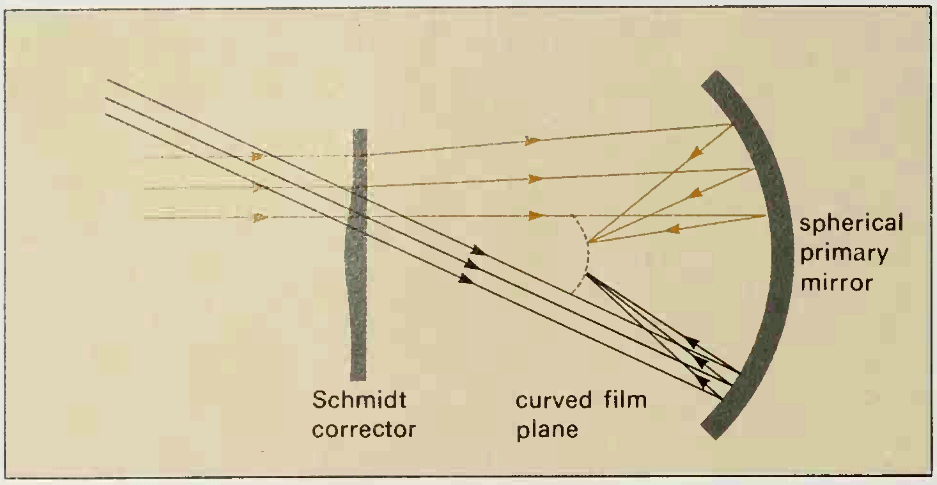
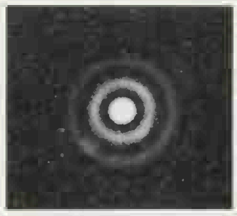


Fig. 9·5
The optical layout of a Schmidt telescope. The 'wavy' surface of the Schmidt corrector is exaggerated here for the sake of clarity.



The spurious disc formed by light in a telescope. This out-of-focus image shows the rings caused by interference of the light waves as they approach the focus.

resolve or pick out fine detail is directly proportional to its aperture, a 2-m reflector having twice the **resolving power** of a 1-m instrument. However, a new approach has been taken in a multiple mirror telescope (MMT) completed at Mount Hopkins, Arizona in 1978. Here a battery of six 1·8 m reflectors are mounted together round a 0·76-m reflector which acts as a guide telescope. The light from the 1·8-m reflectors is fed to the same focus, and the resolution of the six apertures is equivalent to that of a 4·47-m telescope, but it is far easier optically to construct than a 4·47-m instrument would be and only about a third of the cost.

A number of other similar telescopes to the MMT are under construction or being designed, none of which would be feasible without modern computer techniques to maintain the correct degree of alignment of the complicated optical paths. Computers are also essential for the next generation of telescopes now being planned, where to achieve large apertures without massive structural engineering problems, designers are turning to the idea of tesselated reflecting surfaces – that is, surfaces composed of many separate elements, like the tiles on a floor. Such a reflecting surface can be made very thin and light, but all the individual mirror elements must be capable of precise adjustment to provide the necessary optical alignment. Moreover, as the telescope turns to follow objects across the sky, compensation has to be made for the changes in shape due to the whole mirror's alteration in position and gravitational loading. Only with computer control has such sophistication become possible.

Interferometers

The resolution that one can obtain theoretically – 0·16 arc sec. with the MMT – is never realized in practice from Earth-based telescopes. This is because the Earth's atmosphere is never still; turbulence breaks up an image, with the result that the most probable resolution for the MMT is 0·7 arc sec., equivalent to a 0·17-m telescope outside the atmosphere, not a 4·47-m one. If one wishes to measure stellar diameters or resolve very close binary stars, one requires a resolution of 0·03 arc sec. or better and the problem would appear insoluble, for even the 5-m (200-inch) reflector at Palomar only has a practical resolving power of rather more than 1 arc sec. Yet there is a solution, and this is to make use of interferometry, a technique well-known to radioastronomers as we shall see later.

Interferometry is based on the fact that light is a wave disturbance. When waves from a bright point source are brought to a focus in a telescope, although the waves from different parts of the lens are brought together at a point, the routes by which they travel to the focus are not the same. Thus a ray from near the rim of a lens will have further to go than one passing straight through the centre of the lens. In consequence the crests and troughs of the light waves will not be in step or **in phase** with one another. When they meet at the focus they will interfere: where crest meets crest they will reinforce each other to give a bright image; where crest meets trough, they will cancel out and there will be darkness. This is why a highly magnified star image never appears as a point of light but as a false or **spurious disc**, bright in the centre and dimmer towards the edge, and surrounded by alternate dark and bright rings.

The phenomenon of the spurious disc can be made use of if we turn the telescope into an interferometer. To do this the incoming light is separated into two components, and then the two beams are made to interfere. The spurious disc is then seen to be crossed by alternate light and dark bands. This technique, first used on the 2·5-m (100-inch) reflector at Mount Wilson in the 1920s has recently been developed by Hanbury Brown who, with Richard Twiss, worked out the theory of the **intensity interferometer.** Essentially this consists of two large mirrors, each 6·5 m diameter, but composed of 252 small hexagonal mirrors fitted together, and mounted on a special railroad track. These mirrors, whose separation may be altered and can be as great as 188 m – almost twenty-eight times greater than was possible with the 1·5 m – feed light directly into photoelectric detectors and the results are computer processed to give a measurement of the fringes. Using this instrument, diameters of stars as small as 0·00041 arc sec. have been obtained.

Although no ordinary telescope could do as well as this, it is still possible to use interferometry to improve its performance. Theoretically, a telescope like the 5-m (200-inch) should be able to resolve detail down to 0·02 arc sec. However, because of the turbulence or continual movement of the air above a telescope – a movement which we see as the twinkling of starlight – a telescope never achieves this theoretical limit; its results are usually 100 times less precise. In 1970 the French astronomer Antoine Labeyrie suggested a method of overcoming atmospheric turbulences. An analysis of the formation of images showed that the telescope image is composed of a host of tiny images caused by small pockets of air, each about 10 cm across. In some of these 'fly's eye' images or **speckles**, the light waves are in phase, in others out of phase. The speckles are continually changing, but by using short exposure of 0·02 s or less, they may be 'frozen'. Those speckles in which the light is in phase show interference, and by taking a large number of exposures and restricting the light to a very narrow band of wavelengths, it is possible to produce a composite picture. To obtain useful