from the problems of correction feedback and isoplanatic angle, is formidable to say the least.

For these reasons, search for and investigation of *optimum sites* will continue at an accelerated pace: the most effective adaptive optics is a site where nature has taken as much of the load from us as possible. A further revolution has taken place here, in the scientific understanding of atmospheric optics and the means for proper evaluation of the seeing of sites.

Apart from its intrinsic advantages (see "optical efficiency" below), optimized image quality at optimum sites brings rich advantages in instrument development. The "matching problem" of instrument slit size to pixels has meant that instruments become bigger and more difficult the larger the telescope aperture for a given angular image size of a star. This dilemma is expressed by Bowen's Spectrograph Law:

$$b = S \cdot \frac{Y_1}{206265} \cdot \frac{f_{CAM}}{Y_g} = S \cdot \frac{D_1}{206265} (f/no)_{CAM}$$

in which

b =	width of the slit image on the detector
S =	image size of a star in arcsec at the slit
y_1 =	radius of the telescope entrance pupil (normally, the primary mirror)
y_g =	semi-height of the spectrograph grating
f_{CAM} =	focal length of the spectrograph camera
D_1 =	diameter of the telescope entrance pupil (normally, the primary mirror)
$(f/no)_{CAM}$ =	f/number of the spectrograph camera

Clearly, the smaller the value of the image S, the larger can be the f/no of the spectrograph or the smaller the corresponding value of y_g, determining the size of the grating. High quality imaging benefits all modes of observation, not just direct imaging.

Mounting

The alt-az mounting has returned as the standard because of the revolution in 2-axis tracking. But other forms, perhaps above all various forms of spherical mount, will certainly be further developed in the new century. The domination of the alt-az may have a much shorter life than that of the equatorial. It will be seen, too, whether non-rotational forms of mounting are technically feasible or not. Tracking will be the determinant requirement. Better image quality requires better tracking. In the NTT with its alt-az mount, it is already clear that the tracking requirement (combined with field rotation compensation) is the hardest technical specification to fill.

Buildings

The trend away from the conventional dome is clear. Cost is not in its favour, but *control of the conditions of the local air* will be the dominant reason for choosing other forms which are also favoured by the alt-az mount. The revolution here was made by the building of the MMT. Apart from external seeing, the local air will be the decisive influential factor in the final optical quality until adaptive optics is available in a general form.

The optimum size of a telescope: optical efficiency

The classical formula for the optical efficiency of a telescope has been known implicitly ever since photography was introduced into observation about 1850:

$$E = k \left(\frac{D}{d}\right)^2$$

where
E = the optical efficiency
D = diameter of the telescope pupil (normally the primary)
d = image diameter of a star
k = transmissivity

Although this formula is simplistic and only really valid assuming adequate pixel sampling and photon-limited observation in certain regimes, its general validity is proven every night by the integration times used at the NTT. More sophisticated criteria are under investigation for the VLT. A general formula reflecting all different observing conditions, above all background limited, would certainly be more complex. Even if the formula above is accepted only as a rough general approximation, its conclusions are striking: if D is doubled, but d is also doubled, there is no gain in efficiency, but a tremendous amount of money and effort has been wasted: huge "light buckets" of low optical quality are not the path of the future.

After the year 2000, the struggle for bigger size will only give higher efficiency if the conditions of the local air can be adequately controlled or compensated by adaptive optics. These factors will dominate the development scene and determine what the optimum (or maximum) size can be. My colleague Richard West mentioned *cost-effectiveness* yesterday. I should like to take this up and emphasize it. The most *cost-effective* telescope (with instrumentation and detector) is the best for a given observation and size is only one of the parameters involved. The astronomical community will have to think increasingly in these terms to make the best use of its resources. Reduction of d may well be more efficient than increase of D.

It may take 50 years or more to "digest" the size range 10-20 m. Until adaptive optics is available in a fairly complete form (wavelength band, frequency band, reasonable field) the optimum size may be < 20 m or even < 10 m.

2. Space Telescopes

In the absence of an atmosphere, the specification of space telescopes is far simpler than for ground-based tele-

"Tours du Monde, Tours du Ciel"

"Around the world, around the sky" is the title of what is probably the most comprehensive documentary film about astronomy ever made. It was produced by a team of French specialists, headed by Robert Pansard Besson and supported by Pierre Léna and Michel Serres (see also the *Messenger* No. 48, page 33).

During more than three years, Mr. Pansard Besson and his crew travelled to all major observatories in the world, ancient as well as modern. The European Southern Observatory provided support during their visit to Chile and the film includes scenes from La Silla, Paranal and Garching. Many other observatories, also in the ESO member states, are shown and astronomers from all over the world have provided live commentary to various passages in the film.

The film is divided into ten "travels" in time and space: (1) The beginning (160,000 years ago); (2) Around the year 0; (3) From the other end of the world (from –500 to 1000); (4) Around the world, around the sky (1000–1600); (5) Venice, Beijing, Paris (1600–1676); (6) East, West (1642–1743); (7) The starry messenger: the light (1743–1880); (8) The visible and the invisible (1880–1950); (9) Towards the giant mirrors (1950–1970); (10) The light and other messengers (1970–1990). Each part lasts slightly less than one hour. The total playing time is therefore almost 10 hours.

The film is distributed on video cassettes (Pal, Secam, NTSC) from: HATIER, 8, rue d'Assas, F-75006 Paris, France (Tel: 49.54.49.54; Fax: 40.49.00.45). It is available with French commentary, and soon also in English.