ESOcast Episode 34: How to stop a star's twinkle		
00:00 [Visuals start] **[Bob Fosbury]** 1. The Allgäu public observatory lies amidst the picturesque landscape of southern Germany. As night falls, a team of scientists and engineers prepares to field test a very cool piece of technology: a laser guide star unit, which will soon be on its way to ESO's Paranal Observatory.		Allgäu public observatory Dome opens Test team at work Image or timelapse footage of laser
00:30 **ESOcast intro** 2. This is the ESOcast! Cutting-edge science and life behind the scenes at ESO, the European Southern Observatory. Exploring the ultimate frontier with our host Dr J, a.k.a. Dr Joe Liske.		ESOcast introduction
00:50 **[Dr J]** 3. Hello and welcome to the ESOcast. Today we're at the Allgäu public observatory in southern Germany because this is where a team of scientists and engineers from ESO is testing a brand new laser guide star unit. 'What's that?' you ask. Let me explain... Now, we have all looked at the sky at night and seen the stars twinkling. Now, the stars themselves, of course, don't do any twinkling. The twinkling is caused by turbulence in the Earth's atmosphere. As the starlight crosses the atmosphere it encounters different pockets of air with different temperature and pressure which bend the light in different ways, thus causing distortions. In fact you can see this effect often in broad daylight, whenever you look towards a distant object on the horizon on a hot day.		Dr J outside the Allgäu observatory Test team at work Twinkling stars over the Atacama desert Camera cuts to very long lens shot along a road to the horizon showing heat haze/alternatively long distance shot showing trees and church towers.

01:39 [Dr J] 4. Now the twinkling is all very pretty and even romantic, but for us astronomers it's actually a real problem because it means that our images are blurred and less sharp than they could be if it wasn't for the atmosphere. So, what do we do about it? Essentially we need a method to cancel out the distortions, in effect, to "un-twinkle" the stars. The way to do it is to bounce the starlight off a mirror that is slightly deformed in exactly the right manner to cancel out the distortions. But how do you know how to deform your mirror?		Dr J outside Allgäu observatory Time lapse of the clear night sky over the trees and mountains, with passing clouds on the horizon.
02:13 [Narrator] 5. As ESO's Very Large Telescope observes the sky, a specialised computer can pick a bright star and constantly monitor how it twinkles — deducing the atmospheric conditions above the telescope many hundreds of times a second. The computer then sends commands to a series of devices attached to a mirror in the telescope, bending and flexing it precisely in time with the atmospheric turbulence, cancelling out the distortion in the images.		Footage of the VLT Cut to computer simulation of disturbed waveform and adaptive optics system (Still image for online archive needed, too Simulation. Telescope with cross section of atmosphere. Swirling motion of turbulence above the telescope.
02:47 [Dr J] 6. So, for this correction process to work you need a really bright star in the field of view of your telescope. But bright stars are very few and far between, and remember that the VLT was designed to image only a very small part of the sky at any given time. So for most observations there just won't be a bright star in the field of view of the VLT. So what do we do now? Well, we make our own.		Dr. J at Allgäu observatory Time lapse from inside the VLT
03:16 [Dr J] 7. 90 kilometres above our heads, in the upper atmosphere, is a relatively thin layer of sodium. If you fire a powerful laser beam into the sky you can make these sodium atoms glow, thereby effectively creating an artificial star for the computer to lock on to.		Images/footage of the laser guide star at Allgäu public observatory. Dr. J at Allgäu observatory

03:34 [Narrator] 8. In 2006, ESO installed the Southern Hemisphere's first laser guide star on the VLT. This system greatly improves the telescope's power, meaning the VLT can even make sharper images than Hubble for certain types of observation. But this existing system has limitations. It can only create one artificial star at once meaning it can only correct the telescope's vision for a small part of the sky at any one time. It's also very bulky – the equipment has to be kept in a separate laboratory and the laser beam fed along an optical fibre to the telescope.		Images/footage of the laser guide star at the VLT. Also of the equipment and laser lab within the enclosure.
04:20 [Dr J] 9. Based on the experience obtained with its first system, ESO engineers have been working to build a much improved, new laser guide star unit. [Dr J] So, Domenicos, this is it — this is the laser. It's incredibly small, it fits on the back of this small telescope, that's amazing. [Domenicos] Yes. So this is what we've been working on for the past five years, to make a 20-watt laser, very compact and lightweight so that it can be mounted directly on the back of the telescope. So we had to develop fibre lasers first and then developed these kinds of laser heads. [Dr J] So, you've just said it, it's a 20-watt laser. That's quite a bit of power isn't it? [Domenicos] Yes. This is the power we'll need, actually, for the next generation of laser guide star systems. And right now, for example, at Paranal we have about 5-watt in the sky, so this is quite a jump in power. [Dr J] Is the laser beam that comes out of the end of this telescope dangerous? What happens if I put my hand into it? [Domenicos] If you put your hand in, you'll feel warmth. But don't look into the beam. [Dr J] OK, so it won't burn my hand. But what about aeroplanes, is it dangerous for them? [Domenicos] It's not dangerous for the equipment or for the aeroplane, it's dangerous for the eyes for the passengers. And, this laser is above the maximum		Images/footage of the laser guide star at the VLT. Also of the equipment and laser lab within the enclosure.

permitted exposure so we have to avoid planes crossing the beam. In fact, here where we are now we've obtained a no-fly zone above us, so we don't risk hitting a plane.		
05:46 [Dr J] 10. The new device is more reliable, easier to maintain and much smaller. In fact, as we've just seen, the whole unit fits into one small package which is easy to mount on the launch telescope.		Dr J at Allgäu
06:00 [Narrator] 11. Because it's so much smaller, up to four of these lasers can be installed on a single telescope, correcting the VLT's image over a much wider field of view.		Simulation of the VLT with four laser guide stars
06:15 [Dr J] 12. So what's happening here in Germany is that our team is testing the new prototype to make sure that it works perfectly before it gets shipped to Paranal. The facilities here at the Allgäu public observatory are perfect for this— and, what's more, they're only a short drive from ESO Headquarters.		Dr J on site at Allgäu public observatory Footage of astronomers at the observatory
06:33 [Narrator] 13. Laser guide stars like this will be crucial for the forthcoming European Extremely Large Telescope, which will use adaptive optics routinely. The telescope will be many times the size of today's biggest telescopes, which should mean much sharper image quality. But this great image quality will depend on how well the adaptive optics and the laser guide stars work.		Computer animation: ELT with laser guides

06:59 [Dr J] 14. Pioneering new technologies like these will make a big difference to the world's most advanced observatories of the future, especially the E-ELT. This is Dr J signing off for the ESOcast. Join me again next time for another cosmic adventure.		Dr J on site at Allgäu public observatory Fade to black
07:28 [Narrator] 15. While we were filming this episode, we got a stark reminder of why ESO's telescopes are located on mountaintops of Northern Chile, and not here in the hills of Southern Germany. Thankfully, storms like this are not something you ever see at Paranal.		Sound: clap of thunder, wind blowing, etc. Slowly fade to video/images of storm at Ottobeuren
07:50 [Outro]		ESOcast is produced by ESO, the European Southern Observatory. *ESO, the European Southern Observatory, is the pre-eminent intergovernmental science and technology organisation in astronomy designing, constructing and operating the world's most advanced ground-based telescopes.*

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