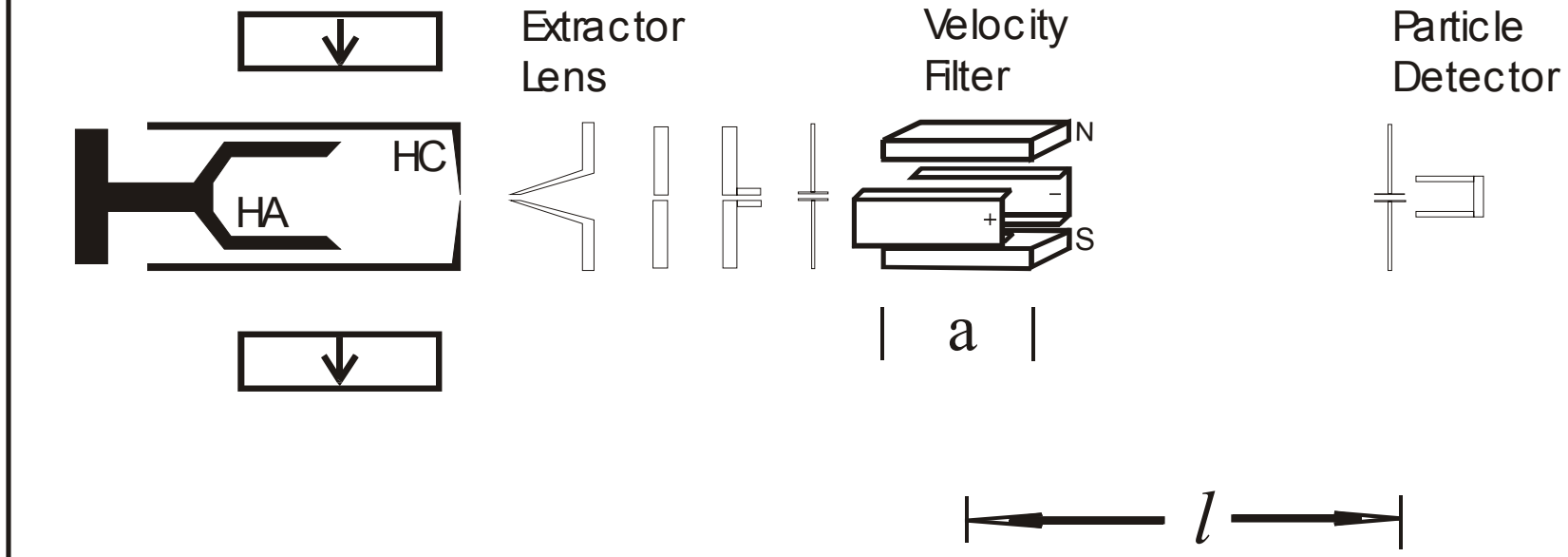
- NIM B **171,** 552 (2000)
- Appl. Phys. Lett. **75,** 4100 (1999)



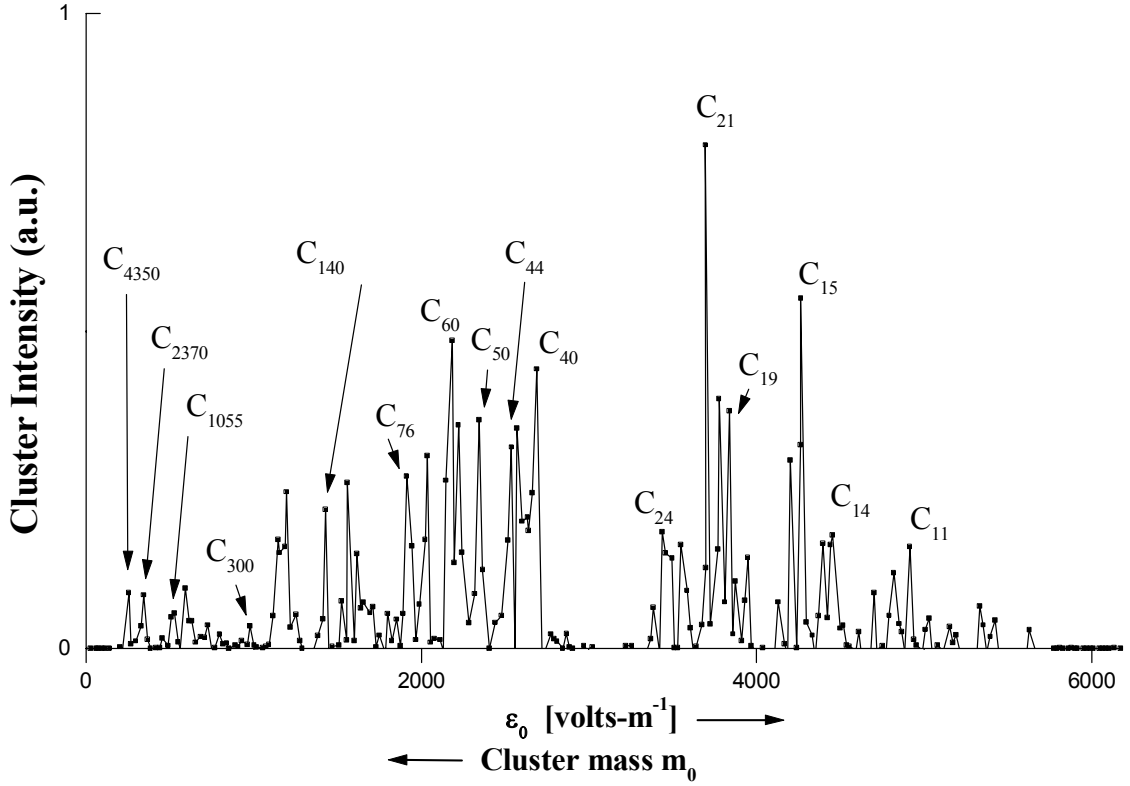
•EPJ D **15**, 349 (2001)

•APL **78,** 1499 (2001)


a
0.06 mbar
CI,CII
& CIII Lines
CI
CII
CIII
CI
NeI λ3520
γ
δ
NeI λ5852
b
20 mbar
α
δ
NeI λ5852
CI,CII
& CIII Lines
β
γ
C2(0,0)
Relative Intensity
Wavelength (nm)

