DISCUSSION: SECTION I

Discussions on contributed papers took place after each presentation and at the final session of each day. They have been compiled here into separate units for each of Sections I-IV. Underlined names in italics denote participants who put questions or made recorded comments; the author or authors for whom a question is intended are shown in parentheses where appropriate. Replies are indicated with the speaker's name underlined in Elite typeface.

Brown (to Beckers): At the start of your paper you mentioned the intention of reducing the MMT telescope natural frequency in the future. How will this be done?

Beckers: At the moment, the natural frequency of the azimuth drive is determined by the spring constant of the motor-gearbox drive. We plan to add another two motor-gearbox drives to the two already existing. In addition to symmetrizing the azimuth drive configuration this will also increase the resonance frequency.

Wlérick: Comment corrige-t-on la rotation du champ?

Beckers: Correction for field rotation on the MMT is accomplished by a mechanical de-rotator which is controlled by the same computer which controls pointing and tracking. The instrument is mounted on this derotator. Sometimes, however, one does not want to correct for field rotation, as in the case of spectroscopy where the slit should be vertical.

Wlérick: Est-ce que l'on fait des photographies en utilisant simultanément les 6 miroirs?

Beckers: The MMT does not have photographic facilities. All imaging is done with electronic cameras, either intensified TV systems or CCD arrays. We do indeed use the individual telescopes simultaneously, sometimes with the images superposed but sometimes with the images separated on purpose. In the latter case we then combine the images later using a computer.

Maillard: What limiting magnitude is expected for the star image used for keeping the mirrors aligned?

Beckers: With the focal-plane viewing digital TV system it will be possible to use 17-18th magnitude stars for co-alignment. However, that will require some temporal integration so that rapid co-alignment will not be possible. For rapid (5-10Hz) co-alignment we will have to use 14-15th magnitude stars.

Beckers (to Lelièvre): The good seeing at CFHT which you reported, is it average or does it represent the best conditions?

C. M. Humphries (ed.), Instrumentation for Astronomy with Large Optical Telescopes, 99–106.

Lelièvre: Not many plates have been completely and carefully measured yet. However, about 100 plates with short and long exposures were taken over a period of 7 nights by J.L. Nieto and myself. 20 of these (of M87) have been reduced carefully, with calibration etc., in order to measure the FWHM image quality, and gave the following results:

FWHM (arcsec)	No. of plates
<0.7	1
<0.8	5
<0.9	7
<1.0	14
<1.1	18
<1.2	20

These plates were selected on scientific content, not *a priori* quality. Images greater than 2 arcsec are quite rare and generally occur with very high altitude, jet-stream winds.

Richardson: Do you think one reason that the seeing quality is so well preserved by CFHT is that the telescope mounting is of the Palomar type which enables the mirror to be located directly above a cooled floor, as compared to other designs in which the mirror is located over the mounting itself?

Lelièvre: The sealing of the observing floor from warm air below and the insulation of the dome are also important.

Rylov: Atmospheric conditions and temperature stability on Mauna Kea are very good but how effectively do observers and operators work at such an altitude?

Lelièvre: The reduced supply of oxygen at the summit makes one aware of the altitude, of course: headaches during the first day, breathing problems during physical effort, intellectual difficulties, etc. Visiting astronomers at CHFT are requested to arrive in Hawaii at least 3 days before they are due to start their observations so that they can acclimatize. Most persons can then function adequately, serious discomfort is extremely rare. Resident astronomers, telescope operators and day crew travel frequently to the summit and get some degree of permanent acclimatization. Normal day-work at the summit is done on a 4-day shift basis. Sleeping accommodation and meals are provided at the mid-level camp (altitude 2800m).

Shcheglov: What is the limiting magnitude of the plate which you showed and what was the S/N?

Lelièvre: The photograph of Abell 2670 was taken by Laird Thompson at the prime focus with the wide field corrector. The exposure time was 2h 15min on baked IIIaJ with a GG 385 filter. A folded PDS intensity scan gave a 0.5" FWHM with a strong 0.4" core. Limiting magnitude is higher than 25. Abell 2670 is the nearest, richness class III cluster and its redshift is 0.078.

