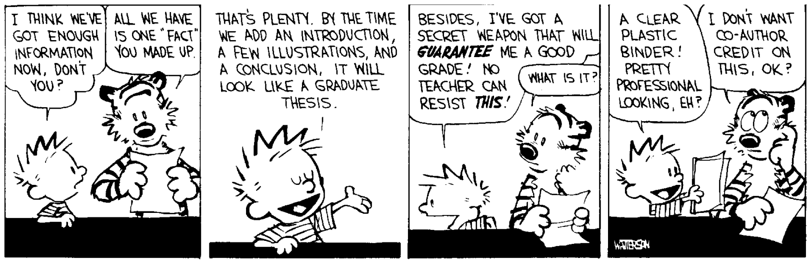
6. Conclusion



Outline

This chapter brings together the conclusions from each chapter and describes the current status of the COAST infrared project. Some suggestions for improvements and future directions are included.

6.1 Status

The COAST project has proved that the concept of optical interferometry with arrays of small telescopes is practical and technically possible. The telescope has recently produced its first map, an image of the binary star α Aur (Cappella) with a resolution of 20 milli-arcsecond.

At the end of this project the COAST telescope is almost complete. The infrared system is capable of making astronomical observations in the 'J' and 'H' bands with modifications for the 'K' band possible. The telescope is operational and able to measure fringes on astronomical targets routinely. Although the infrared system is not aligned perfectly, the experience with the visible system suggests that only a little extra effort is required.

The camera built for COAST has performed well. The aim of building a system based on visible CCD camera technology and the techniques has been proved. In particular this route has produced an infrared camera with exceptionally good read noise.

6.2 Improvements to COAST

The COAST infrared system can potentially produce a great deal of astronomical data. Although in its current state it achieves most of the design aims there are a number of improvements and additions which can be made. These are listed below in decreasing order of practicality.

6.2.1 Enhanced Optical Coatings

Now that the design of the infrared system has been proved to work, a number of components can be replaced with items optimised for the infrared. The most obvious of these are the windows at the entrance to the optics lab which have an anti-reflection coating optimised for visible wavelengths and so absorb a large proportion of the infrared light. In addition to this the camera lens and dewar window can be given anti-reflection coatings which will reduce the flux losses from these components by around 25%. These anti-reflection coatings have already been designed and tested on the beam-splitter compensating plates. The anti-reflection coatings will almost eliminate the flux losses in the transmission components and so this would double the flux reaching the detector.

6.2.2 Fringe tracking

At short baselines the position of the path compensation trolleys can be easily calculated from the co-ordinates of the star and the geometry of the baseline. At longer baselines the extra atmospheric path introduces an uncertainty in the position of the fringe envelope which is larger than the coherence length. In this case the fringe visibility would drop as the light from different telescopes moved out of phase.

To obtain high visibility fringes continually, it is necessary to track the movement of the fringe envelope and correct for any extra atmospheric path. This would be done the controlling system continually receiving measurements of the fringe visibility in real-time and responding to a drop in visibility by moving the path compensation trolleys. Unfortunately it is not possible from just a change in visibility to know in which direction to apply the correction. However if the system observed simultaneously at several wavelengths then by monitoring if the visibility dropped more quickly at shorter or longer wavelengths the servo loop can be closed. The possibility and advantages of multi-wavelength operation is described below.

6.2.3 Multi-wavelength observing

It may be possible to extend the infrared system to simultaneously observe at a number of different wavelengths. All the components in the telescope and path compensation system are achromatic. The beam-splitters were also designed to operate at all infrared wavelengths. The output of the correlator is four parallel beams containing all the light from the telescopes, modulated into a fringe pattern. It is only the filter in the camera which selects which of the wavelengths in these beams actually reaches the detector.

In the visible system a multi-wavelength approach has been suggested largely in an attempt to improve the light gathering efficiency. Since the visible system observes in narrow bands, typically 10 nm, a large fraction of the light is wasted. If the outputs of the beam combiner were dispersed into a spectrum then each 10 nm width of this spectrum could be imaged onto a separate detector. In the infrared case it would be simplest to disperse each beam into only two pixels giving two wavelength channels in each infrared band. This could be achieved with a thin prism placed after the camera lens and would require no changes to the dewar. There is a reduction in the signal to noise since only half the light is detected by each pixel, but the read noise remains the same. However for bright objects this would be acceptable. The case of two wavelength channels in the same infrared band is easily possible. An alternative scheme could be to disperse the entire infrared region so that the J and H bands fell into single pixels with the atmospheric water band between them. This would remove the need for the infrared band selecting filters, but a cooled short-pass filter would be needed to prevent the thermal background at longer wavelengths from reaching the detector.

6.2.4 K band operation

The current prototype camera cannot be used for observations with COAST at the longest near infrared wavelength , K band = 2.2μm. The simple dewar arrangement allows too much of the thermal background emission, from the instrument and building, to reach the detector. To avoid this background signal each pixel must be allowed to only ‘see’ the beam of light from the correlator or cold components inside the dewar. The simplest solution to this problem is to extend the front of the dewar so that there is a cold field stop at the position of the camera lens. Although the majority of the detector elements would still receive a signal from the background, the four pixels used by the instrument could only receive light from the output beams of the beam combiner.

The original reason for considering a 'K' band system was the expected improvement in the observations of fainter objects. The improved atmospheric conditions at longer wavelengths should allow larger telescopes and wider bandwidths to be used. However in COAST the fixed size of the telescope means that there is little improvement in limiting magnitude when moving to the longer wavelengths. Although a wider observing bandwidth should be possible from purely atmospheric considerations, the thermal background emission at longer wavelengths means that a narrower filter must be used.

6.2.5 Larger mirrors

As described in chapter 1, a major reason for working in the infrared is the improved atmospheric conditions. The most significant effect of this is the ability to use much larger aperture telescopes while achieving the same level of wavefront perturbations. Table 4.2 in chapter 4 shows the size of possible telescope for each band if apertures 2.8 r_0 were used. Observing in the K band would allow telescopes of 1.5m aperture to be used, giving 14 times the collecting area of the 0.4m telescopes used currently at COAST.

The COAST telescope primary mirrors could be replaced with larger apertures, since they are fixed and do not need to be supported under a varying load. The only difficulty with increasing the mirror size is the cost. The siderostat mirrors are more difficult. It would be probably be impossible to use large conventional glass mirrors with the current mount design. New technologies being developed for space applications such as composite or thin metal mirrors could offer a solution.

6.2.6 Better site

Although COAST is designed to avoid the atmospheric seeing which limits the resolution of conventional telescopes it is not totally immune to atmospheric affects. The size of the telescope apertures and the length of the exposures are directly linked to the stability of the atmosphere. By moving to a good astronomical site COAST will be able to make use of larger mirrors, particularly at shorter visible wavelengths, and so will be able to observe fainter objects. Unfortunately most good astronomical sites are on mountain tops which lack the large flat areas needed to build an interferometer.