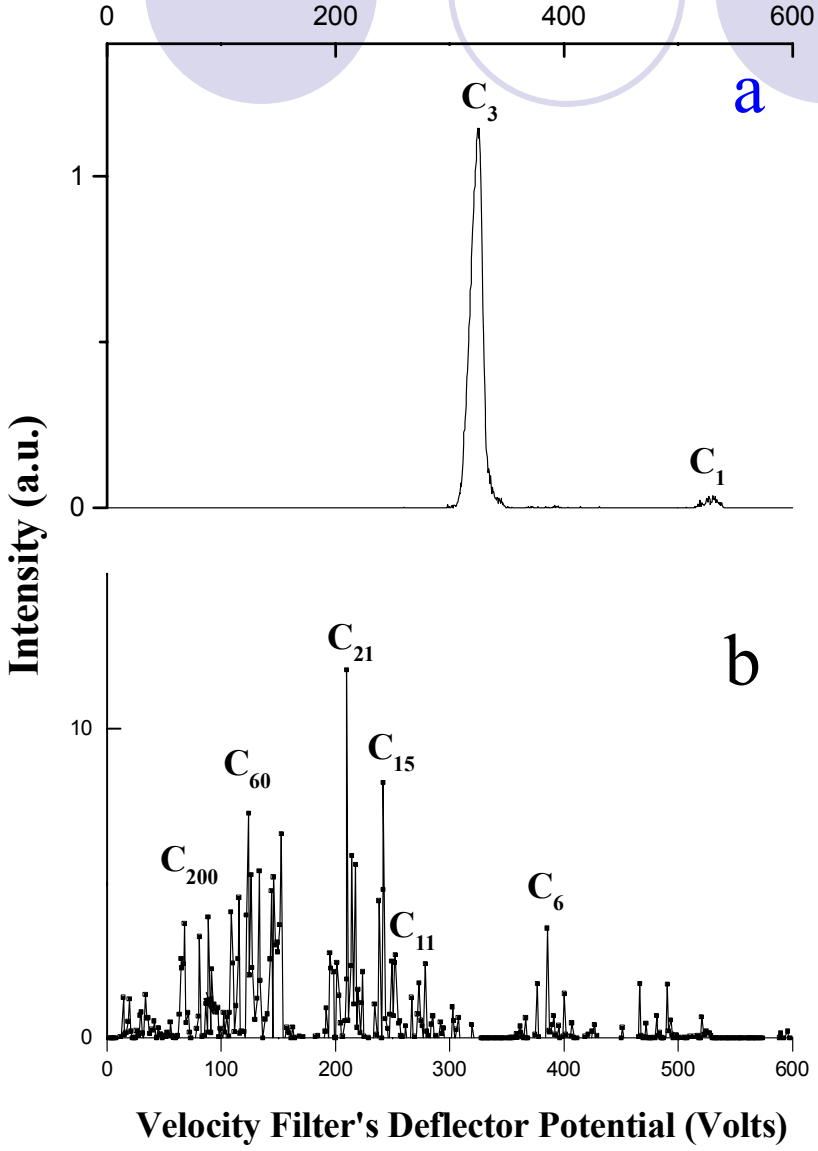

Extractor
Lens
Velocity
Filter
Particle
Detector
HC
HA
N
S
a
l

- NIM A **452,** 370 (2000)
- REDS **153,** 35 (2000)
- Phys. Lett. A**261,** 327 (1999)
- Eur. Phys. J. Appl. Phys. **5,** 111 (1999)

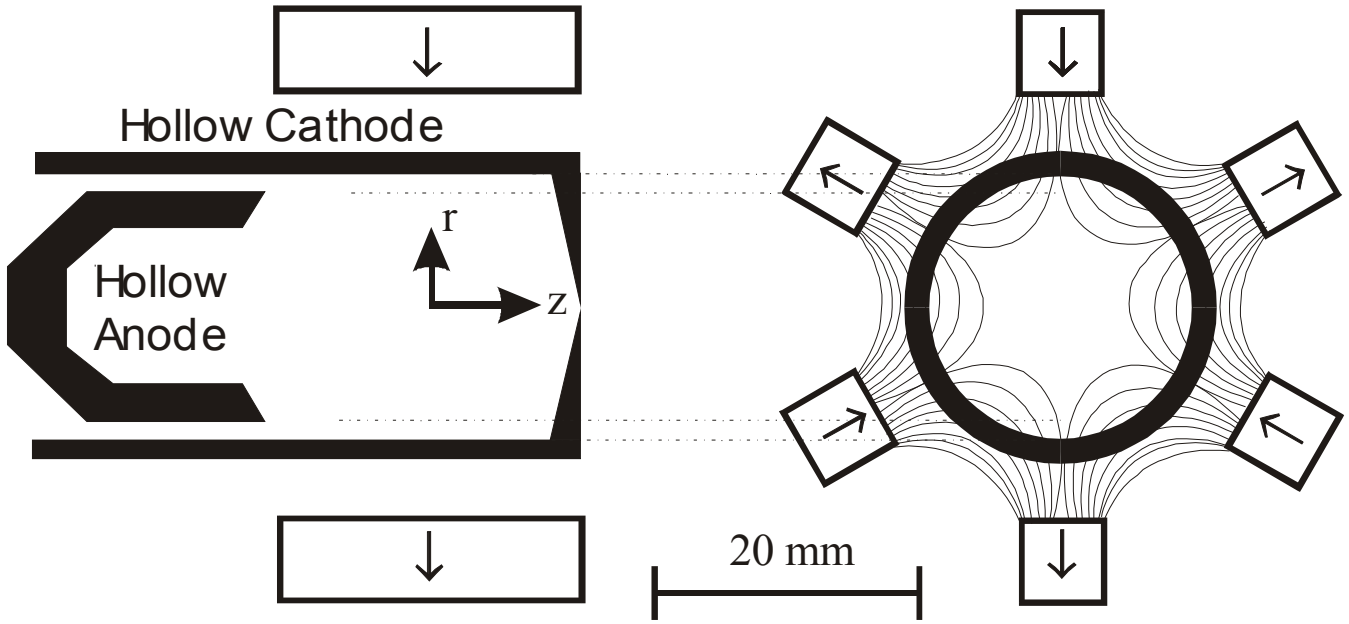


Transition from C_3 to sooting discharge

Phys. Rev. E, 79, 026408 (2001)

