enhancer elements only when there is less than 1 kb of 5'-flanking sequence between the cap site and the SV40 repeats.

Tissue-specificity in the action of immunoglobulin gene enhancers may explain some earlier failures of expression in transfected cells. The complete mouse κ-gene construct of Queen and Baltimore is expressed only at low levels in mouse 3T3 fibroblasts. Similarly a different mouse κ gene was not expressed at all in mouse L cells under the control of its own promoter[14], and a mouse λ gene was expressed incorrectly in mouse fibroblasts and human or monkey cells[13]

There is considerable interest in knowing whether enhancers are common elements in eukaryotic genomes. Human papovavirus BKV 68-bp repeats that have been shown to enhance the chloramphenicol acetyltransferase (CAT) gene in HeLa cells were accordingly used as a probe to screen a human genomic library (N. Rosenthal and G. Khoury, NCI). A unique clone was isolated which had about 100 20–21-bp repeats in tandem, with a 'core' sequence similar to that of the BKV repeats. This human fragment was found to function as a low-level enhancer in the CAT assay (although it is not known whether it has any activity *in vivo*). It remains to be determined whether the BKV-related and immunoglobulin enhancers are rare elements in eukaryotic genomes, or represent families of related structures with common core elements but different flanking sequences responsible for tissue-specific gene expression of a large number of proteins.

In the meantime, the immunoglobulin gene enhancer has implications for the activation of cellular *myc* genes translocated to the immunoglobulin heavy-chain locus. In human tumours with such translocations, the c-*myc* gene seems to be orientated in the opposite transcriptional direction from the immunoglobulin genes. If c-*myc* activation were due to the immunoglobulin enhancer, clearly the orientation of the oncogene would not matter. □

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Space Shuttle

Spacecraft that glows in the night

from Michael J. Rycroft

THE Space Shuttle has very considerable potential for carrying large instruments into space. Many of the instruments will view the Earth, or the cosmos, in the visible and/or infrared (IR) parts of the electromagnetic spectrum. Since optical observations made above the atmosphere are not subject to absorption or scintillation (twinkling), which always limit the quality of observations made from Earth, it is expected that high-quality results should be obtained from the Space Shuttle. However, a recent discovery that the Space Shuttle itself glows may well limit the quality of observations made from this platform in space.

The stunning colour photograph on the front cover of the February 1983 issue of *Geophysical Research Letters* is a night-time view taken from the aft flight-deck window during the third Space Shuttle mission of March 1982. From an altitude of 240 km, the foreground is illuminated by the filament of an electron emitter which is used to investigate the potential of the Shuttle with respect to the potential of the surrounding ionospheric plasma. In the middle distance there is an orange or pinkish glow just off one side of the orbiter's tail, but not off the other. And in the background is seen a greenish band of airglow emitted from the limb of the Earth at an altitude of about 100 km over the southern polar regions, and many stars.

Not only has this glow been noted from the Space Shuttle, it has also been observed from rockets, NASA's Atmospheric Explorer-C and -E satellites, and in the laboratory. For the fourth Shuttle mission, a simple spectrographical experiment was devised to investigate the glow further, using a conventional camera equipped with an objective transmission grating, again viewing from the aft flight-deck window.

Five consecutive papers in *Geophysical Research Letters*[1–5] are devoted to a discussion of the properties, origin and consequences of the spacecraft glow. The glow radiation is emitted over a continuum, and not in discrete spectral lines, in the visible region of the spectrum, and is strongest at the longer wavelengths, particularly beyond 0.63 μm. It is strongest when the Shuttle is at low altitudes and, for altitudes above 160 km, the brightness decreases exponentially with increasing altitude and with a scale height of 35 ± 2 km; this is appropriate to atomic oxygen at a thermospheric temperature $\sim$ 600K. Thus it has been deduced that the glow arises from an interaction between the spacecraft and the ambient atmosphere. The brightness varies with the size of the spacecraft; for the Shuttle it could be as much as $\sim$ 100 kRayleighs.

The crucial property of the glow radiation is that it is strongest in the ram direction, that is in the direction of the spacecraft's velocity vector. Because the spacecraft is moving at a velocity of 8 km s^{-1}, it strikes ambient atmospheric oxygen atoms, providing each of them with an energy of 8×10^{-19} J, or 5 eV. Not yet investigated for the Shuttle, but observed for other space vehicles, is a small enhancement of radiation in the wake direction, antiparallel to the velocity vector.

The brightness of the glow is enhanced after the operation of the Shuttle's thrusters, small rocket engines which control the vehicle's orientation. As determined from star occultation, the radiation is emitted in a layer 5–10 cm thick just beyond the spacecraft surface. The interpretation is that after catalysis on the surface of the spacecraft, excited (or metastable) molecules are ejected. The dimensions of the glowing layer are consistent with a radiative lifetime of the emitting molecule of about 5 ms. Thus the emitter could be nitrogen dioxide or, more likely, hydroxyl formed by $O\,(^3P)^* + H_2O$ (adsorbed)$\rightarrow OH + OH$, the radiation being vibration–rotation bands in the Meinel system.

The results give cause for alarm. Any earth-viewing remote-sensing experiment, or any astronomical experiment, operating in the visible or IR aboard the Space Shuttle, may be subject to contamination from the Shuttle's glow. The effect places constraints on the viewing geometry of any low-light-level instrument carried aloft by the Space Shuttle. For example, on Spacelab 1, which is due to be launched on 30 September 1983, one experiment consists of an array of imaging spectrometers. Anticipating the effect, the location of this instrument on the payload was planned so that no part of the Shuttle surface was viewed. Operating from the ultraviolet to well into the IR, to 1.2 μm, this instrument is designed to study weak radiation from several atmospheric species. Although the main research programme will not be conducted when the instrument is viewing in the ram direction, a special study of the glow radiation will be conducted over the full wavelength range. Finally, this contaminating effect is worst at sunspot maximum, when the density of the Earth's upper atmosphere is greatest. □

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