Twinkle, Twinkle Little Star

Our atmosphere is a dynamic creature. Its tiny particles constantly dance around the sky. Our eyes only see the dance in its effects; such as mirages, heat haze and the twinkling of a star.

Astronomers dislike this twinkling. Their photos are blurred and they can't see as much detail as they would like. Following Isaac Newton's advice that "the only remedy is a most serene and quiet air, such as may perhaps be found of the tops of the highest mountains", many observatories have moved to Hawaii, Chile or the Canary Islands (where I worked last summer). The twinkling is reduced, but is still a problem.

NASA spent $2billion putting the Hubble Space Telescope into space, above the dancing atmosphere. It has been a fantastic success, but only a few astronomers are lucky enough to be able to use it.

The problem is that rays of starlight travel in straight lines through space, but are deflected in the atmosphere by the changing speed of light. Rays arriving at different points on a large telescope have all been deflected differently.

European astronomers, led by Fritz Merkle, have recently been able to take photos in which the stars don't twinkle. They were able to measure exactly how much all the rays had been deflected, and so deform a flexible mirror to deflect the rays back to where they should be. "The greatest technical problem," says Merkle, "was the computer system." This needs to translate the ray deflection measurements into the correct deformation of the mirror surface, making several hundred million operations per second.

As you can see from the ceaseless twinkling of a star, the deflections caused by the atmosphere change constantly. The deflections have to be measured up to several hundred times per second to prevent the photo becoming blurred, and to stop the stars from twinkling. Lots of starlight is needed in order to measure the ray deflection, and so only a fraction is left to create the image. Only rays from bright stars which appear to be close to the star of interest can be measured. This is so that rays from the two stars pass through the same part of the atmosphere and are deflected in the same way.

This technique is a success, but can only be used in parts of the sky where there is a nearby bright star. It requires high-performance measurement devices, flexible mirrors and computers that were not available a decade ago but, for a few years now, several groups of astronomers have been taking photos in which the stars don't twinkle.

How can astronomers take photos of the rest of the stars? Helped by recently declassified "Star Wars" research on laser weapons (the US military had a similar problem, their laser beam was twinkling as it went upwards through the atmosphere, and missing its target), American astronomer Laird Thompson creates his own stars in the sky with a laser beam. Some of the laser light scatters back from particles in the atmosphere and returns to the telescope. It is deflected just like real starlight. This extra light is used to measure the deflections and there is now some real starlight left over for the astronomer.

Unfortunately these laser stars are not as good as real stars. Their rays don't follow quite the same path through the atmosphere as rays from distant stars. Also, some real starlight must still be measured, in order to correct for the twinkling of the laser beam. (This problem wasn't spotted by the highly respected military scientists who first proposed the idea!)

This technique is just beginning to be used by astronomers, mainly on converted military sites. The US military has encouraged its scientists to cooperate with astronomers, and work has concentrated on building powerful lasers to return enough light from the sky. With purpose-built lasers just coming into use, the next challenge is to create a constellation of laser stars for use on the largest telescopes. These will be as good as light from the star itself.

This will not be easy. Very little work has yet been done with more than one laser star, and some astronomers doubt that they will ever be able to stop the stars twinkling on the largest telescopes. However, many are enthusiastic and Laird Thompson foresees a time when most telescopes, including Britain's Isaac Newton Telescope on the Canary Islands, will be able to see the heavens as clearly as Hubble. Thompson estimates the cost of such a system at under $4 million, less than 1/500th that of Hubble.

For the rest of us, the stars will continue to twinkle as they always have done and we can leave to astronomers the task of rewriting nursery rhymes.