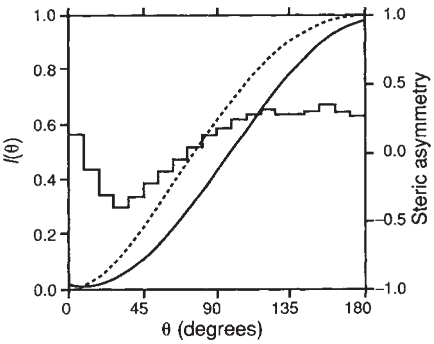

FIG. 2 Angular distribution of the measured (bold line) and predicted (stepped line) steric asymmetry and KI product intensity $I(\theta)$ (dashed line) for $CH_3I + K \rightarrow KI + CH_3$ as a function of the scattering angle θ for an incoming K velocity corresponding to a collision energy of 0.78 eV (ref. 8).

will occur, in which, owing to the deacceleration caused by reaching the top of the energy barrier, the negative end of the molecule will spend most of its time pointing towards the negative field electrode. Moreover the rotating molecule also experiences a torque which tends to bend the plane of rotation such that the negative end of the molecule will point away from the negative electrode.

Calculation of the remaining amount of orientation, ⟨cos γ⟩, is difficult because one needs to compute both the Stark effect and the eigenstates[11,12] for a large number of rotational states of known occupation. This calculation, which indeed leads to a near cancellation of orientational effects, was carried out by Loesch and Remscheid[6] for some simple molecules (KI, CH_3I and ICl) assumed to be cooled rotationally (T = 5–30 K) by expansion through a supersonic nozzle. Figure 1 shows the E/T values for which ⟨cos γ⟩ was calculated. With an accuracy of about ±20 per cent the results for small orientations can be expressed empirically as ⟨cos γ⟩ = 0.3x, which is about equal to the Boltzmann value.

Fortunately, the Bielefeld team was not discouraged by the weakness of the calculated alignment (⟨cos γ⟩ = 0.0063) for CH_3I (resulting from their conditions of T of about 31 K and E of 16 kV cm^{-1}), and continued their attempt to measure the steric effect for $K + CH_3I \rightarrow KI + CH_3$. Indeed their superb experimental technique permitted a direct measurement of the orientational effect upon the angular recoil of the KI product. Figure 2 shows that scattered intensity of the KI product $I(\theta)$ is peaked in the backscattering direction θ = 180°. In other words, the product is ejected preferentially in a direction opposite to that of the incoming K reactant. Interestingly, the steric asymmetry (the difference in reactivity when K approaches towards the I atom or towards the CH_3 group) mimics the shape of $I(\theta)$. It reaches its maximum value of 1 (I-end reacts only) for θ = 180° and its minimal value –1 for θ = 0° (CH_3-end reacts only). The measurements of Loesch and Remscheid suggest that the KI product is ejected along the direction of the incoming CH_3I axis. That this type of information cannot be obtained from other data is exemplified by the very different steric asymmetry predicted from calculations[8] using an empirical potential surface designed to account for all earlier observations[13].

The paper in this issue[1] addresses the complementary problem of controlling the field-induced orientation. Typically the rotational-state populations within a nozzle beam are only approximately thermal. Friedrich and Herschbach demonstrate on ICl (see Fig. 1) that laser-induced fluorescence can be used to detect the orientation induced by the electric field for a single rotational state. The observed field-induced violation of the standard selection rules of spectroscopic transitions provides a quantitative characterization of the reactant orientation achieved.

