Astronomy Talk 13th February 2016
Active and Adaptive Optics

This talk was given by Mark Gibbons from the Cotswold Astronomical Society.

Mark explained the limits to resolution including quantum effects such as Airy disc diffraction and that one needs as large an objective aperture as possible. This excludes refractors as the weight of the glass in a large lens causes distortion. Accurate grinding of mirrors is critical, and today surfaces are made smooth to 14 nm, which is in proportion to a 2 cm mountain on the European continent.

Mirrors too are distorted by gravity, and a 5m single mirror is about as big as you can get. Larger modern mirrors are segmented, though the segmentation can cause diffraction.

Active optics includes actuators that keep the mirror as correctly shaped as possible, e.g. the 8.2 m Subaru telescope has 261 actuators.

Adaptive optics try to sort out the atmospheric problem of scintillation. In still air a cycle time of .01 seconds works OK, but in turbulent conditions it needs to be .001 seconds. The actuators are located on the 2nd 3rd or 4th mirrors, which makes the system much easier to control as these are much smaller than the primary.

To date these are mostly in infra-red, which needs less actuators than optical, but it's coming soon for optical wavelengths. A guide star is created using a laser, pointing about 2" away from the target. Reflecting the beam from an altitude of 30 km, .5" resolution can be corrected to .07". Another method is to excite sodium at 90 km, which needs a lot of power but can achieve a resolution of .008". Better than Hubble!

The JWST will have resolution of .1", but it will be in the infra-red.

The Giant Magellan telescope will have 10 times better resolution than Hubble, at a cost of £365 million: Hubble has cost £1.6 billion. The European Extremely Large telescope (E-ELT) will make images 15 times sharper than Hubble.

The atmosphere is opaque to many ranges of wavelength, especially to X-rays and gamma rays, so we'll still need lots of telescopes in space.