The study of giant resonances (GR) populated in 
\((p,p')\) reactions at \(E_p = 115\text{ MeV}\) on Si and \(^{92}\text{Zr}\) targets 
reported earlier\(^1\) has been completed. The measurements 
covered the angular ranges between 10° to 34° for Si 
and 14° to 30° for \(^{92}\text{Zr}\) in 2° steps. The scattered 
particles were detected using intrinsic germanium de-
tectors in a telescope configuration. The resolution 
was 200 keV. Collective model DWBA calculations have 
been performed for both the low-lying states as well as 
the GR region in Si and \(^{92}\text{Zr}\). The proton optical model 
parameters used in these calculations are listed in 
Table I.

The experimental angular distribution data for Si 
and the DWBA predictions for the various multipoles 
are shown in Fig. 1. It is found that this region is well 
described by contributions from \(L=1,2,3\) and 4 multipoles. 
Similar analyses performed for \(^{92}\text{Zr}\) are shown 
in Fig. 2. In this case, in addition to \(L=1,2\) and 4 
multipoles, an \(L=0\) contribution is also required to 
explain the data. The percentage energy-weighted sum 
rule (EWSR) strengths determined from collective model 
calculations are given in Table II.

The following conclusions emerge from the present 
work:

1) As expected, the GR region is dominated by the 
Giant Quadrupole Resonance (GQR). The EWSR strengths 
extracted are generally in good accord with those

<table>
<thead>
<tr>
<th>A</th>
<th>(V_R)</th>
<th>(a_R)</th>
<th>(r_R)</th>
<th>(W_I)</th>
<th>(a_I)</th>
<th>(r_I)</th>
<th>(V_{SO})</th>
<th>(W_{SO})</th>
<th>(a_{SO})</th>
<th>(r_{SO})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^{28}\text{Si})</td>
<td>-22.75</td>
<td>0.749</td>
<td>1.265</td>
<td>-6.00</td>
<td>0.644</td>
<td>1.409</td>
<td>-3.43</td>
<td>1.38</td>
<td>0.588</td>
<td>0.972</td>
</tr>
<tr>
<td>(^{92}\text{Zr})</td>
<td>-26.80</td>
<td>0.716</td>
<td>1.24</td>
<td>-8.85</td>
<td>0.643</td>
<td>1.35</td>
<td>-3.30</td>
<td>+1.51</td>
<td>0.594</td>
<td>1.052</td>
</tr>
</tbody>
</table>

Units are MeV and fm.
2) The Giant Dipole Resonance (GDR) cross sections calculated using both the phenomenological isovector potential and microscopic optical potential agree reasonably well with each other. It is found that the GDR contribution (with 50% and 100% strengths for $^{28}$Si and $^{92}$Zr) to the total GR cross sections is relatively small.

3) The present work has indicated the presence of measurable $l=4$ strength in the GR region consistent with other experimental data and theoretical calculations.

A detailed report of the present work has been prepared for publication.


2) K. Van der Borg, Thesis (1979), KVI, Groningen, the Netherlands.


### Table II. Deformation parameters and energy-weighted sum rule strengths

<table>
<thead>
<tr>
<th>$A$</th>
<th>$E_x$ (MeV)</th>
<th>$J^\pi$</th>
<th>$(\beta R)_{opt}$ (fm)</th>
<th>$S_u$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{28}$Si</td>
<td>1.78</td>
<td>$2^+$</td>
<td>1.70</td>
<td>16.6 ±5.7</td>
</tr>
<tr>
<td></td>
<td>4.62</td>
<td>$4^+$</td>
<td>0.49</td>
<td>1.0 ±0.3</td>
</tr>
<tr>
<td></td>
<td>6.89</td>
<td>$3^-$</td>
<td>0.69</td>
<td>10.7 ±3.6</td>
</tr>
<tr>
<td></td>
<td>GR</td>
<td>$2^+$</td>
<td>0.83</td>
<td>44.0 ±1.0</td>
</tr>
<tr>
<td></td>
<td>(15.7-24.1)</td>
<td>$4^+$</td>
<td>0.96</td>
<td>3.0 ±0.9</td>
</tr>
<tr>
<td></td>
<td>4.98</td>
<td>$0^+$</td>
<td>0.35</td>
<td>4.0 ±2.0</td>
</tr>
<tr>
<td></td>
<td>$2.35$</td>
<td>$3^-$</td>
<td>0.66</td>
<td>16.3 ±4.9</td>
</tr>
<tr>
<td></td>
<td>LEOR</td>
<td>$3^-$</td>
<td>0.59</td>
<td>49.9 ±1.3</td>
</tr>
<tr>
<td></td>
<td>(5-10.5)</td>
<td>$2^+$</td>
<td>0.53</td>
<td>99.8 ±9.9</td>
</tr>
<tr>
<td></td>
<td>GR</td>
<td>$4^+$</td>
<td>0.61</td>
<td>16.7 ±0.4</td>
</tr>
</tbody>
</table>

a) Product of $\beta$ and radius $R$ obtained from DWBA analysis.

b) Percent EWSR using uniform mass distribution. Errors quoted are obtained from fitting the measurements with DWBA calculations.

c) Low energy octupole resonance.