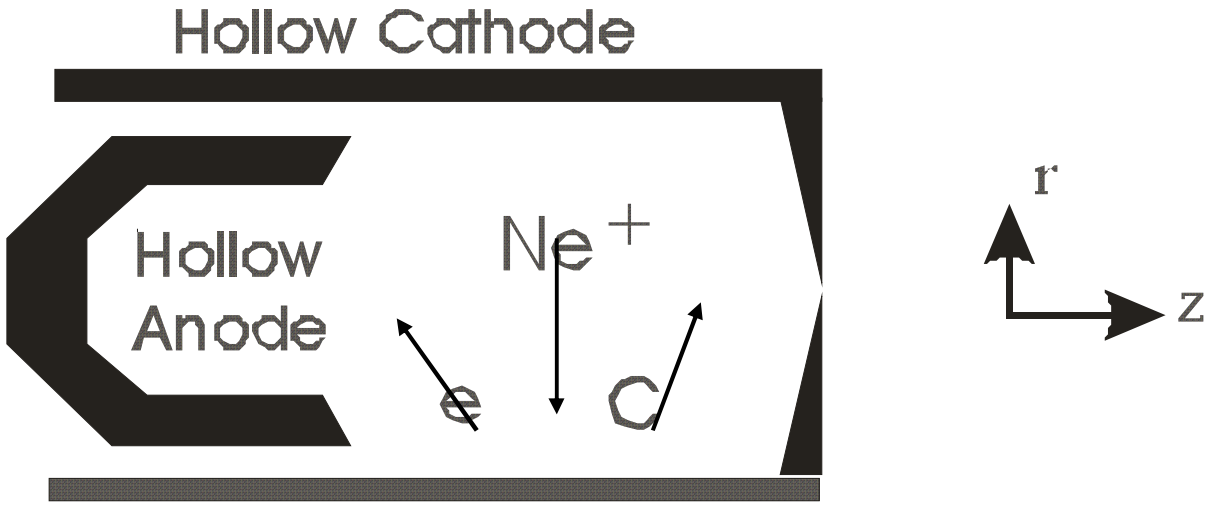


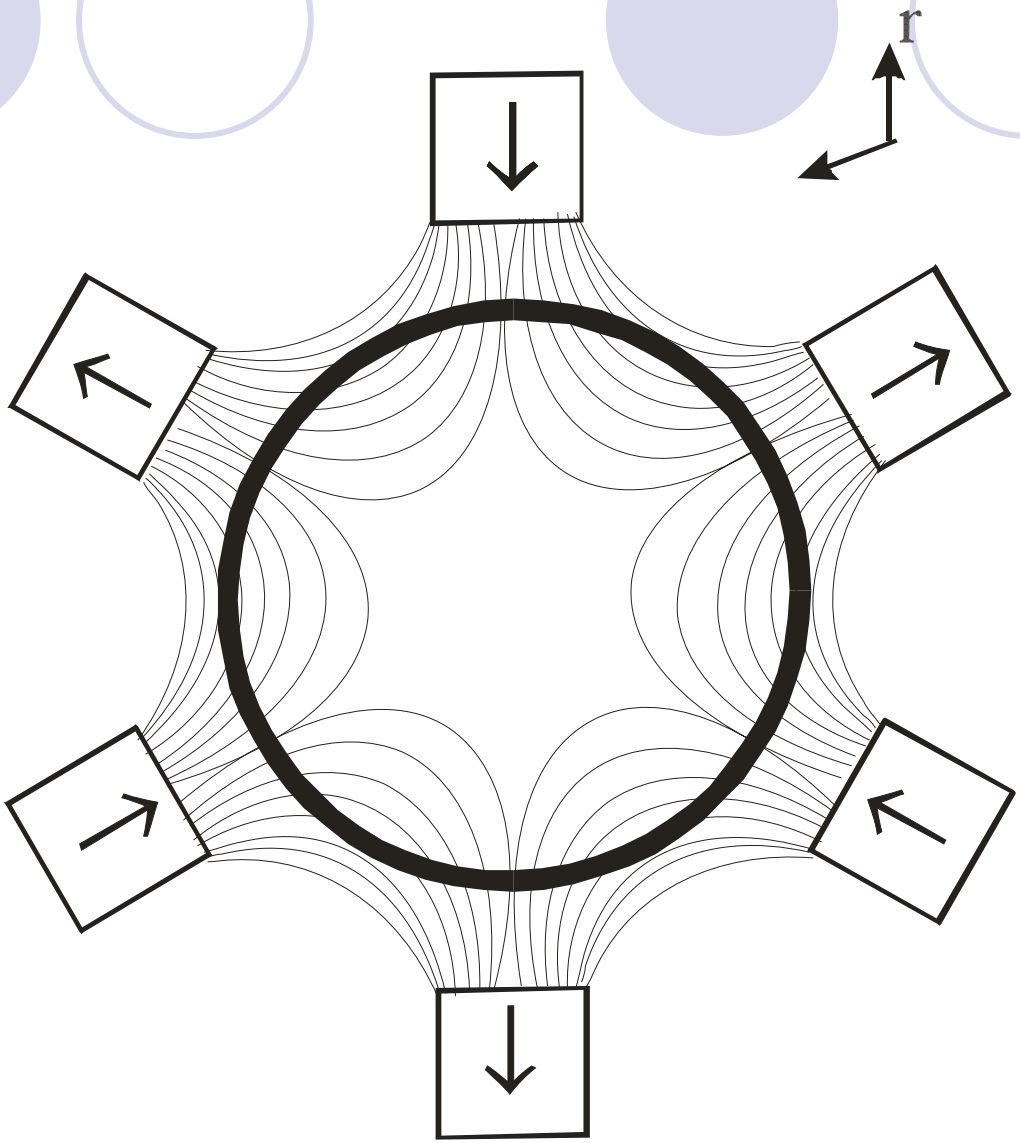
- The cusp field, hollow cathode cluster source

