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A VERY BIG TELESCOPE

Ken Tapping, 1st July, 2014

A few days ago the news programmes were showing images of about a million tonnes of rock being blown off the top of Cerro Armazones, a 3,000 metre high mountain in Chile. This lowered the top of the mountain by about 40 metres and provided a flat area on which to build the world's largest optical telescope: the European Extremely Large Telescope or ELT, which will have a primary mirror or light collector 39 metres in diameter. Unlike traditional telescope mirrors, which were single pieces of glass, this huge light collector will consist of 789 1.4 metre hexagonal tiles.

The requirement for this behemoth comes from a growing need to collect more light. As we probe out to the edges and remote past of the universe, to see what the first galaxies and stars were like, the objects we are observing get fainter and fainter, simply because they are very far away, and their light has been travelling for billions of years.

Over the last two decades or so there has been a revolution in imaging devices and other astronomical instruments, which has led to our being able to observe fainter objects than ever before. For example, in the past it was very difficult to take pictures of stars in the sky with an ordinary camera. These days, almost any digital camera can do it quite easily. However, this dramatic improvement in imagers and detectors is unlikely to continue for much longer, at least using known technologies. We are beginning to crash into the fundamental limits set down by Mother Nature. Therefore, the only way we know to improve our ability to observe extremely faint objects, like those out in the farthest depths of space, is to make a bigger light collector. The ELT will collect 15 times more light than any existing telescope.

That such a telescope can be built would have been unthinkable a couple of decades ago. That we can do it now is due to a revolution in telescope design and manufacturing techniques, and in the development of new methods for observing.

It was not that long ago that the largest telescope in the world had a mirror 200 inches across. It was a single piece of special glass where great efforts were made to get the most strength for the least weight. Mirrors bigger than that did not work because their weight became too large for them to stay in shape. Then engineers came up with a new approach; the mirror did not have to *stay* in shape, instead we would *keep* it in shape. Instead of being a rigid, heavy structure, modern mirrors would be thin, light, flexible and possibly made up of multiple pieces. Computer-controlled actuators would then move the parts and flex the surface to keep the structure precisely in shape. This process, called "active optics" makes it possible to make bigger light collectors and as yet it is hard to see what the upper size limit is likely to be.

The other bugbear for ground-based astronomy is the atmosphere. Turbulence makes stars twinkle prettily, and makes astronomical images blur and dance around. Putting telescopes on mountains gets us above the worst bit of the atmosphere. To see how much this improves things have a look at some of the images on the Canada France Hawaii Telescope (CFHT) website. However we can go further, using a process called "adaptive optics"; we can sense what the atmosphere has done to the light we are observing and then undo it.

Ground-based telescopes will have a big role in astronomical research for the foreseeable future because we cannot put big telescopes in space, and it is not easy to make improvements once they are there. Therefore we can look forward to even bigger telescopes coming along in the future. However, what will we call them? What will come after the Extremely Large Telescope?

Saturn and Mars lie high in the southwest during the evening, and Venus rises about 4 am. The Moon will reach First Quarter on the 5th.

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