Tokovinin (to Barnes): Will the mirror support system for the new Texas telescope be passive or active?

Barnes: It will be active.

Brown: Have any diffraction based calculations of the light distribution in the images been made? There are considerable dangers in accepting the geometrical data from spot diagrams, particularly where the surface errors are periodic and of fairly high frequency.

Barnes: No. We are using the ray tracing method to examine the consequences of mirror thickness, material, thermal environment, wind, and support system on the image quality. Once we have settled on what appears to be the most acceptable configuration, we will then look at the possibility of checking it by diffraction based calculations.

Murdin (to Gajur): If your polar-viewing telescope looked to the zenith it would sample a range of galactic co-ordinates and give information on galactic structure.

Gajur: Such a system was studied but due to the short exposure times which would result, the mirror wouldn't be used efficiently.

Wlérick: Vous pourriez avoir un champ de 1^{o} avec un correcteur de champ semblable à celui du télescope C.F.H.

Gajur: Thank you for the information.

Richardson: Where will the telescope be located?

Gajur: Here at the Special Astrophysical Observatory.

Steshenko (to Murdin): Why don't you slice your existing 4.2m primary mirror into 3 thin mirrors of this diameter?

Murdin: We considered this but judged the risk too high in relation to the benefit.

Brown: I should like to point out that the optical specification for the 4.2m primary of the Herschel telescope is intended to optimise performance in very good seeing. The most technically demanding requirement is for extreme smoothness of the surface. For points on the mirror with lateral separation 2cm the difference in wavefront height is required to be less than $\lambda/50$ rms with a target of $\lambda/60$ or better.

Shcheglov: The seeing distributions you mentioned were based on the Walker and McInnes measurements, you said. Have you been able to make

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any other measurements? Also how large was the cost reduction obtained by re-tailoring the dome?

Murdin: Polaris trail measurements have been correlated with micro-thermal measurements and we will proceed further when telescopes are erected on the site. The total gain by the Tiger Team amounted to nearly half the original forecasted cost.

Rylov: Don't you think that the secondary foci of large altazimuth telescopes (Nasmyth type focus) need closed rooms instead of open balconies? These foci can then have advantages similar to those of coudé foci. For the 6m telescope secondary foci, we shall be building such closed rooms.

Murdin: I discussed this point with Professor Boyarchuk earlier this year. Since the Special Astrophysical Observatory is the only one with experience in this respect, we will learn from your efforts.

Richardson: Is the spectrograph which you described restricted to use at only one dispersion?

Murdin: Yes. This is a low dispersion spectrograph optimised for sky-limited faint objects.

Picat: What is the size of the camera mirror? I was wondering about the size of the CCD equipment.

Murdin: Cooling of the CCD in the spectrograph camera is a problem which we recognise but we have not finalised the details.

Brown (to Richardson): Are there any polarisation effects from your high-efficiency coatings at the angles required?

Richardson: Yes. An all-dielectric reflective coating can completely depolarize the incident light. On the other hand, a metal-based coating, such as the silver-based "red" coating used at DAO (which is also very efficient in the blue-green region) preserves the incident polarzation to a high degree. Bora (Univ. of Laval, Quebec) who used these mirrors with the radial velocity spectrometer at the 1.2m telescope of DAO to measure stellar polarization (not radial velocity), was able to measure polarization weaker by an order of magnitude than had been achieved previously. With that system the high reflectance mirrors (with enhanced silver coatings) exhibit polarization which is much less than that of ordinary aluminium mirrors.

Humphries: Defocussing the Cassegrain secondary will introduce aberrations which would otherwise be absent. How serious are these?

Richardson: This spherical aberration is removed by the re-imaging lenses.

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<u>*Rylov*</u> (to Courtès et al.; Use of Large Telescopes in High Focal Ratio Mode): What are the specific advantages of the focal reducer you described?

<u>Boulesteix</u>: The main advantage is the gain of about 16 in exposure time and a very large aberration-free field, together with rational use of the interference filters in the focal plane of the telescope. In the M33 hydrogen emission, the 3 hour exposure at f/1 would otherwise be extended to an impossible 50 hours! New detectors will not improve this situation because nobody has one 15cm in diameter.