The Bielefeld and Harvard teams have already shown[6–8] that the scepticism about the possibility of producing oriented molecule beams with strong electric fields was misplaced. Although the net orientation that has been achieved is small (⟨cos γ⟩ of up to 0.01), appreciable improvements can be expected with lower temperatures or stronger fields (E/T up to 10, see Fig. 1). The demonstration of the practicability of molecular orientation for molecules other than symmetric tops now promises experimental insights into the mechanism not only of chemical reactions, but also of a growing number of other molecular collision processes for which the approach angle of the molecular axis is important. □

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1. Friedrich, B. & Herschbach, D. R. *Nature* **353,** 412–414 (1991).
2. Levine, R. D. & Bernstein, R. B. *Molecular Reaction Dynamics and Chemical Reactivity* (Oxford University Press, New York, 1987).
3. Kramer, K. H. & Bernstein, R. B. *J. chem. Phys.* **42,** 767–770 (1965).
4. Brooks, P. R. *Science* **193,** 11–16 (1976).
5. Stolte, S. in *Atomic and Molecular Beam Methods* (ed. Scoles, G.) Vol. 1, 631–652 (Oxford University Press, New York, 1988).
6. Loesch, H. J. & Remscheid, A. *J. chem. Phys.* **93,** 4779–4790 (1990).
7. Friedrich, B. & Herschbach, D. R. *Z. Phys.* D**18,** 153–161 (1991).
8. Loesch, J. J. & Remscheid, A. J. *J. phys. Chem.* (in the press).
9. Atkins, P. W. *Molecular Quantum Mechanics* (Oxford University Press, 1983).
10. Van Zijl, P. C. M., Ruessink, B. H., Bulthuis, J. & MacLean, C. *Accts chem. Res.* **17,** 172–182 (1984).
11. Von Meyenn, K. *Z. Phys.* **231,** 154–160 (1970).
12. Kryachko, E. S. & Yanovitskii, O. E. *Int. J. Quantum Chem.* **40,** 33–53 (1991).
13. Blais, N. C. & Bernstein, R. B. *J. chem. Phys.* **85,** 7030–7037 (1986).

DAEDALUS

Wings of the wind

LAST week Daedalus described the 'Ramcraft', a sea-going hovercraft whose air-cushion is pressurized by its own forward motion. Its hull is suspended inside a light, broad, parachute-like envelope whose forward facing 'mouth' scoops in the air. Its only contact with the water is the shaft carrying the propeller that drives it along.

Daedalus is now taking this elegant concept to its ultimate conclusion. His novel 'Windhover' is a wind-powered and wind-inflated hovercraft with no propeller at all. At first sight, this seems impossible. A sailing vessel exploits the differential motion between wind and sea. Deprived of water-contact, it would simply accelerate helplessly downwind until it reached wind-velocity; it would then feel no wind force, either of propulsion or lift. It needs a keel, both to define a direction of easy motion and to establish a load against which the force of the wind can usefully act.

But a light and speedy surface-skimmer like the Windhover would be fatally slowed by the viscous drag of a conventional keel. Daedalus plans to provide it instead with a line of thin disks mounted in good bearings. As the craft skims over the water, the disks project below it; each dips a little of its periphery into the water, and rotates freely in consequence. Thus its wetted surface is almost stationary with respect to the water, and imposes only a tiny fraction of the drag of a normal keel. More cunning still, each disk can also be pivoted vertically, like a rudder. As well as providing steering, this lets the craft twist at any angle to its direction of travel. It can even run fully sideways, with its disks lined up coaxially like those of a disk-harrow.

This subtle arrangement provides the Windhover with lift and thrust in any wind. By pivoting the disks, the whole craft can be rotated about its direction of travel. Thus the air-scoop of its over-arching envelope can be kept facing the wind, maintaining the air-cushion pressure which keeps the craft hovering. To provide thrust, secondary openings can be made in the envelope through which the trapped air emerges in jet fashion. The envelope thus redirects the wind, in much the same fashion as a conventional aerofoil sail.

In a lively wind, the interactions between lift and thrust and keel-force will be so complex and rapid that the Windhover will need elaborate computer-control. But it should then prove wonderfully fast and flexible, outpacing even the fastest yachts with its low drag and amazing turning capacity. Its wheel-like keel-disks will even enable it to make good progress over land. DAVID JONES