APPENDIX-A

The constants required for the computations in this work are presented in tabular form as follows.

The calculations of ionization cross-section and ionization rate coefficients of HeI, HeII, NeI, NeII, NeIII, NeIV, CuI, CuII and CuIII in the CVL discharge plasma requires the binding energy and the ionization potentials of these species. The computations of the ionization cross section using Lotz formula needs the constants $a_i$, $b_i$ and $c_i$. The values of $a_i$ and $b_i$ are negligible when compared to $a_i$ and therefore, they are neglected in the present work. The value of the constant $a_i$ is taken as $4.5 \times 10^{-14}$ cm$^3$ sec$^{-1}$ eV$^{-2}$. The ionization of above species provided by Charlotte. E. Moore are presented in table A-1

**Table A-1**

<table>
<thead>
<tr>
<th>Element</th>
<th>Helium</th>
<th>Neon</th>
<th>Copper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atom/ion</td>
<td>HeI</td>
<td>HeII</td>
<td>NeI</td>
</tr>
<tr>
<td>Ionization potential in Volts</td>
<td>24.58</td>
<td>54.50</td>
<td>21.55</td>
</tr>
</tbody>
</table>

For computations of dielectronic recombination rate coefficients, the necessary values of the constants are as below.

*Appendix A*
Table A-2 (For CuI)

<table>
<thead>
<tr>
<th>State</th>
<th>Level</th>
<th>$\chi_{ij}$</th>
<th>$a_{ij}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^2P$</td>
<td>30783.686</td>
<td>0.1403</td>
<td>1.9246</td>
</tr>
<tr>
<td>$^2P$</td>
<td>45879.311</td>
<td>0.2091</td>
<td>2.3321</td>
</tr>
<tr>
<td>$^2P$</td>
<td>49382.950</td>
<td>0.2250</td>
<td>2.4156</td>
</tr>
<tr>
<td>$^2P$</td>
<td>54784.060</td>
<td>0.2497</td>
<td>2.5372</td>
</tr>
<tr>
<td>$^2P$</td>
<td>56343.740</td>
<td>0.2568</td>
<td>2.5714</td>
</tr>
<tr>
<td>$^2P$</td>
<td>57948.710</td>
<td>0.2641</td>
<td>2.6055</td>
</tr>
<tr>
<td>$^2P$</td>
<td>59275.330</td>
<td>0.2701</td>
<td>2.6336</td>
</tr>
<tr>
<td>$^2P$</td>
<td>60070.600</td>
<td>0.2737</td>
<td>2.6499</td>
</tr>
<tr>
<td>$^2P$</td>
<td>60595.000</td>
<td>0.2761</td>
<td>2.6609</td>
</tr>
<tr>
<td>$^2P$</td>
<td>60958.000</td>
<td>0.2762</td>
<td>2.6610</td>
</tr>
</tbody>
</table>

Table A-3 (For CuII)

<table>
<thead>
<tr>
<th>State</th>
<th>Level</th>
<th>$\chi_{ij}$</th>
<th>$a_{ij}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^1P$</td>
<td>73595.860</td>
<td>0.2236</td>
<td>2.9491</td>
</tr>
<tr>
<td>$^1P$</td>
<td>117231.690</td>
<td>0.3562</td>
<td>3.66813</td>
</tr>
<tr>
<td>$^1P$</td>
<td>112867.920</td>
<td>0.3733</td>
<td>3.7481</td>
</tr>
<tr>
<td>$^1P$</td>
<td>125399.800</td>
<td>0.3810</td>
<td>3.7833</td>
</tr>
<tr>
<td>$^1P$</td>
<td>135958.460</td>
<td>0.4131</td>
<td>3.9252</td>
</tr>
<tr>
<td>$^1P$</td>
<td>137212.700</td>
<td>0.4169</td>
<td>3.9416</td>
</tr>
<tr>
<td>$^1P$</td>
<td>138593.100</td>
<td>0.4211</td>
<td>3.9595</td>
</tr>
<tr>
<td>$^1P$</td>
<td>140984.200</td>
<td>0.4284</td>
<td>3.9902</td>
</tr>
<tr>
<td>$^1P$</td>
<td>145955.700</td>
<td>0.4435</td>
<td>4.0532</td>
</tr>
</tbody>
</table>

Appendix A
Table A-3 (For CuIII)

