NEWLY IDENTIFIED RESONANCE LINES
OF Ni xix, Cu xx, AND Zn xxI

BY
U. FELDMAN
L. COHEN
M. SWARTZ

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NASA
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NEWLY IDENTIFIED RESONANCE LINES OF Ni xix, Cu xx and Zn xx1

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U. Feldman*, L. Cohen, and M. Swartz
Goddard Space Flight Center
Greenbelt, Maryland

ABSTRACT

Using a grazing incidence spectrometer and a low inductance condensed spark source, the authors have observed spectra of Ni xix, Cu xx and Zn xx1. By extrapolating the known data of the Ne 1 isoelectronic sequence, the new lines have been identified as belonging to transition arrays between the ground level 2s²2p⁶¹S₀ and the following electronic configurations: 2s²2p⁵3s, 2s²2p⁵3d, and 2s2p⁶3p. Some of these lines maybe emitted from the solar corona.

*NASA - National Academy of Science, National Research Council Postdoctoral Research Associate.
Lines classified as belonging to the Ne I isoelectronic sequence have been reported for ions up to Co XVIII for the following transition arrays: 2s²2p⁵3s,3d, 4d and 2s2p⁶3p to the ground level 2s²2p⁶¹S₀ (Tyren 1938). We have recorded and identified lines of nickel (Ni), copper (Cu), and zinc (Zn) as belonging to this isoelectronic sequence.

The sources used was a vacuum spark chamber with electrodes made of the elements under investigation. The low inductance discharge circuit consisted of a 14 μF capacitor charged to 12 kV, and triggered by the discharge of a tesla coil placed near the ground electrode. The spectra were recorded on Kodak SWR glass plates, using a modified Jarrell-Ash 3-meter, 88 degree angle of incidence, spectrometer. The grating was a Bausch and Lomb gold replica having 1200 lines per mm, and blazed at 2°35'. To eliminate excessive background fogging of the plates in this range of wavelengths, aluminum and formvar filters each of about 2000 Å thickness were placed between the grating and the entrance slit.

With this equipment it was possible to record lines of Ni, Cu, and Zn between 10Å and 14Å. Most of the lines of the observed spectra appeared in the second order, enabling us to determine their wavelengths by comparison with the known lines of C v, O vii, and Fe xvii. By plotting the known data of the Ne I isoelectronic sequence and extrapolating to the elements Ni, Cu, and Zn (Fig. 1) we have been able to identify the lines (Table 1). The lines belong to transitions between
Figure 1: Reduced energy level diagram $\nu/\zeta$ vs. $\zeta$ of the Ne i isoelectronic sequence, where $\nu$ is the wave number in cm$^{-1}$ and $\zeta$ is the spectrum number.
<table>
<thead>
<tr>
<th>Transition</th>
<th>Ni XX</th>
<th>Cu XX</th>
<th>Zn XX</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2s^22p^6 \rightarrow 2s^22p^53s^1p_1^o$</td>
<td>$\lambda(A)$</td>
<td>Int</td>
<td>$\nu(cm^{-1})$</td>
</tr>
<tr>
<td>$-2s^22p^63d^1$</td>
<td>14.03</td>
<td>6</td>
<td>7128000</td>
</tr>
<tr>
<td>$-2s^22p^53d^1p_1^o$</td>
<td>13.77</td>
<td>4</td>
<td>7262000</td>
</tr>
<tr>
<td>$-2s^22p^53s^1p_1^o$</td>
<td>12.80</td>
<td>2</td>
<td>7813000</td>
</tr>
<tr>
<td>$-2s^22p^53d^1p_1^o$</td>
<td>12.64</td>
<td>4</td>
<td>7991000</td>
</tr>
<tr>
<td>$-2s^22p^53d^1p_1^o$</td>
<td>12.42</td>
<td>6</td>
<td>8052000</td>
</tr>
<tr>
<td>$-2s^22p^53d^1p_1^o$</td>
<td>11.59</td>
<td>0</td>
<td>8628000</td>
</tr>
<tr>
<td>$-2s^22p^53d^1p_1^o$</td>
<td>11.53</td>
<td>1</td>
<td>8673000</td>
</tr>
</tbody>
</table>
the three electronic configurations \(2s^2 2p^6 \, 3s\), \(2s^2 2p^5 3d\), \(2s2p^3 3p\) and the ground level \(2s^2 2p^6 \, ^1S_0\). Wavelengths, wave numbers, and visual intensities of the new lines are given in Table 1. In Table 2 are given the term values and the \(2s^2 2p^5 \, \ell^0\) limit. We have used LS coupling designations because for these stages of ionization the configurations are far from pair coupling, unlike neutral Ne (Kastner et al. 1966).

The relatively high abundance of nickel in the sun gives us reason to believe that some of the intense lines of Ni \(xx\) may exist in the solar corona.

ACKNOWLEDGEMENT

The authors would like to thank Dr. W. Neupert for many helpful discussions and to W. Gates, and W. Booth for help in the experimental aspects of this work. We would like to thank the NRL Plasma Physics Division for the use of their low inductance capacitor.
Table 2  Energy scheme for terms in Ni xix Cu xx and Zn xx1

<table>
<thead>
<tr>
<th>CONFIGURATION DESIGNATION</th>
<th>J</th>
<th>Ni xix(cm⁻¹)</th>
<th>Cu xx(cm⁻¹)</th>
<th>Zn xx1(cm⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2s² 2p⁶ 3p⁶ ¹S₀</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2s² 2p⁵ 3s 3s³ ¹P⁺</td>
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<td>7128000</td>
<td>7800000</td>
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</tr>
<tr>
<td>2s² 2p⁵ 3s 3s³ ¹P₀</td>
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<td>7262000</td>
<td>7962000</td>
<td>8688000</td>
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<tr>
<td>2s² 2p⁵ 3d 3d³ ¹P⁺</td>
<td>1</td>
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<td>8525000</td>
<td>9259000</td>
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<tr>
<td>2s² 2p⁵ 3d 3d³ ¹D⁺</td>
<td>1</td>
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<td>9372000</td>
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<td>9551000</td>
</tr>
<tr>
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<td>1</td>
<td>8628000</td>
<td>9390000</td>
<td></td>
</tr>
<tr>
<td>2s 2p⁶ 3p 3p³ ¹P₀</td>
<td>1</td>
<td>8673000</td>
<td>9434000</td>
<td>10235000</td>
</tr>
<tr>
<td>Limit 2s² 2p⁵ ²P₃/₂</td>
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<td>12477000</td>
<td>13695000</td>
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REFERENCES