<u>*Rylov:*</u> The gain cannot equal $(f_{prime}/f_{reduced})^2$ because scattering in the emulsion decreases the gain not only for point sources but also for extended sources.

<u>Boulesteix</u>: The scattering effect with relatively large images, even at f/1, is not very severe and anyway, in deciding to use a focal reducer one opts for the ability to obtain new results on very faint extended monochromatic sources.

<u>*Wlérick*</u> (to Courtès et al., A Coronographic Mode ...): What was the diameter of the occulting disk in the case of the observations of Saturn?

<u>Boulesteix</u>: The coronographic mask, initially designed to exceed slightly the diameter of Saturn, turned out to be insufficient because of poor seeing and we were compelled to use a much larger spare mask whose diameter corresponded to 2.6 Saturn diameters. The planet was generally not centred on the mask so as to uncover as much as possible of the east and west sides alternately. In spite of these precautions, a strong halo of atmospheric origin still remained on all our plates.

<u>*Courtès*</u> (communicated comment): For a study of the solar Lymanα corona I built a reflecting coronograph which could be used for stellar observations. It is a Gregorian design and this has two advantages: (1) a real image is formed before the light reaches the secondary mirror. This image can be intercepted by an occulting disk; (2) if properly designed, an image of the secondary holding spider can be formed by the primary onto the secondary itself where its diffracted light can be intercepted by a mask.

<u>*Brown*</u> (to Rösch): Do you think any further improvement will be obtained by the use of a window on the 2m dome and do you expect to proceed with this solution?

<u>Rösch</u>: The answer largely depends upon the results we shall obtain with the present design, and how much they could be convincing for financial and technical support of the next step, or at least a full study of it.

<u>*Boulesteix:*</u> Couldn't a single large plate be substituted by a mosaic of smaller ones?

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Rösch: Only if all the elements of the mosaic produced the same phase difference, to the required fraction of a wavelength.

Angel: Is the thin plastic advertized in Sky and Telescope of any use?

Rösch: I doubt it very much. If, for mechanical reasons, this plastic is something like mylar, we can expect, from our experience, variations in optical thickness of several λ over a few square centimeters of a 6μm sheet.

Angel: As pointed by N. Woolf, adiabatic turbulence alone is of no consequence for seeing degradation. Temperature differences such as the radiative dome cooling mentioned by Beckers are needed with the air flow. Good results would be obtained in a dome of arbitrary shape if it were radiatively isolated (silvered) and insulated.

Rösch: It is well known that adiabatic turbulence in itself does not introduce deleterious temperature fluctuations. But the turbulent flow may cause a mixing with air masses at different temperatures; for instance, the flow around the dome may suck out warm air through the dome aperture. Indeed, we once observed that while the stellar images were very sharp in the eyepiece of a 60cm refractor under a conventional dome, with the wind blowing from the opposite direction, the image suddenly "exploded" every time we heard a wind gust striking the dome behind us.

Beckers (to Brown): Where does the seeing at the UK Infrared Telescope originate, inside and near the telescope and dome, or outside?

Brown: At the time the observations were made, about two thirds of the image deterioration was due to external turbulence. Dome turbulence and telescope errors were about equal and accounted for the other one third. This was without any significant contribution from astronomers and their instrumentation in the dome.

Shcheglov: Have you made measurements of r_o at Mauna Kea?

Brown: In the limited time available only a few measurements were made. For most of the time a value r_o = 12.8cm at λ 0.61μm for combined external and dome seeing is typical. The results are in good agreement with the earlier work of Dainty and Scaddan.

Tokovinin: We have developed a coherence interferometer for the measurement of atmospheric coherence length and used it in Crimea for three years. Each year about 100 measurements were obtained. The mean value is about 7cm and differs remarkably little from other sites.

Roddier: I would like to mention that two-dimensional MTF's can be obtained experimentally with a rotation shearing interferometer.