<table>
<thead>
<tr>
<th>State</th>
<th>Level</th>
<th>$\chi_{ij}$</th>
<th>$a_{ij}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^2F$</td>
<td>68963.600</td>
<td>0.1571</td>
<td>2.8755</td>
</tr>
<tr>
<td>$^2P$</td>
<td>85446.400</td>
<td>0.1947</td>
<td>3.1877</td>
</tr>
<tr>
<td>$^2F$</td>
<td>128679.400</td>
<td>0.2932</td>
<td>3.8700</td>
</tr>
<tr>
<td>$^2F$</td>
<td>138982.000</td>
<td>0.3167</td>
<td>4.0115</td>
</tr>
<tr>
<td>$^2P$</td>
<td>140200.900</td>
<td>0.3195</td>
<td>4.0278</td>
</tr>
</tbody>
</table>

Appendix A
APPENDIX B

LIST OF SYMBOLS AND ABBREVIATIONS

A → Einstein’s rate coefficient
a → Constant
b → Constant
B → Rate of stimulated emission
C → Velocity of light
Cu → \(^2\)S Ground state copper density
Cu_m → \(^2\)D Metastable copper density (Lower laser state)
Cu* → \(^2\)P Copper density (Upper laser state)
Cu** → Lumped radiative state in copper
Cu^+ → Copper ion
CuI → Copper atom
CuII → Singly ionised copper
CuIII → Doubli ionised copper
C_e → Rate coefficient of elastic collision
C_in → Rate coefficient of inelastic collision
C_dex → Deexcitation rate coefficient
E_i → Energy of excited state of particles
E_k → Kinetic energy of excited state of particles
E_{mn} → Energy required to raise a valence electron of an atom from level m to level n
E_s → Threshold energy
E_j → Energy of J th state excited by elastic collision
E_{ej} → Energy of Jth resonance transition
E_c → Energy transferred in elastic collision
EIE → Electron impact excitation
$e^-$ → Charge on electron

$f_1$ or FRAA1 → Fractional abundance of neutral atom

$f_2$ or FRAA2 → Fractional abundance of singly ionised species

$f_3$ or FRAA3 → Fractional abundance of doubly ionised species

$f_{2j}$ → Oscillator strength of jth resonance state

$F_Z$ → Fractional abundance of species with charge $Z$

$\text{He}$ → Helium atom in ground state

$\text{He}_m$ → Metastable state helium

$\text{He}^+$ → Helium ion

$\text{He}_2^+$ → Molecular helium ion

$\text{HeI}$ → Helium atom

$\text{HeII}$ → Singly ionised helium

$\text{HeIII}$ → Doubly ionised helium

$I$ → Ionisation potential

$I_Z$ → Ionisation potential of ion of charge $Z$

$I_{Z-1}$ → Ionisation potential of ion of charge $Z$-1

$I_H$ → Ionisation potential of hydrogen

$J$ → Laser intensity

$L$ → Length of the discharge tube

$K$ → Boltzmann's constant

$KE$ → Kinetic energy

$N$ → Principle quantum number

$n_c$ → Density of copper

$n_b$ → Density of buffer gas

$N_e$ or $n_e$ → Electron density

$N_j$ → Density of state $j$ which lies energetically above the laser state

$N_{\text{HeI}}$ → Density of helium atoms

$N_{\text{HeII}}$ → Density of helium atoms in metastable state

$N_{\text{HeI}}$ or $N_{\text{HeII}}$ → Density of singly ionised helium

Appendix B
\( N_u \rightarrow \text{Density of upper laser state} \\
N_l \rightarrow \text{Density of lower laser state} \\
N_e \rightarrow \text{Electron density along the axis of the discharge tube} \\
N_{Z+1} \rightarrow \text{Density of ions with charge } Z+1 \\
N_{\text{Cu}} \rightarrow \text{Density of copper atoms} \\
N_{\text{Cu}^+} \rightarrow \text{Density of singly ionised copper atoms} \\
NeI \rightarrow \text{Neon atom} \\
NeII \rightarrow \text{Singly ionised neon} \\
NeIII \rightarrow \text{Doubly ionised neon} \\
NeIV \rightarrow \text{Triply ionised neon} \\
n(\, t_{ij}) \rightarrow \text{Initial inversion density} \\
m_e \rightarrow \text{Mass of electron} \\
P \rightarrow \text{Penning Ionisation rate coefficient} \\
P_c \rightarrow \text{Laser gas pressure} \\
P_{\text{ex}} \rightarrow \text{Extrernal gas pressure} \\
P_g \rightarrow \text{Buffer gas pressure} \\
P_i \rightarrow \text{Binding energy of the electron which is to be removed} \\
P_{\text{sp}} \rightarrow \text{Vapor pressure of copper based on the wall temperature} \\
p \rightarrow \text{Number of equivalent electrons in the outer shell} \\
R \rightarrow \text{Electron impact excitation rate coefficient} \\
R_d \rightarrow \text{Instantaneous discharge impedance} \\
R_{\text{He}*} \rightarrow \text{Electron impact excitation rate coefficient helium metastable state from ground state} \\
R_o \rightarrow \text{Radius of the discharge tube} \\
T_u \rightarrow \text{Fluorescence life time of upper laser state} \\
S_h \rightarrow \text{Stimulated emission rate coefficient} \\
S_e \rightarrow \text{Electron impact ionisation rate coefficient of ion of charge } Z \\
T \rightarrow \text{Duffendack ionisation rate coefficient} \\

