VELOCITY MAP IMAGING OF DISSOCIATIVE ELECTRON ATTACHMENT TO OXYGEN (O_2) AND NITRIC OXIDE (NO)

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Velocity map imaging (VMI) has been one of the recent techniques developed for the study of photo-ionization, photo-dissociation and photo-detachment by measuring the two momentum components in the given plane of interest [1]. We successfully modified this technique for low energy electron collision experiments [2]. This technique can provide simultaneous data on kinetic energy and angular distribution in the entire 2π angles, including the forward and backward directions with respect to the electron beam. This has helped us in solving two long standing problems regarding the DEA to two simplest molecules namely O_2 and NO.

Resonances in e^- - O_2 collisions has been a subject of much discussion in relation to vibrational and electronic excitation by electron impact [3], dissociative electron attachment [4] and electron collisions on condensed and adsorbed molecules [5]. The DEA to O_2 is known to show only one broad resonance in the O^- channel arround 6.5eV electron energy. This resonance is assigned to the $^2\Pi_u$ negative ion state based on the angular distribution studies using the conventional technique [6]. But the $^4\Sigma_u^-$ state of O_2^- is known to be the dominant resonance contributing to the vibrational excitation of the ground state of molecular oxygen under electron impact, as a broad peak centered at 9 eV in the vibrational excitation functions [3, 7]. Excitation to very high lying vibrational levels, close to dissociation threshold of the ground state has been observed at these electron energies [7]. Considering this, it is expected that the resonance would have long enough lifetime to manifest in the DEA channel. Based on the selection rules for DEA, the clear cut evidence for the presence of the $^4\Sigma_u^-$ state is likely manifest in the backward and forward directions in this case. Our measurements in the entire 2π angles using the VMI provide conclusive evidence for the first time on the contribution from this state to the DEA process.

DEA to NO is known to form O^- ions with the cross section curve showing a broad peak in the 8 to 11 eV region [8]. There are three possible channels through which O^- could be formed:

$$NO + e^- \rightarrow NO^{-*} \rightarrow O^- + N\ (^4S) \quad \text{(Channel 1)}$$
$$\rightarrow O^- + N\ (^2D) \quad \text{(Channel 2)}$$
$$\rightarrow O^- + N\ (^2P) \quad \text{(Channel 3)}$$

The energy thresholds for these channels are 5.074 eV, 7.457 eV, and 8.650 eV respectively. There have been contradictory findings based on O^- kinetic energy measurements regarding the presence of these three channels in the DEA process. All the kinetic energy measurements carried out at 90 degrees to the electron beam direction showed that the first channel is absent and the process is dominated by the second channel, with one experiment pointing to the possibility of some contribution from the third channel [9, 10]. This is in contrast to the only measurements in the forward direction which showed the presence of all three channels, with the first channel being the most significant one [11, 12]. Our VMI data on DEA to NO show clearly distinct contributions from channels 2 and 3, in terms of both kinetic energy and angular distributions. The data also rule out the possibility of channel 1.

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