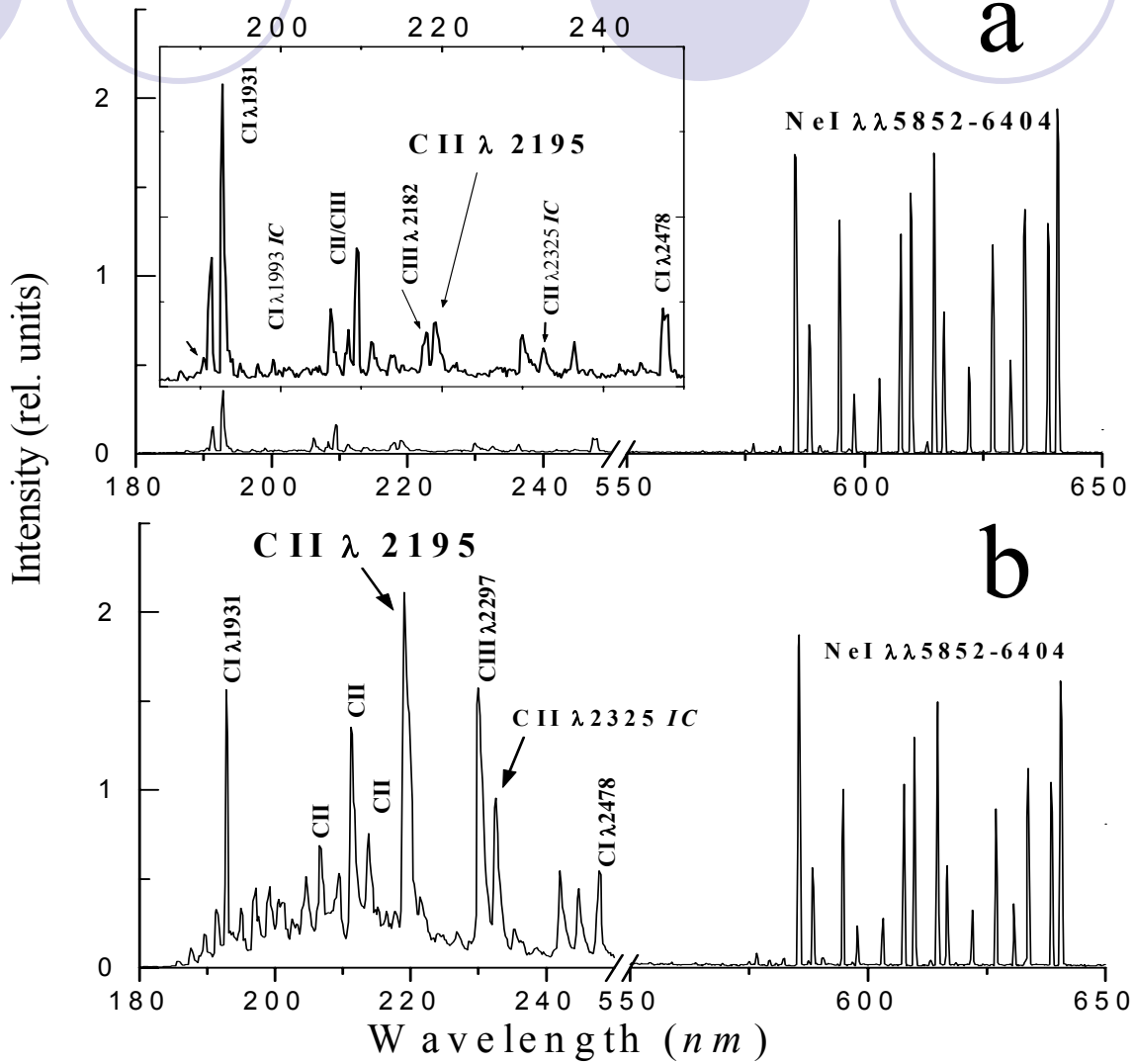


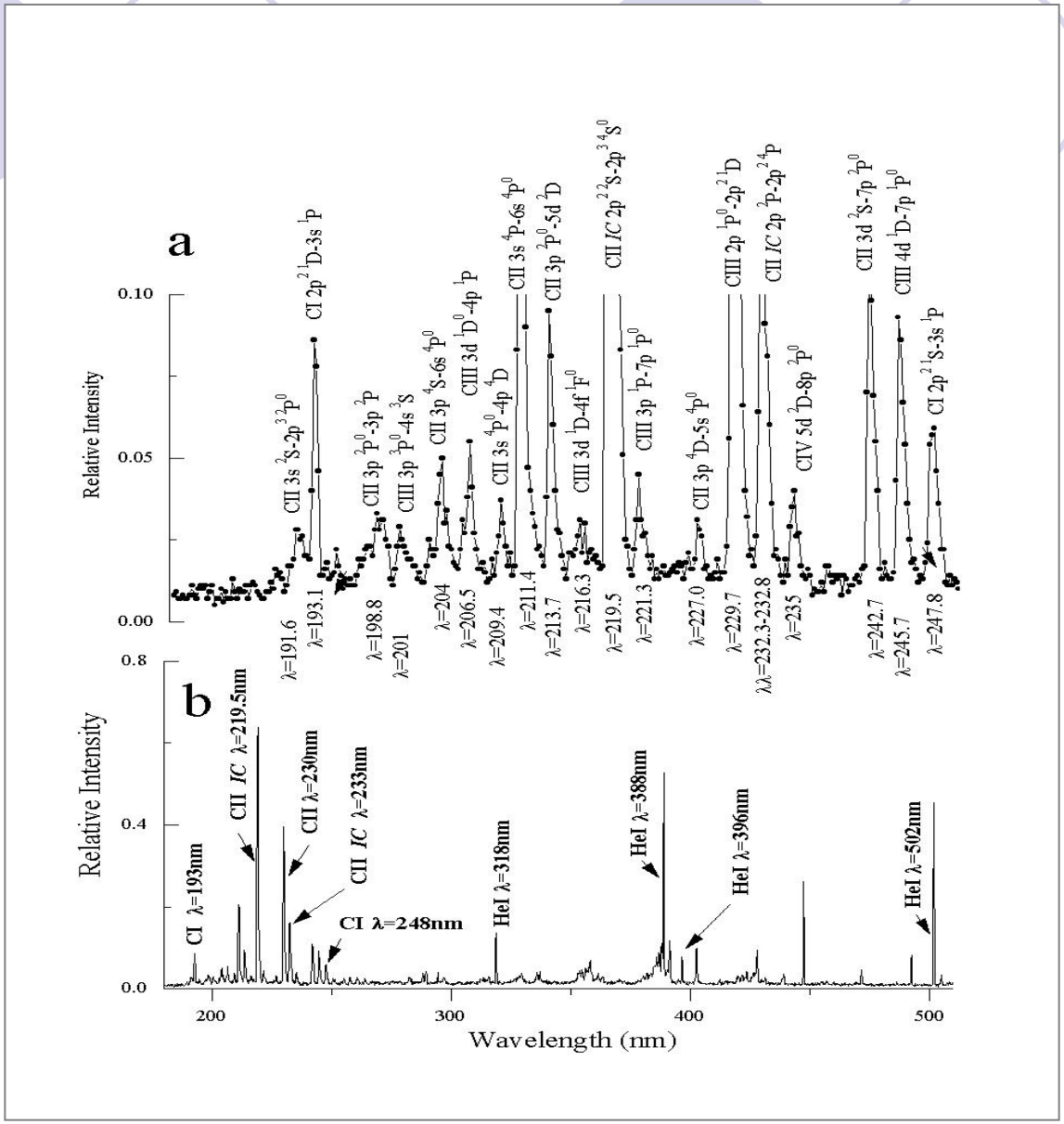
Ne Discharge

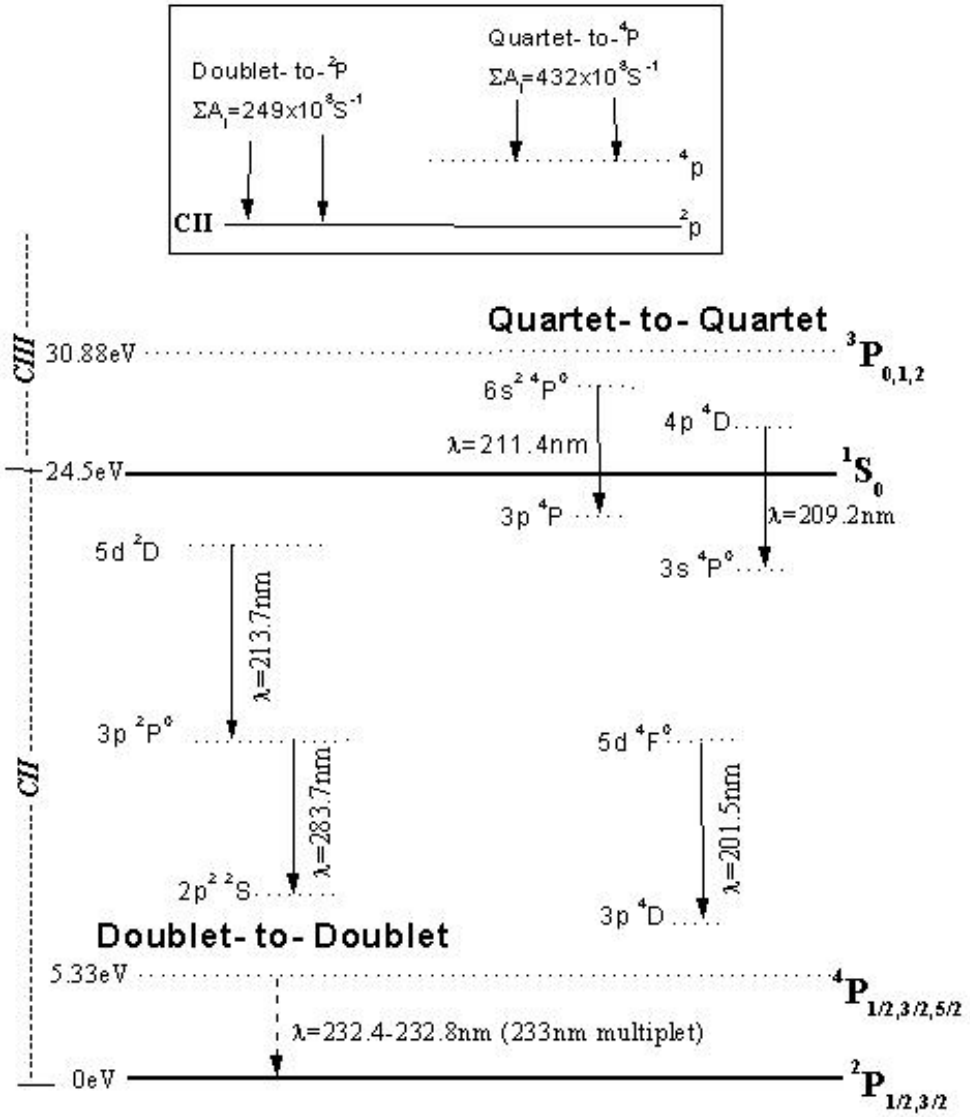
- $Ne \Rightarrow Ne^{+} + e^{-}$
- $Ne^{+} \Rightarrow$ graphite $\Rightarrow C_m + e^{-}$

