§29. Calibration of the CHS YAG Thomson Scattering Device by Raman Scattering in H₂

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Raman scattering in molecular hydrogen is thought to be the best candidate for the calibration of Thomson scattering [1]-[3], because of the large wavelength shifts and well established data for the cross section and wavelength shift available. The calibration can be made without any change of the set-up of the CHS YAG Thomson scattering.

We have used two rotational Raman transitions: 2-0 and 3-1 anti-Stokes lines, whose wavelengths are shorter than that of the incident YAG lasers, suited for the polychromators in the system. The cross section, \( \sigma^R \), shifted wavelength, \( \lambda' \), and population of the initial level of J at \( T=300 \) K, \( N_j \), are listed in Tab.1.

<table>
<thead>
<tr>
<th>( J \rightarrow J' )</th>
<th>( \sigma^R \times 10^{31} \text{ cm}^2 )</th>
<th>( \lambda' ) (nm)</th>
<th>( N_j )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-0</td>
<td>4.72</td>
<td>1027.2</td>
<td>0.117</td>
</tr>
<tr>
<td>3-1</td>
<td>6.73</td>
<td>1004.5</td>
<td>0.089</td>
</tr>
</tbody>
</table>

Tab.1. Major quantities of the rotational Raman lines used in the calibration.

As the Raman cross sections are much smaller than that for Thomson scattering (\( \sigma^R/\sigma^T \times 10^{-7} \)), the calibration has been carried out at several pressure points up to 400 Torr. Fig.1 shows an example for the pressure dependence of the Raman intensities measured with different wavelength channels in a polychromator. The solid and broken lines correspond to 2-0 and 3-1 Raman transitions, respectively. Clear linearities have been seen in both lines. The calibration factors are obtained from the gradients of these lines and spectral sensitivities for each channel. The ratios between the factors for 2-0 and 3-0 lines agree well with those expected from the cross section data and sensitivities. The angular distribution of Raman scattered photons significantly differs from that for Thomson scattering [4], because Raman scattering is a quadrupole transition whereas Thomson scattering is a dipole transition. We have determined the calibration factors by taking the difference into account.

Fig.2 shows an example of the measured electron temperature and density profiles of an NBI heated plasma in CHS. The maximum temperature and density are about 400 eV and \( 8.5 \times 10^{13} \text{ cm}^{-3} \), respectively. It is observed that the density profile is somewhat hollow while the temperature profile is nearly parabolic.

The Raman calibration has been applied to the CHS YAG Thomson scattering. However, it has been also found that some improvements are needed for more reliable and accurate electron density measurements.

Reference