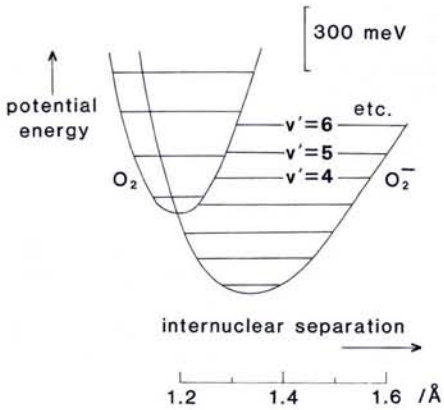


*Fig. 7 — Potential energy curves for $O_2$ and $O_2^-$. See discussion in text. Note that the v' = 0,1,2 and 3 states of $O_2^-$ are bound with respect to $O_2$. Curves are taken from Celotta R.J., Bennett R.A., Hall J.L., Siegel M.W. and Levine J., Phys. Rev. A **6** (1972) 631.*

beyond, implying that near head-on collisions play a dominant role in $e^-$-$O_2$ scattering. On this basis and using a theory of rotational excitation developed by Fiquet-Fayard (see [1]) it has been possible to model data such as those in Figs. 4, 5 and 6 fitting our observations with natural linewidths of the resonances of between 2 and 3 meV. Corresponding lifetimes are 0.2 to 0.3 ps which are of the order of 200-300 times the fly-by time mentioned above. Analyses have also shown that the resolution in the incident electron beam was ≅ 3.5 meV FWHM and that we had indeed succeeded in performing electron scattering at photon resolution, 0.2 Å (at 786 Å) in this case.

This still leaves the question of what underlying physical mechanism operates in rotational and vibrational excitation. Turning first to rotation, the strength of long range electrostatic interactions depends on molecular orientation and collisions give enough torque to the molecules to accelerate or decelerate their rate of rotation with high cross-section. We have been dealing with $O_2$ which attaches an electron to form (say) rotationally excited $O_2^-$ which a fraction of a picosecond later expels the electron to leave a rotationally excited $O_2$. Cross-sections for rotational excitation in $O_2$ are a few tenths of 1 $Å^2$. For molecules which possess a strong permanent dipole moment, *e.g.* HCl, HBr, an anisotropic charge-dipole interaction may lead to cross-sections of 10-100 $Å^2$ for rotationally inelastic scattering. Thus strong anisotropy of the e-molecule interaction potential leads to large cross-sections for rotational changes in the target accompanied by small changes in $J$ since these are dictated by the angular momentum available in the collision [7].

Vibrationally inelastic events take place through a quite different mechanism. In $O_2$ we have proposed that the electron briefly attaches through a shape resonance and the molecular negative ion being of longer bondlength than the parent, expands in size to suit. At some later moment, typically after 0.2-0.3 ps have elapsed, the ion autodetaches with a finite probability of leaving behind an $O_2$ molecule with a bondlength more suited to $v = 1$ than $v = 0$. Vibrational excitation results, accompanied of course by a more slowly departing electron, leaving with an energy depleted by one quantum of $O_2$ vibration plus any rotational contribution. In $O_2$ it so happens that the $v' = 6$ resonance (Figs. 5 and 6) leads nine times out of ten to a vibrationally elastic process; however $v' = 8$ for example (see Fig. 4) is 51% inelastic and actually includes a small contribution to the formation of $O_2$ ($v = 2$).

These data on $O_2$ begin to show in detail how energy is exchanged between low energy electrons and molecular gases. The mechanisms I have touched upon (with others such as nuclear excited Feshbach resonances which I have not had space to discuss) should determine the manner in which electrons make their way through natural or artificial plasmas and discharges giving rise as they do to important characteristic properties such as electron and molecular rotational temperatures. The ability to perform electron scattering at optical resolution provides a means by which the necessary data may be forthcoming.

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# Hewlett-Packard Europhysics Prize 1990

**Call for Nominations**

The Selection Committee for the Hewlett-Packard Europhysics Prize invites nominations for the 1990 award. The prize is given for an outstanding contribution to condensed matter physics within the previous five years, with the potential for leading to advances in the fields of electronic, electrical or materials engineering. Nominations may be submitted by EPS members as individuals or as representatives of a Division or Section.

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1986 – F. Mezei
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1988 – J.G. Bednorz and K.A. Müller
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***A.R. Mackintosh***