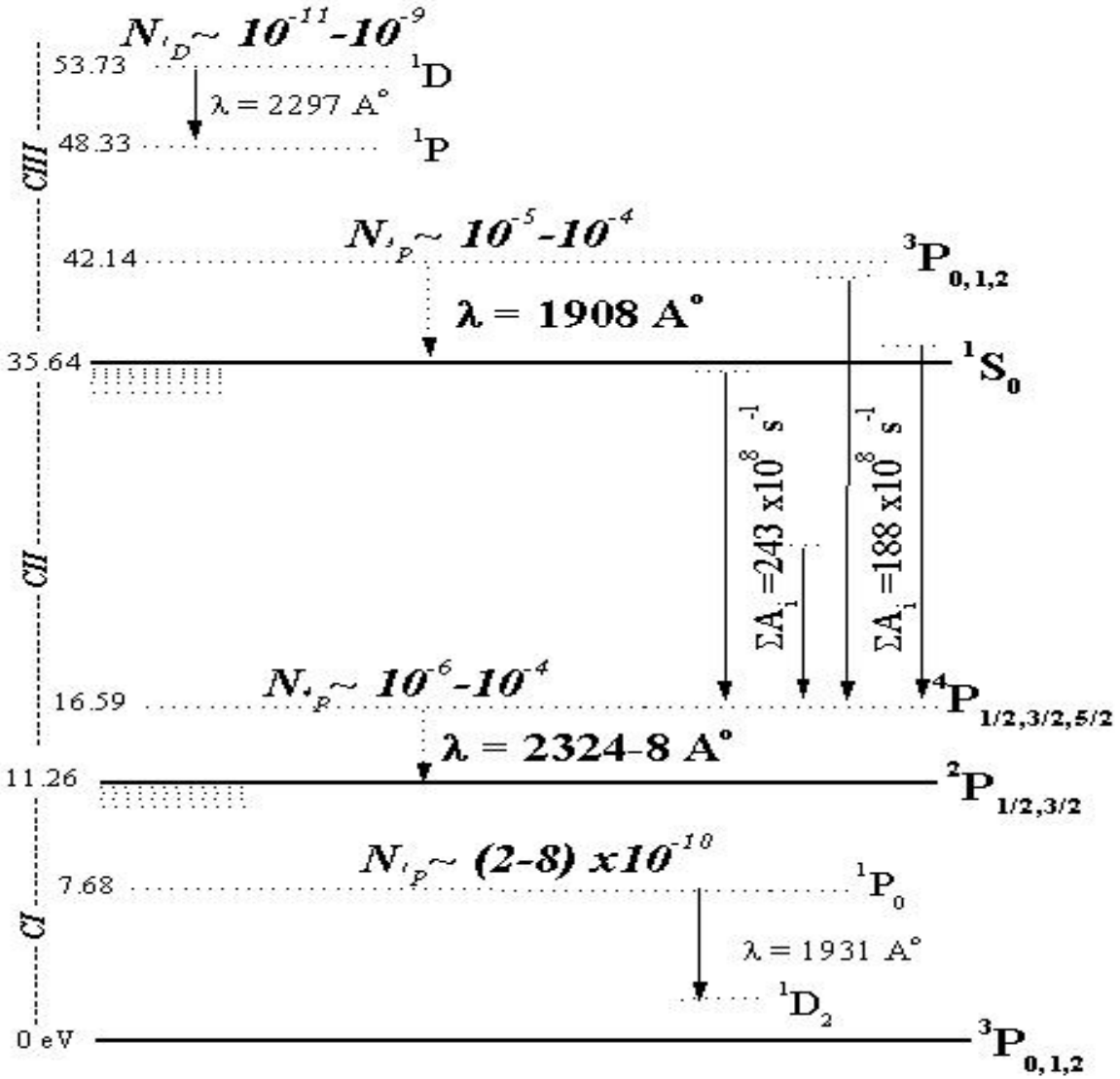



r


a
b
Intensity (rel. units)
Wavelength (nm)
CI λ1931
CI λ1993 IC
CII/CIII
CIII λ 2182
C II λ 2195
CIII λ2325 IC
CI λ2478
NeI λλ5852-6404
CII
CIII λ2297
C II λ2325 IC


