From the methanogenic bacterium *M. thermoautotrophicum* it is possible to isolate a yellow, low molecular weight nickel-containing compound with an absorption maximum at 430 nm, hence named factor F_{430} (ref. 7). This factor has been found in every methanogenic bacterium so far examined[8]. The extinction coefficient at 430 nm is high, $\sim 23 \times 10^3$ per cm per mol Ni. The exact structure of this pigment has not yet been elucidated but there is evidence from the biosynthetic incorporation of δ-amino laevulinic acid that F_{430} is a nickel tetrapyrrole[14]. Chemical degradation products of F_{430} have appreciable absorption in the region 500–600 nm and react with cyanide. It has been suggested that the spectrum resembles that of vitamin B_{12} with, presumably, the implication that the nickel species is related to nirrin, the nickel analogue of corrin[1]. There is evidence of a mechanistic kind that the carbon monoxide oxidation in acetogenic bacteria may also involve a prosthetic group similar in structure in vitamin B_{12} but with nickel in place of cobalt[15]. There is a very recent report that the co-enzyme of the purified methyl reductase of *M. thermoautotrophicum* is F_{430}, with a stochiometry of 1 mol of nickel per mol of F_{430} and 2 mol of F_{430} per mol of methyl reductase[16].

Thus it is now clear that there are at least two new classes of nickel-containing enzymes: the nickel-containing hydrogenases and those with a nickel tetrapyrrole-related co-factor. Much work on their structural elucidation needs to be carried through. □

1. Thauer, R.K., Diekert, G. & Schonheit, P. *Trends biochem. Sci.* **11**, 304 (1980).
2. Dixon, N.E., Gazzola, C., Blakeley, R.L. & Zerner, B. *J. Am. chem. Soc.* **97**, 413 (1975).
3. Albracht, S.P.J., Graf, E.G. & Thauer, R.K. *FEBS Lett.* **140**, 311 (1982).
4. Legall, J. *et al. Biochim. biophys. Res. Commun.* **106**, 610 (1982).
5. Cammack, R., Patil, D., Afluire, R. & Htchikian, E.C. *FEBS Lett.* **142**, 289 (1982).
6. Drake, H.L., Hu, S.L. & Wood, H.G. *J. biol. Chem.* **255**, 7174 (1980).
7. Diekert, G., Klee, B. & Thauer, R.K. *Arch. Microbiol.* **124**, 103 (1980).
8. Whitman, W.B. & Wolfe, R.S. *Biochem. biophys. Res. Commun.* **92**, 1196 (1980).
9. Brooks, R.R., Morrison, R.S., Reeves, R.D., Dudley, T.R. & Akman, Y. *Proc. R. Soc.* **203**, 387 (1979).
10. Bartha, R. & Ordal, E.J. *J. Bact.* **89**, 1015 (1975).
11. Lancaster, J.R. Jr *FEBS Lett.* **115**, 285 (1980).
12. Bossu, F.P. & Margerum, D.W. *Inorg. Chem.* **16**, 1210 (1977).
13. Diekert, G.B. & Thauer, R.K. *FEMS Microbiol. Lett.* **7**, 187 (1980).
14. Diekert, G., Jaenchen, R. & Thauer, R.K. *FEBS Lett.* **199**, 118 (1980).
15. Diekert, G.B. & Thauer, R.K. *J. Bact.* **134**, 597 (1978).
16. Ellefson, W.L., Whitman, W.B. & Wolfe, K.S. *Proc. natn. Acad. Sci. U.S.A.* **79**, 3707 (1982).

Remote operation of telescopes

from Michael Penston

BRITISH astronomers have recently moved to the fore in several branches of optical astronomy, thanks largely to the building of new telescopes in favourable sites abroad — in particular the Anglo-Australian Telescope at Coonabarabran, New South Wales, and the UK Infrared Telescope (UKIRT) on Mauna Kea in Hawaii. Access to the telescopes has, not surprisingly, so far depended on the opportunities provided by air travel. Now, astronomers have begun discussing whether modern communications technology offers an alternative way of working. Early in June experts in communcations and computer technology came together with astronomers and builders of astronomical instruments at the Royal Greenwich Observatory (RGO) to discuss the feasibility of remote operation of telescopes*.