Appendix B
$T_e \rightarrow$ Electron temperature in eV
$T_g \rightarrow$ Gas temperature
$T_1 \rightarrow$ The electron temperature in eV where ionisation starts
$T_2 \rightarrow$ The electron temperature in eV where the saturation takes place
$t_n \rightarrow$ Inversion life time
$v \rightarrow$ Electron collision frequency
$V_d \rightarrow$ Diffusion velocity of copper
$V_e \rightarrow$ Velocity of electrons
$V_s \rightarrow$ Speed of sound in the gas
$V_o \rightarrow$ Maximum velocity on the capacitor
$V_{He} \rightarrow$ Velocity of helium atoms
$Z \rightarrow$ Charge on the species
$\alpha \rightarrow$ Total recombination rate coefficient of ion of charge $z$
$\alpha_{rz} \rightarrow$ Radiative recombination rate coefficient of ion of charge $z$
$\alpha_{dz} \rightarrow$ Dielectronic recombination rate coefficient of ion of charge $z$
$g \rightarrow$ Reaction cross section
$\sigma_T \rightarrow$ Duffendack excitation cross section
$\sigma_P \rightarrow$ Penning excitation cross section
$\mu \rightarrow$ Number of empty spaces
$\eta \rightarrow$ Resistivity of the plasma
$^\wedge \rightarrow$ A numerical constant
$v \rightarrow$ Frequency of radiation
$\theta \rightarrow$ Gas temperature
$\chi \rightarrow$ Ionisation Potential
$\xi \rightarrow$ The number equivalent electrons in the outer most shell from where the ionisation takes place
## List of Publications

<table>
<thead>
<tr>
<th>Name of Author/s</th>
<th>Year of Publication</th>
<th>Title of the Paper</th>
<th>Name of the Journal</th>
</tr>
</thead>
<tbody>
<tr>
<td>-- do--</td>
<td>1999</td>
<td>The study of optimization of discharge parameters and power saturation in the CVL discharge.</td>
<td>do--------</td>
</tr>
<tr>
<td>-- do--</td>
<td>2000</td>
<td>Experimental measurement of angle of divergence in the cyclic lasers.</td>
<td>Proc. of ISCA held at Pune.</td>
</tr>
<tr>
<td>-- do--</td>
<td>2000</td>
<td>The process of recombination explains high gain and different power saturation in He-Zn⁺ laser discharge.</td>
<td>Proc. of INCOLA held at Tiruchirapalli</td>
</tr>
<tr>
<td>-- do--</td>
<td>2000</td>
<td>The idea of fractional abundance helps in explaining several experimental results in gaseouc laser discharge.</td>
<td>do--------</td>
</tr>
<tr>
<td>-- do--</td>
<td>2000</td>
<td>Electron impact excitation produces population inversion on 77 transitions of first and second positive system of nitrogen molecule.</td>
<td>Published in AJP Vol 9, No 2</td>
</tr>
<tr>
<td>-- do--</td>
<td>2000</td>
<td>The concept of fractional abundance explains the nature of radial profiles in He-Cd⁺ laser discharge.</td>
<td>Published in AJP Vol 9, No 2</td>
</tr>
<tr>
<td>-- do--</td>
<td>2001</td>
<td>Possibility of use of CVL beam for the study of composites.</td>
<td>Proc. of NCCS held at Amravati</td>
</tr>
<tr>
<td>-- do--</td>
<td>Accepted for publication in AJP</td>
<td>The idea of fractional abundance helps in explaining several experimental results in gaseous laser discharge.</td>
<td></td>
</tr>
<tr>
<td>-- do--</td>
<td>2001</td>
<td>The role of Kerr and Pockels effect in increasing Bit density on optical fibre.</td>
<td>Proc. of International conference on BBOFCCT held at Jalaon</td>
</tr>
</tbody>
</table>