a
Relative Intensity
0.10
0.05
0.00
λ=191.6
CII 3s 2S-2p 3 2P0
λ=193.1
CI 2p 2 1D-3s 1P
λ=198.8
CII 3p 2P0-3p 2P
λ=201
CIII 3p 3P0-4s 3S
λ=204
CII 3p 4S-6s 4P0
λ=206.5
CIII 3d 1D0-4p 1P
λ=209.4
CII 3s 4P0-4p 4D
λ=211.4
CII 3s 4P-6s 4P0
λ=213.7
CII 3p 2P0-5d 2D
λ=216.3
CIII 3d 1D-4F 1F0
λ=219.5
CII IC 2p 2 2S-2p 3 4S0
λ=221.3
CIII 3p 1P-7p 1P0
λ=227.0
CII 3p 4D-5s 4P0
λ=229.7
CIII 2p 1P0-2p 2 1D
λλ=232.3-232.8
CII IC 2p 2P-2p 2 4P
λ=235
CIV 5d 2D-8p 2P0
λ=242.7
CII 3d 2S-7p 2P0
λ=245.7
CIII 4d 1D-7p 1P0
λ=247.8
CI 2p 2 1S-3s 1P
b
Relative Intensity
0.8
0.4
0.0
CI λ=193nm
CII IC λ=219.5nm
CII λ=230nm
CII IC λ=233nm
CI λ=248nm
HeI λ=318nm
HeI λ=388nm
HeI λ=396nm
HeI λ=502nm
200
300
400
500
Wavelength (nm)


Doublet- to-²P
ΣA_i=249x10⁸S⁻¹
Quartet- to-⁴P
ΣA_i=432x10⁸S⁻¹
⁴p
CII
²p
Quartet- to- Quartet
CIII
30.88eV
³P_0,1,2
6s² ⁴P°
λ=211.4nm
4p ⁴D
24.5eV
¹S_0
3p ⁴P
λ=209.2nm
3s ⁴P°
5d ²D
λ=213.7nm
3p ²P°
λ=283.7nm
2p² ²S
5d ⁴F°
λ=201.5nm
3p ⁴D
Doublet- to- Doublet
CII
5.33eV
⁴P_1/2,3/2,5/2
λ=232.4-232.8nm (233nm multiplet)
0eV
²P_1/2,3/2

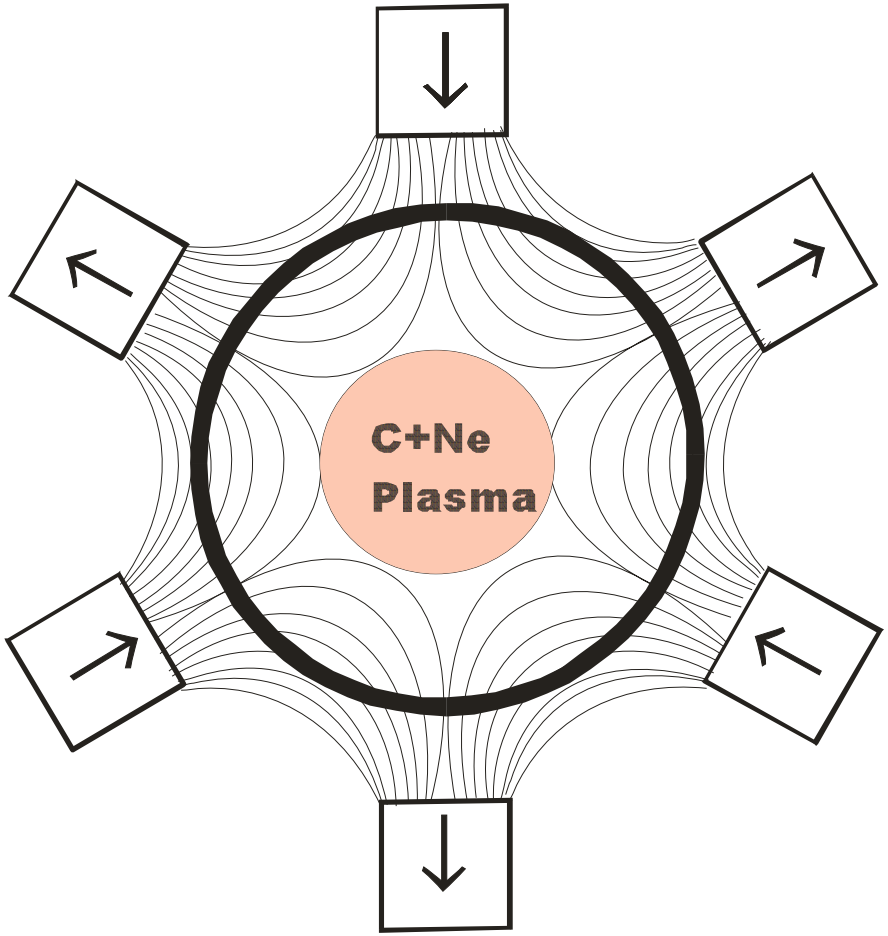

$N_{^1D} \sim 10^{-11}$-10^{-9}
53.73
^1D
λ = 2297 A°
48.33
^1P
CIII
$N_{^3P} \sim 10^{-5}$-10^{-4}
42.14
$^3P_{0,1,2}$
λ = 1908 A°
35.64
$^1S_0$
CII
ΣA_i =243 x10^8 s^{-1}
ΣA_i =188 x10^8 s^{-1}
$N_{^4P} \sim 10^{-6}$-10^{-4}
16.59
$^4P_{1/2,3/2,5/2}$
λ = 2324-8 A°
11.26
$^2P_{1/2,3/2}$
$N_{^1P} \sim (2\text{-}8)\ x10^{-10}$
7.68
$^1P_0$
λ = 1931 A°
$^1D_2$
CI
0 eV
$^3P_{0,1,2}$