Remote operations of telescopes is possible and, indeed, has already been carried out in an experimental way by Kitt Peak National Observatory and UKIRT. The Kitt Peak 4 m and 2.1 m telescopes have been used by observers at the end of telephone lines both from nearby downtown Tucson and at distant sites in Michigan and the East Coast of the United States. Three lines were used — one for voice, one for TV pictures needed by the astronomer to identify his target star and one to run a remote terminal linked to the computer in the telescope dome. UKIRT is running a similar system which offers the major advantage of being able to diagnose and solve instrumental problems from sea level without suffering the problems of lack of oxygen at the Mauna Kea telescope site 14,000 feet higher up.

There is little difficulty in sending the acquisition images of star fields. Images with 10,000–20,000 pixels with 3–4 grey levels transmitted each 10–20 seconds are perfectly adequate as this update rate is used by current integrating TV systems on telescopes. These could pass down a standard 9.6 kbit line even without data compression. In fact, the Kitt Peak experiment had found a 30 second update rate to be satisfactory. On the other hand, present astronomical practises regarding weather monitoring and protection of the instruments from damage were not so easily compatible with remote operation. A better ways of determining whether the humidity is high enough to hazard the telescope mirror than the traditional test of 'whether the dome rail is wet' needs to be developed. A more professional approach would even benefit conventional observing with the observer present.

The financial benefits of remote observing are obvious, given rising air fares and falling communications costs. Advantages in flexibility might also be provided — the difficulties of scheduling simultaneous observations on different telescope and/or satellites might, for example, be eased. When some particularly demanding meteorological requirement is expected to be met for only a short time (for example, conditions dry enough to use an IR telescope in the 350 μm 'window') it would be easier to put a different observer on the telescope if he did not have to travel so far to exploit this short period. Efficiency would also be improved as astronomers would spend less time travelling and recovering from jet-lag.

There are individual problems in communicating from different sites as reports by Paul Bryant (Rutherford and Appleton Laboratories) and Peter Kirstein (University College London) showed a somewhat anarchic situation in the communications field. There are differences in computer-to-computer communication protocols, in line tariffs and in regulations from country to country so that the best solution at one observatory might not apply at another. Obviously, however, common requirements exist and common solutions and standards are highly desirable as participants, looking ahead, foresaw a network for remote operation of telescopes linking Australia, Hawaii, Chile, continental United States, the Canary Islands and Europe. One solution to the present problem was to separate the difficulties of communication and control, defining interfaces between these segments only. Thus cheap entry to the field could be obtained with use of dial-up telephone lines, as at present, and when wide band lines or public packet switching networks become cheaper it would be possible to change to them with minimum distruption. The eventual use of wide-band 50 kbit lines was foreseen since that would allow near-real-time transmission of astronomical data from the telescope to the site of remote operations. In the meantime it seems most practical to progress using two to three dedicated telephone lines.

At the end of the meeting Alec Boksenberg, Director of the RGO, undertook to have remote operation from Herstmonceux of the 2.5 m Isaac Newton and 1.0 m telescopes on La Palma working by the end of next year. Obviously at this pace, the sky is the limit in the remote operations field. □

*The two-day workshop on 'Remote operation of telescopes' was held at Herstmonceaux Castle, home of the Royal Greenwich Observatory. Participants included representatives from UKIRT, Kitt Peak National Observatory, the European Southern Observatory and the European Space Agency as well as British astronomers and experts in computer networking.

Michael Penston is at the Royal Greenwich Observatory, Herstmonceaux Castle, Hailsham, East Sussex BN27 1RP.

0028-0836/82/320603-01$01.00

© 1982 Macmillan Journals Ltd