Brown: The rotational shear method is very useful for obtaining 2-dimensional atmospheric MTF data. To separate the effects of external and dome turbulence, it is necessary to have an interferometer from which the wavefront errors from both long and short exposures can be reconstructed by simple reduction procedures. I prefer linear shear for this purpose.

GENERAL DISCUSSION RELATING TO SUBJECT MATTER OF SECTION I

Raouf: I would like to describe very briefly the plans which are being made to establish the Iraqi National Astronomical Observatory (INAO). Iraq is currently experiencing a rapid cultural, scientific and technical renaissance, and astronomy is a natural focus for the country's pride in the past achievements of the civilizations which have flourished in Iraq. The current plans of the Astronomy and Space Research Center (ASRC) include building a major astronomical observatory to work in the optical, IR and radio regions of the spectrum.

The core of the optical facility will be a 3.5m telescope together with a 1.25m telescope designed for efficient performance in the IR, (but also with good optical performance). These telescopes will be equipped with instruments for photographic, photometric and spectroscopic observations. The facility will also include a number of smaller telescopes for student research and training purposes. A 30m dish is to be built for millimetre/radio observations.

The ASRC has already selected an excellent observing site in the northern mountains of Iraq which has good seeing and clear, dark skies. The site selection was made with the collaboration of several leading astronomers and observatories from various countries and the ASRC anticipates further international co-operation in its future activities.

Brown: When do you expect the telescopes to become operational?

Raouf: We expect the 1.25m telescope to be operational in the summer of 1985 and the 3.5m telescope to follow a year later.

Beckers: There are many plans for large optical astronomical telescopes, all of which are general purpose telescopes and all of which will be oversubscribed once built. I suggest that there is another way to construct telescopes, by building special purpose telescopes. These will still be oversubscribed when finished but will be more economical in the sense of giving the same total power for less money, or more power for the same money. A telescope optimized for speckle observations, for example, needs only a small field of view and can afford to have relatively poor tracking because of the short exposure time. A meridian-only pointing telescope with a CCD array sky tracking option can be used for imaging and probably objective prism spectroscopy. There are probably many other examples where specialised designs could be usefully pursued.

Humphries: The importance of measuring and describing image quality in quantitative terms should once again be emphasised, particularly at this meeting where we are comparing efficiencies of different systems. Visual estimates of image size from a photographic plate or a video screen simply will not do since these are invariably underestimated, often by large amounts.

Shcheglov: I think I would be expressing the general opinion if I say that visual image quality estimates should not be used. We have made a comparison at Sternberg Institute and found a strong (2-3 times) discrepancy between visual image diameter estimates at our 1.25m telescope and photoelectric measurements of D_{80} (diameter of circular diaphragm transmitting 80% of the incident light). Similar results were found by Hoag for the 91cm KPNO coudé feed. And so, I argue that the photoelectric D_{80}, or D_{50} (=FWHM), should be used if the distribution of light in the stellar image is verified to be Gaussian.

I was also pleased with the results of the British group in the Canary Islands who referred to the possibility of lowering the telescope's tower to a height of 10 metres. We also (Gur'yanov, my postgraduate student) made measurements in Central Asia at 3 mountain tops at altitudes 2000-2500m. He found that during the night, the air layer 5-30m high does not decrease the image quality of a telescope substantially and so I think that the British figure could even be lowered a little, to $\sim$5 metres above ground.

Wlérick: Il est facile de mesurer objectivement la qualité des images quand on dispose de clichés électronographiques grâce à la caractéristique linéaire "éclairement - densité optique", une coupe diamétrale effectuée avec un microdensitomètre donne directement le profil photométrique de l'étoile. Nous avons constaté qu'avec des miroirs fraichement aluminé ce profil est pratiquement gaussien. On peut alors caractériser la qualité des images par un paramètre: mon équipe utilise la largeur à mi-hauteur du profil photométrique comme paramètre caractéristique. Nous avons mesuré ainsi beaucoup de clichés obtenus à l'OHP et un certain nombre de clichés obtenus à l'ESO. Pour une durée de pose supérieure à une heure, nous trouvons:

OHP	meilleure image	d = 1,05"
	plus mauvaise image (mistral)	d = 4,5"
ESO	meilleure image	d = 1,0"

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