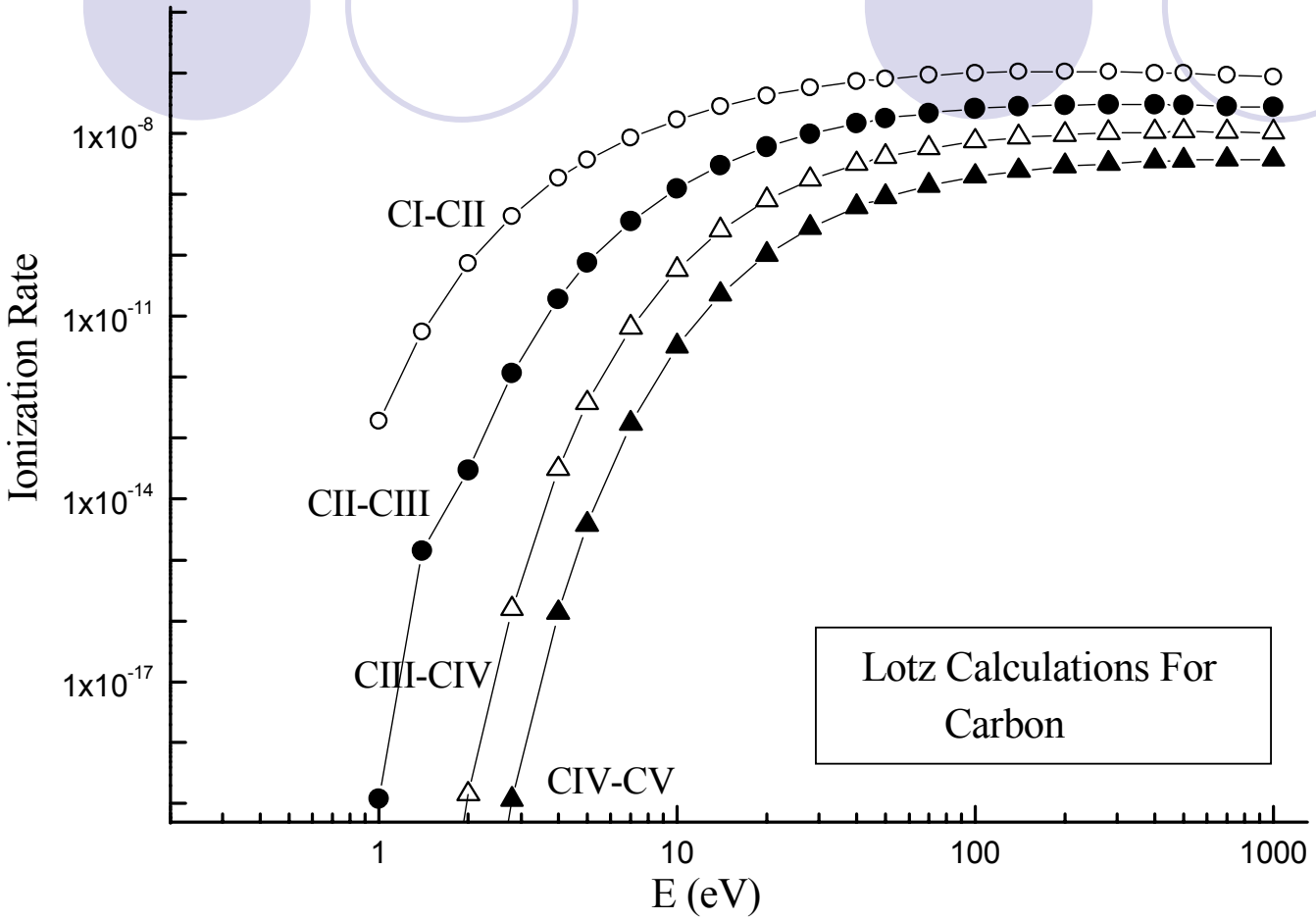
Two modes of the inclusion of carbon into the neon plasma are:

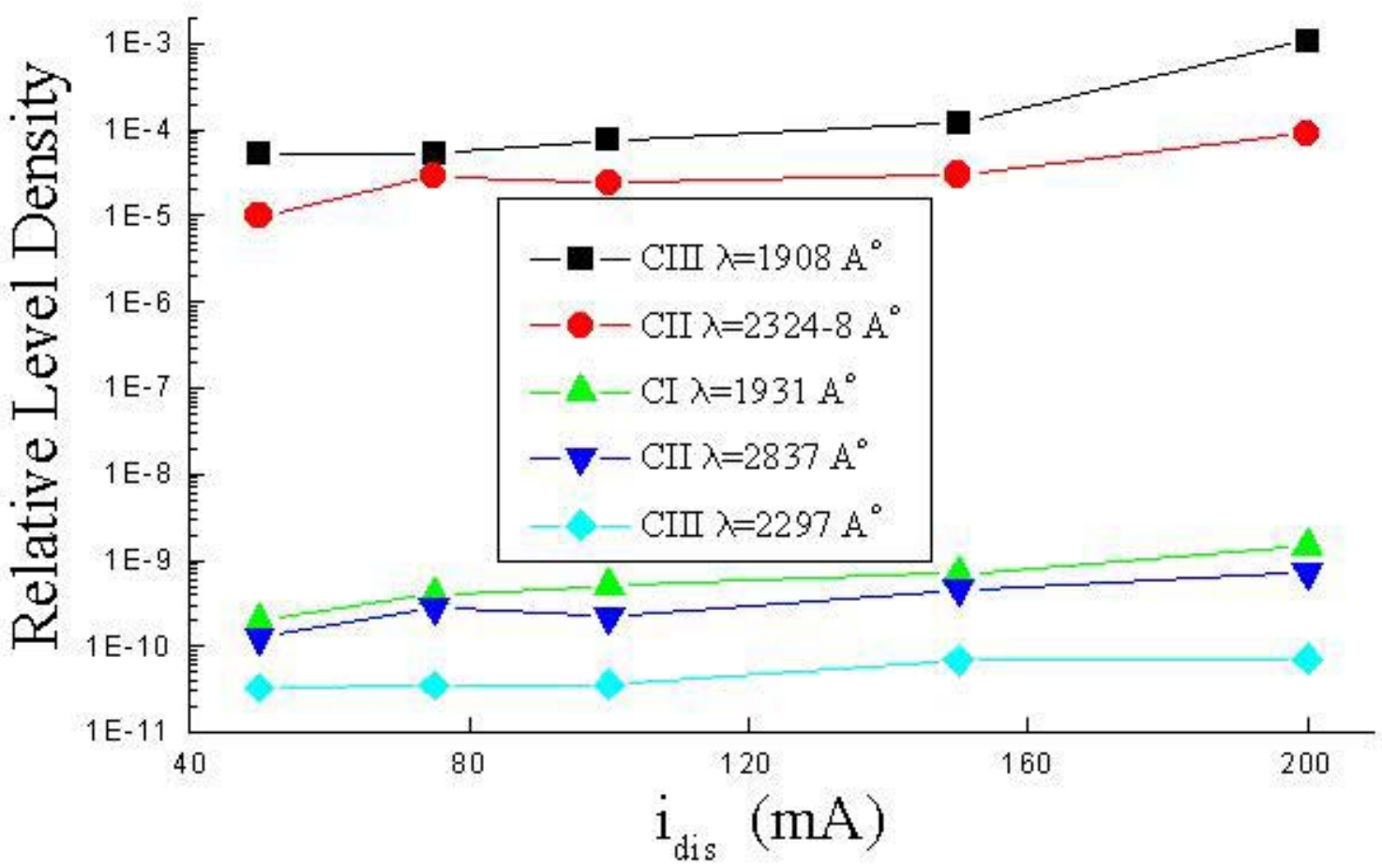
(1) The first mode is the high T_e and n_e regime of the discharge. Higher values of V_{dis} and i_{dis} initiate the sputtering of the carbon cathode with the subsequent excitation and ionization of the carbon. ***The singly ionized C content participates efficiently in the kinetic sputtering of the cathode along with NeII.***

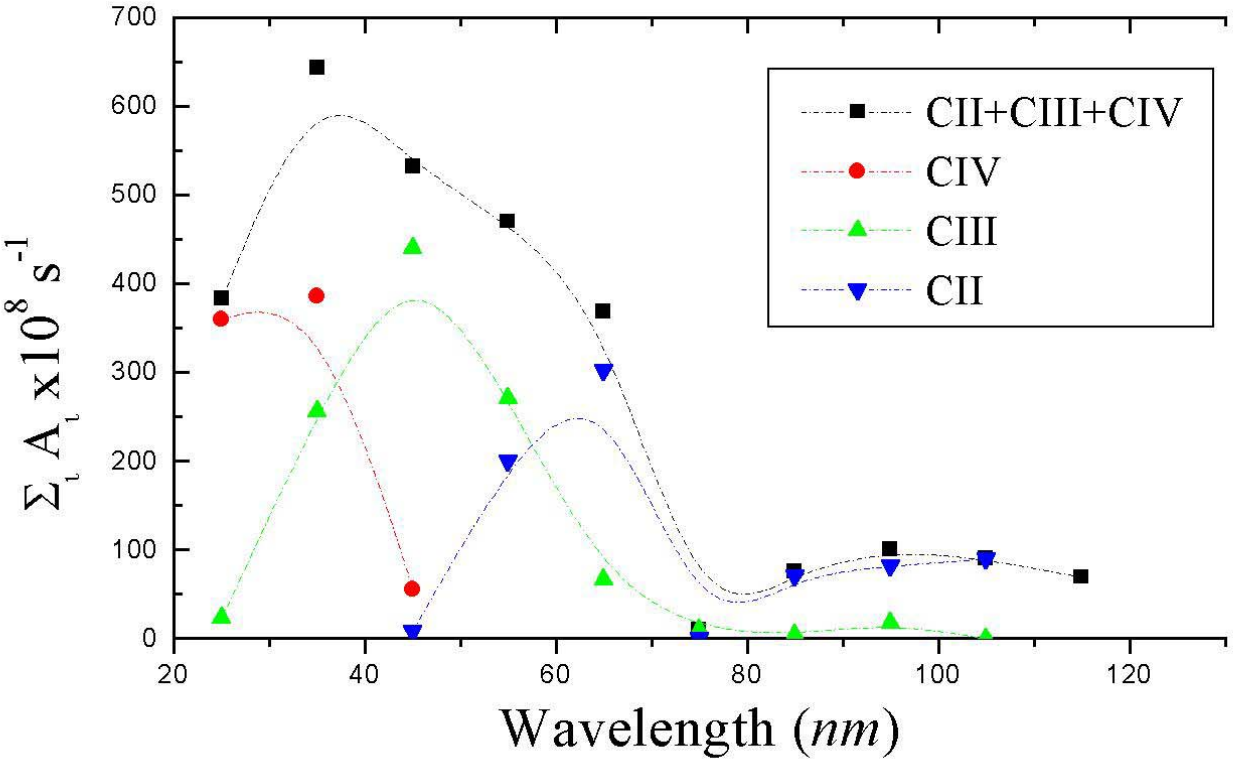
(2) The second mode of discharge can be classified as the sooting mode which may be associated with high pressure discharges where the density of the ionized species CII and NeII considerably reduces. ***A constant but gentle surface erosion by potential sputtering dominates this mode.***

- The cusp magnetic fields act as:
- The traps for high energy electron and low energy ions
- The lowest field contours define the outer boundaries of the plasma




Ionization Rate
1x10-8
1x10-11
1x10-14
1x10-17
CI-CII
CII-CIII
CIII-CIV
CIV-CV
Lotz Calculations For Carbon
1
10
100
1000
E (eV)


Relative Level Density
1E-3
1E-4
1E-5
1E-6
1E-7
1E-8
1E-9
1E-10
1E-11
40
80
120
160
200
i_{dis} (mA)
CIII λ=1908 A°
CII λ=2324-8 A°
CI λ=1931 A°
CII λ=2837 A°
CIII λ=2297 A°



A histogram in which the cumulative Einstein transition probabilities of the three charged states of C are plotted as a function of the wavelength.

Conclusions

1. Exploitation of this unique carbonaceous discharge is proposed that is composed of a positive column whose outer boundaries are defined by the cusp magnetic field contours to operate as a source of enhanced *VUV* light and soft x-rays. These contours confine and trap high energy electrons and low energy *C* ions. The graphite hollow cathode acts as a cavity that traps the charged species whose radiative decay can yield a strong *VUV* radiation field that exists between $\lambda = 20\text{-}80\ nm.$

2. The main contributions to this field are the radiative and dielectronic recombinations of *CII*, *CIII* and *CIV*. When all three ionized states are present then three distinct regimes of wavelength exist;

(a) below *40 nm*, emission from *CIV* dominate *Ephoton~ 40 eV*,

(b) (b) between *40-60 nm* emissions from *CIII*, *Ephoton~ 25 eV*, and

(c) (c) above *60 nm*, emissions from *CII* dominate *Ephoton ~ 20 eV*.

The entrapment of the C ions along the cusp magnet fields and their subsequent collisions with energetic electrons that are similarly trapped but gyrate with different frequencies is the essence of this mechanism.